Pop-Up Constructions Motivate and Reinforce Science Learning for Upper Elementary Students

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Abstract

Pop-up boxes and folder constructions support student inquiry while integrating art, craft, spatial, and creativity skills. Step-by-step illustrated directions for constructing pop-up boxes are provided with example images of pop-up boxes focused on ecological issues. Teachers used these pop-up constructions to assist fourth- and fifth-grade students in understanding environmental problems with youth-implemented solutions. Classroom testing showed that combining art with science through pop-up constructions allowed students to be creative, to have both minds-on and hands-on activity, and to use motor and spatial skills in constructing the pop-ups, along with paper engineering concepts in their pop-up designs. Teachers reported strong student engagement, collaboration, and productivity during the lessons with students expressing enjoyment in the activity. Examples of two additional pop-ups addressing the topic areas of simple machines and ecosystems are provided.

Key Words: pop-up constructions, scientific inquiry, crafts, arts integration, creativity, spatial skills, paper engineering

Introduction and Background

Science includes both the natural world and the designed world. By planning and constructing their own science-related products, students can simultaneously learn about design and science. Hendrix (2004) observed, "One possible way to look at the whole area of children's design is to find some product that children will want to design, will enjoy designing, and will teach them something in the process" (p. 2). Pop-up books, cards and constructions are very appealing to students, simple pop-ups are easy to make, and science inquiry learning can be supported by their creation. These attributes make pop-up scenes an excellent product to support science learning. In this introduction, we note the history and educational value of pop-up constructions, outline how pop-up constructions support science inquiry, and provide evidence of the efficacy of arts and crafts integration with science, before explaining the importance of such creative endeavors to twenty-first century learning.

Pop-up Constructions

Pop-up constructions are part of "moveable books:" books with pages having parts such as flaps to be lifted, foldouts to be opened, or wheels to be turned, that have been in existence for over 700 years (Montanaro, 2005). The first moveable book with images that stood up automatically when the page was opened was invented in 1929 with the term "pop-up" being coined in 1932 (Glassner, 2002). Pop-ups are still popular today with many greeting cards and children's books employing this paper engineering device. Some currently-available books on how to make a large variety of simple to complex pop-ups include those by Jackson (1993), Irvine (2008), and Birmingham (2011). Additionally, there is free software available on the Internet to design and view pop-ups electronically before printing, cutting, and constructing them (Hendrix, 2005).

The act of producing a construction that presents a summary of the concept allows students to organize their thoughts and solidify their understandings. Craft activities have a tactile, cognitive dimension of manipulating materials to create a product. The paper, cardstock, cardboard and craft glue pop-up projects described here have essential characteristics such as tensile strength, stiffness, tearing, and adhesion properties that give tangible, kinesthetically-understood meaning to these aspects of science and engineering (Hendrix & Eisenberg, 2006). Pop-up constructions also present students with interesting cognitive and spatial thinking challenges as two dimensional devices are used to simulate three dimensions (Shannon & Samuels, 1985).

Inquiry-Based Science

The National Research Council's recent framework for K-12 science education emphasized the need for students to actively engage in scientific practices to deepen understanding of core ideas (Keller & Pearson, 2012). Among the many recommendations set forth were eight essential practices that should be included in quality science and engineering practices (National Research Council, 2011). Table 1 shows how these eight practices can be supported by making pop-up constructions.

This science pop-up project also supports the application of the Next Generation Science Standards (Achieve Inc., 2013) to our environmental education lessons with fourth and fifth grade students who created pop-up constructions. Standard 4-ESS3-1 states: "Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment" (Achieve Inc., 2013, p. 36). During the lessons, students learned of many environmental challenges, including the origin and use of fossil fuel energy sources and their effects on water, air quality, and habitats. Students investigated ways they

might make a positive impact as youth and depicted these in their pop-up scenes. The fifth grade standard 5-ESS3-1: "Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment" (p. 45) was addressed during these lessons as students investigated local projects (e.g., Adopt a highway, tree planting) in which they might participate to help the environment. This work also involved students in the science and engineering practices of "obtaining, evaluating, and communicating information" (Achieve Inc., 2013, pp. 36 & 45) from books and other resources through their pop-up scenes that were put on display in the school lobby to educate peers and school visitors.

[Insert Table 1 about here.]

Arts Integration

Jackson (2000) analyzed John Dewey's (1934) lecture series on aesthetics, *Art as experience,* explaining the important role the arts play in reinforcing and enhancing the educational value of experience:

> The arts, Dewey tells us, reveal the rewards of bringing an experience to fruition. They reveal what it takes to fashion works whose form and structure are holistic and unified, yielding a reaction on the part of both artist and audience that is at once satisfying and fulfilling. In this way they hint at what life might be like if we sought more often to shape ordinary experience in a more artistic manner (p. 6).

The arts support creativity and curiosity while reinforcing cognitive abilities, suggesting that arts integration with science should be pursued (Appel, 2006). Many Nobel prize-winning scientists such as physicists Luis Alvarez and Albert Einstein, along with chemist von Euler-Chelpin attributed their ground-breaking abilities of visualizing science processes and experiments to their arts instruction (Root-Bernstein & Root Bernstein, 2013).

Arts-integration into the curriculum boosts student performance. Observations of nature and experimental results through drawing or painting support visual imaging abilities, a major predictor of success in science (Winner & Casey, 1992). Art, music, and dance allow students to recognize, form, and play with patterns, another important component of scientific thinking. Craft-making builds fine motor manipulative skills necessary to laboratory research. Catterall (2009) found that, especially in students from socioeconomically disadvantaged school districts, arts instruction had a positive effect on standardized test scores, even when the tests did not address arts-related material. Significantly, Root-Bernstein and Root-Berstein (2013) showed that the more arts and crafts that scientists engaged in across their lives, the greater the likelihood of them producing important science results in their fields.

The National Art Education Association (1999) identified key opportunities that teachers should provide students through art. The pop-up constructions students made in the activity described here supported many of these, particularly "Organizing, evaluating, and reorganizing works in progress to gain an understanding of the formal structuring and expressive potential of line, form, color, and texture in space." As students design their pop-up scenes, they consider color, arrangement, along with shapes, lines, and textures of images. They also must take into account the three-dimensional layout of the scene, the scales of various components, and the mechanical operation of the opening and closing of the scene.

Creativity

The twenty-first century skills movement (e.g., Trilling & Fadel, 2009) has promoted creativity, innovation, problem-solving and technology skills for personal and national economic growth. Torrance, an eminent researcher in the field of creativity, showed that creativity could be taught (1987) and integrated with the content of all school subjects (Torrance & Safter, 1990).

Another prominent creativity scholar, Csikszentmihalyi (1999), demonstrated that many creative skills are field-specific, indicating that development of innovative scientists needs to start with creative science activities. According to a study of university faculty by Marquis and Vajoczki (2012), even though participants defined creativity differently, they all agreed that it could be applied to any field and needed to be taught. The current article describes a creative project easily conducted with different science topic areas. Some creative skills addressed by making pop-ups are: imagination and mental visualization during the planning stages; spatial thinking and transformation from two dimensional images to three dimensional displays; elaboration of ideas and detail in the scene; storytelling articulateness with arrangement of pictures and text; originality of approach to topic or choice of images; and breaking boundaries in which implicit rules (e.g., use only realistic colors) are ignored.

The next section describes a technique for making pop-up boxes, a more robust and three-dimensional variation of pop-up pages or cards. Illustrated examples of pop-up use in science teaching are presented followed by conclusions.

Materials and Procedures for Pop-Up Constructions

The science activities described here were first enacted with teachers in a graduate-level education course. They each made a pop-up box that explained an environmental problem when a viewer opened the drawbridge-style door with a pop-up scene on one side of the box and then depicted what elementary students might do to solve the problem through a similar pop-up scene that opened on the opposite side of the box. These environmental pop-up boxes were used as models during science instruction with four and fifth grade students at a low-income school with a diverse population. The elementary students subsequently made pop-up scenes in folders rather than boxes because of time constraints.

POP-UP CONSTRUCTIONS

Environmental Pop-up Boxes

Figures 1 through 3 each show multiple views of three environmental themed pop-up boxes. The front fold-out scene of the pop-up box in Figure 1 shows the problem of disappearing prairie lands and the ecosystems they support. The pop-up scene on the reverse side shows images of youth planting native grasses and studying prairie life. The display provides other suggestions such as talking to city officials about prairies, having a prairie garden at school, and teaching others about the importance of prairies. Figure 2 shows the polar ice cap melting box from different sides. The maker of this scene presented facts about ice loss and ways to ameliorate the situation such as planting more trees and reducing fossil fuel consumption by driving less and using alternative forms of energy. Figure 3 provides several perspectives of the rainforest destruction pop-up box. This construction conveys how animals depend upon the rainforest habitat and how it is being destroyed. A pop-up scene shows actions elementary students can take to help preserve rainforests such as supporting organizations that are conserving rainforests and reducing use of rainforest products.

[Insert Figure 1 about here.]

[Insert Figure 2 about here.]

[Insert Figure 3 about here.]

Making a pop-up box rather than a simpler card or folder scene takes extra effort, but is rewarding because the final product is durable, three-dimensional, and multi-faceted. Table 2 provides materials, tools, and instructions for preparing the pop-up box, while Table 3 gives details of constructing the pop-up scenes used in the boxes and also in folders. Figure 4 illustrates the process of folding and cutting a piece of stiff paper to make a pop-up. The materials and tools necessary for the pop-up scenes are cardstock (manila folders work), white

craft glue, scissors, a ruler, and images. Images for the pop-ups can be obtained by drawing and coloring with markers, colored pencils or paints; taking and printing photographs; cutting images from magazines, or printing images from Internet searches. Text should be used to title and label the work, present important ideas, and/or deliver callout messages from figures in the scenes.

[Insert Table 2 about here.]

[Insert Table 3 about here.]

[Insert Figure 4 about here.]

Observations and Discussion of Elementary Student Work in Pop-up Creation

Figure 5 and Figure 6 present pop-up constructions made by elementary students using folders, construction paper, and magazine pictures. The two pop-up folders featured in Figure 5 show both the cover and the pop-up scene inside each folder. The first construction (Figure 5a) shows the problem of litter. The student placed himself in the scene, declaring, “Make our school a litter free zone” and “Let’s have a litter pick-up day.” He was pleased to incorporate a cartoon can for humor and used bright colors to enhance his work. The second construction (Figure 5b) focused on deforestation. The student explained on the cover that half of the world’s trees that are cut are used for firewood. She cleverly used a homophone she cut from a magazine in this phrase “*Sea,* it’s a problem.” She also found the phrase “Do it yourself” in a magazine, completing it with “if your classmates don’t help.” Her arrangement of images in the scene was balanced with the more intricate textured items drawing attention into the center of the arrangement.

Figure 6 displays the interiors of four pop-up scenes. Students were clever in their use of magazine pictures. The student who constructed the scene in Figure 6a noticed a photo of money and used it to make the point that it should be spent to save rainforest lands. Colorful tropical

birds make her work particularly appealing. The girl who made the pop-up in Figure 6b enjoyed making a visual collection of lamps to accentuate her point that turning off lights saves energy. She added additional words to "Saving energy" that she snipped from a magazine to complete the suggestion: "also saves money." She added an attractive flower to symbolize playing outdoors and enjoying nature. The student who constructed the pop-up in Figure 6c wrote positive sentiments about the prairie: "Gosh, if only there were more of it," and "Plant prairies; it will be fun." She cut out eyeglasses to illustrate "Can't you see?" The last pop-up creation, Figure 6d, shows a student's scene of what kids can do about hunting and poaching. Besides a pleasing arrangement of components and interesting color scheme of purple, green and blue, she also made use of text from the magazine to emphasize her point. These example pop-up constructions show that students incorporated many creative elements while utilizing their skills to produce interesting, colorful arrangements with a variety of lines, shapes, and textures. Therefore, not only did students portray their science-related convictions of doing something to help the environment, they effectively integrated art concepts and creativity with their science work.

[Insert Figure 5 about here.]

[Insert Figure 6 about here.]

Observations made by Teachers during Elementary Student Work

The teacher-made pop-up boxes were used to provide initial information about a wide range of environmental problems to elementary students. At their first introduction, fourth and fifth grade students became very excited, clamoring to make them as a project. Each student was asked to select a pop-up box, study it, and then present to classmates its essential information. Students, then, traded boxes until they had the opportunity to look at each one. This was

followed during another lesson by structured use of de Bono Breadth thinking skills (de Bono, 2000), such as determining the pluses, minuses, and interesting aspects of a particular action, or the views of many different people and animals of a situation, to discuss environmental problems and their solutions. During other lessons, students read juvenile literature about what youth can do about environmental issues and wrote essays about one chosen issue that would become the subject of a pop-up construction. Students recognized the importance of all the topics being addressed by someone. Therefore, they coordinated choices (without complaint) so that each person focused on a different topic.

During pop-up construction, students went back to the model boxes to see how they were arranged and how the pop-up parts opened or folded as the box was closed. Students were engaged during the pop-up construction work. No one was off-task or finding distractions, as sometimes occurred during other instructional events. The students expressed that time passed quickly. Some students (who had never before taken things home to do further work) took their pop-up scenes home to add more to them. All students requested more time to work on the project, suggesting they skip lunch and perhaps the rest of the school day to continue work, but this could not be done. One fifth grade student who missed the class because of another activity insisted on coming in to work with the younger fourth grade students so that he would not miss having enough time to work on his pop-up scene.

The classroom was a pleasant hum of activity during the pop-up construction work. Students engaged in more collaboration than in other activities. Students looked out for each other's needs, finding items that supported their environmental topics. Students helped each other find effective visuals in the magazines. Peer coaching occurred as students made suggestions phrased in positive ways such as, "Here's a cool picture; you know how you might

use it…" Students seemed truly interested in each other's pop-ups and how these constructions were developing. They praised others' choices of images and put aside some pictures that they thought might be helpful to others. When a student's glue bottle became empty, another student quickly offered her glue bottle so that work could continue for all.

Students exhibited creativity during the work, playing with words regarding the images as was described earlier. Instead of finding a photo of trash, a student realized he could make a wad of some scraps and use that for trash in his scene. Students realized that items could be symbolic, for example, one student used dollar signs to represent money. Students expressed emotions by assigning callouts to animals in their scenes. In a scene focused on the problem of full landfills, a magazine photo frog complained, "All my family was buried by trash."

Students indicated that they felt empowered by the activity. One girl declared, "Yes, I can actually make a difference!" Students wanted to share their final products with others. They suggested sharing them with younger students or peers in other classes. The pop-up scenes were put on display in a glass case in the school's front lobby for everyone to view. Students made plans to actually plant trees at school, remove litter from the grounds, and to raise funds to help with other environmental issues.

Conclusions and Implications for Teaching

There was considerable evidence that students enjoyed the pop-up activities and surrounding environmental lessons: They were enthusiastic, focused, on-task, collaborative, and even spontaneously thanked the teachers for allowing them to make pop-ups. The lessons raised acute awareness of the environmental issues resulting in the students actually taking action. The pop-up activities were effective in exercising student fine motor skills and developing spatial skills and concepts of paper engineering.

Implications and Suggestions for Teaching

We suggest the teacher make a model pop-up box so that he/she will understand the process well and can use it as an example. Provide enough quality materials with a variety of colors, textures, lines, and shapes. In the student-made pop-ups we displayed here, magazine pictures were used as a way of modeling reuse of materials and also to facilitate real world connections. As students paged through magazines, they constantly attempted to connect their environmental topic to the images they saw. The teacher may want to amass a scrap box of fabric pieces, unusual papers, and colorful paper scraps for student use. Internet pictures, drawings, magazine pictures, photos of themselves, photos of places around the school or neighborhood may be used in pop-up constructions. Allow enough time so students can plan and carefully create their pop-up constructions (2-3 hours over a few days for a folder pop-up; about 5 hours for a pop-up box).

Extensions

Any science topic could be used in pop-ups. Joan Irvine's book (2008) on pop-ups that move is resource for making constructions on force and motion topics. A wheel-and-window motion book would be an effective culminating display of the life cycles of organisms, the water or rock cycle, or parts of other systems. The final two sections here highlight, with pictorial examples, two more areas that may be explored with pop-up constructions: simple machines and ecosystems.

Simple Machines

A unit on simple machines is one area in which a teacher could use a pop-up box or folder. This topic supports crosscutting concepts for grades 3-5 in which "Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and

meet societal demands" (Achieve Inc., 2013, p. 23 & 32). One side of the pop-up could feature and explain a specific simple machine while the other side shows examples of manufactured items utilizing that concept, making the pop-up a self-directed learning tool. An example pop-up construction following this format is shown in Figure 7. Another way to engage students with simple machines using pop-ups might be to have one side showing or describing certain simple machines. The opposite side could then show popular or well-known toys that use those same types of simple machines. For instance, a screw is a type of simple machine that converts rotational movement into lateral movement. This could be described on one side of the pop-up. There are several types of simple toys that require a child to turn a small handle. When this occurs, the main element of the toy moves forwards or backwards. This is done by threading the toy on a type of screw, turning the rotational movement into lateral movement. A toy such as this might, then, be located on the other side of the pop-up and students need to match with the simple toy used.

To take a broader look at simple machines, a teacher could also start the pop-up box or folder in the same manner as described above for the toy. However, instead of focusing on toys, the other side might have actual tools, or more complex machines in which simple machines are combined. Students could match and compare, gaining a sense for how prevalent simple machines really are in the world. Along with any of the ideas presented, students could be asked to write about connections or comparisons they make between the two sides of the pop-ups. Seeing the ideas literally pop out at them can be much more motivating that seeing the idea in a book or other standard medium. It is hoped that students would be motivated to both make the connections and to write about their ideas with enthusiasm.

[Insert Figure 7 about here.]

Ecosystems

Next Generation Science Standard 5-LS2-1 states: "develop a model to describe the movement of matter among plants, animals, decomposers, and the environment" (Achieve Inc., 2013, p. 42). This may be accomplished through making pop-up constructions. The task requires students to work on two sides of a box/folder pop-up, in which one side identifies all of the components of the system and the other shows their relationships to each other.

Students might investigate the ecosystem of a local pond. First, they would visit the pond, recording notes of their observations and photographing pond organisms. They might also draw sketches of components or a plan of the pop-up construction. The double folder pop-up construction shown in Figure 8 features the ecosystem of a lake in the Midwestern US. This model has two pop-up constructions: one depicts information about the components of the lake ecosystem, while the other shows the relationships between those components. The back cover gives suggestions for how elementary students might investigate the lake's ecosystem.

[Insert Figure 8 about here.]

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Captions for Figures

Figure 1. Disappearing prairies pop-up box. 1a is the front of the box; 1b is the back panel. 1c, 1,d, 1e, and 1f show different views of the pop-up scenes.

Figure 2. Polar ice cap melting pop-up box. 1a is the front of the box; 1b is the back panel. 1c, 1,d, 1e, and 1f show different views of the pop-up scenes.

Figure 3. Rainforest destruction pop-up box. 1a is the front of the box; 1b is the back panel. 1c, 1,d, 1e, and 1f show different views of the pop-up scenes.

Figure 4. Steps in making a pop-up construction. 4a Fold the paper in half; 4b and 4c Cut a tab in the folded edge and fold back and forth. 4d Cut another tab and fold. 4e Open the folded paper and push the folded tabs into the interior. 4f View of the back side of the pop-up. 4g Put glue on the vertical sides of the pop-ups for adhering images. 4h and 4i Images installed in pop-up that fold down when it is closed.

Figure 5. Student-made pop-up constructions. 5a Cover and interior of pop-up made with a folder related to what kids can do to stop littering. 5b Cover and interior pop-up about deforestation.

Figure 6. Four interior scenes of student-made pop-ups. 6a scene related to saving the rainforest. 6b pop-up about saving energy. 6c Pop-up construction about planting prairies. 6d Pop-up scene discussing what kids can do to stop hunting and poaching.

Figure 7. Pop-up folder about simple machines and where they are found in daily life. 7a and 7b front and back of back-to-back folders. 7c Description of different simple machines. 7d Examples of simple machines in daily life. 7e and f Views of the opened folder pop-up.

Figure 8. Pop-up folder describing the ecosystem of a lake. 8a and 8b front and back of back-to-back folders. 8c Information about the components of the ecosystem. 8d Relationships between the ecosystem components. 8e and f Views of the opened folder pop-up.

Table 1. How pop-up constructions can support science inquiry practices

Essential Science Inquiry Practice	How the Practice is Supported by Science Pop-up Construction Work
Asking questions and defining problems	Choosing a problem to investigate and portray with a pop-up construction; delineating the most important concepts or examples to show; researching information on different aspects of the issue or concept.
Developing and using models	Determining how to construct a pop-up scene and what aspects of the topic to portray; considering how a concept will be shown or explained in this visual model.
Planning and carrying out investigations	Planning the theme and message of pop-up scenes; determining how to fit images on a page for efficient printing; Arranging parts in the pop-up construction for effective viewing.
Analyzing and interpreting data	Finding and selecting visual and factual information to be displayed in the pop-up construction; sometimes presenting primary data collected by the student with interpretations.
Using mathematics, information and computer technology, and computational thinking	Conducting Internet searches to obtain effective images; considering the scale of images and adjusting accordingly; spatial thinking skills for arranging pop-up images.
Constructing explanations and designing solutions	Providing explanations of a science concept or presenting problems with evidence along with solutions to these problems.
Engaging in argument from evidence	Using images to support the messages being made regarding science concepts or issues; choosing appropriate visual and text messages as evidence of a concept or problem solution.
Obtaining, evaluating, and communicating information	Sharing the pop-up construction with an appropriate audience; providing feedback to classmates regarding their pop-up scenes.

Table 2. Instructions for preparing the pop-up box

Instructions	Materials Needed
1. *First drawbridge door on box.* Use craft glue to seal the open top of the box. Cut the front panel to open like a drawbridge. Enlarge the door with an extra strip of cardboard at the top so that it does not fall into the box interior.	Empty cereal, cracker, cookie, or similar box, white craft glue, scissors, recycled copy paper
2. *Reinforcing box with paper.* Cover the entire box with torn pieces (approximately 8 x 8 cm.) of recycled copy paper that have been coated on one side with craft glue. Face the printed side of the paper down so that the side showing is white. Bend and mold the glue-covered paper around the corners and edges, overlapping to completely cover all surfaces.	
3. *Making the other drawbridge.* Cut a cardboard panel from another recycled cardboard box to match the drawbridge you have cut for the box. Attach this to the opposite side of the first box with a glued-on paper strip so that the box now has drawbridges that open on each side of the box. Note that the back panel of the box prevents one from seeing through the box. Cover the added drawbridge and hinge with paper.	Additional cardboard from another recycled box
4. *Painting the box.* Paint the entire box with white gesso (a thick type of acrylic paint) to stiffen it so that it will be very durable. Dry in the sun, overnight, or with a hairdryer. Paint the box the desired color or colors with acrylic paints. Edges may be outlined with a contrasting or color.	White gesso, acrylic paints, paintbrushes, hairdryer

Table 3. Instructions for making the pop-up scene (cardstock paper, glue, scissors, ruler, and images needed).

Instructions
1. *Planning the two pop-up scenes.* These scenes may show the negative effects of a problem and then possible solutions. Or, one pop-up scene may focus on parts and explanations of a concept, while the other side shows application of this idea in the real world. It is also possible that one scene identifies components of a system while the other shows interrelationships. Alternatively, the first side may show the "before" condition, while the second shows "after."
2. *Preparing the cardstock bases for pop-up scenes.* Begin with the side with the second drawbridge door. Prepare the supporting panel ("Cardstock Base") for the pop-ups from cardstock paper. Measure the drawbridge door panel and prepare a panel of cardstock paper (overlap and glue sheets together as needed) that is just a little smaller when folded in half. This piece of cardstock paper should *fit like a liner* with its fold line matching the hinge of the drawbridge door. Prepare an identical cardstock panel for other side of the box, matching the hinge lines. The pop-up backing *will not extend* into the hollow part of the box, but this background area can be decorated with glued-on items that will appear behind the pop-up.
3. *Plan the placement of images in the pop-up scene*. Decide how many vertical supports are needed on the cardstock base and at what position (foreground or background) these need to be. It is best to experiment with scrap paper first if one is inexperienced to learn how to cut the supports so that they will appear in the desired positions.
4. *Making the pop-up scene supports.* Begin by making two supports: one in the foreground and one in the background. Hold the folded cardstock base and prepare to cut into the folded edge. For the background support, about 2 cm from the end of this folded edge, make a 3 cm snip that cuts into both layers of the cardstock. Cut another parallel snip about 3 cm away. You now have a tab in the folded edge that can be bent back and forth. Fold it back and forth several times, returning it to its original position. Then move farther down the folded edge and cut another snip into that edge. This snip should be about 5 cm deep for the foreground support. Cut a parallel snip about 2 cm. away. Bend and fold this tab back and forth several times, returning it to its original position. Open the folded cardstock and push on the tabs from behind so that they form steps inside. Fold the cardstock base closed so that the tabs bend inside and the folded edge seems to have two large rectangular gaps in it. Cut additional pop-up supports as desired, following these same instructions.
5. *Decorating the scene with images.* Open the cardstock base. The images used to decorate the pop-up should be glued securely to the front vertical supports of the pop-up steps. They may need to be backed with cardstock if the paper they are printed or drawn on is not very stiff. Make sure the glue is dry before closing the pop-up. Paper clips can be used to hold images in place while drying.
6. *Installing the pop-up scenes into the box.* After the pop-up scenes have been decorated with images and text callouts or labels, install them in the box. For the drawbridge scene that has a flat back (not the inset box) coat the back and bottom of the scene's cardboard base (but not any parts that are tabs or steps) with glue and carefully glue it onto the drawbridge and back of the box, making sure the hinge of the drawbridge and hinge of the pop-up scene align. The other scene should have its bottom panel coated with glue and be affixed to the drawbridge. The back part can be anchored to the front edge of the box with glued-on tabs or a small box support that about 10 cm high can be glued in place to the box bottom and the back of the scene behind it. The hinge line of the pop-up needs to align with the hinge of the drawbridge door rather than be pushed backward into the box so that the pop-up stands up when the drawbridge is opened.
7. *Finishing the box.* Additional images should be used to decorate the rest of the box, including titles on the outsides of the drawbridge doors. The maker's name can be printed on the box bottom.

Figure 1. Disappearing prairies pop-up box. 1a is the front of the box; 1b is the back panel. 1c, 1,d, 1e, and 1f show different views of the pop-up scenes.
310x462mm (96 x 96 DPI)

Figure 2. Polar ice cap melting pop-up box. 1a is the front of the box; 1b is the back panel. 1c, 1,d, 1e, and 1f show different views of the pop-up scenes.
307x455mm (96 x 96 DPI)

Figure 3. Rainforest destruction pop-up box. 1a is the front of the box; 1b is the back panel. 1c, 1,d, 1e, and 1f show different views of the pop-up scenes.
324x475mm (96 x 96 DPI)

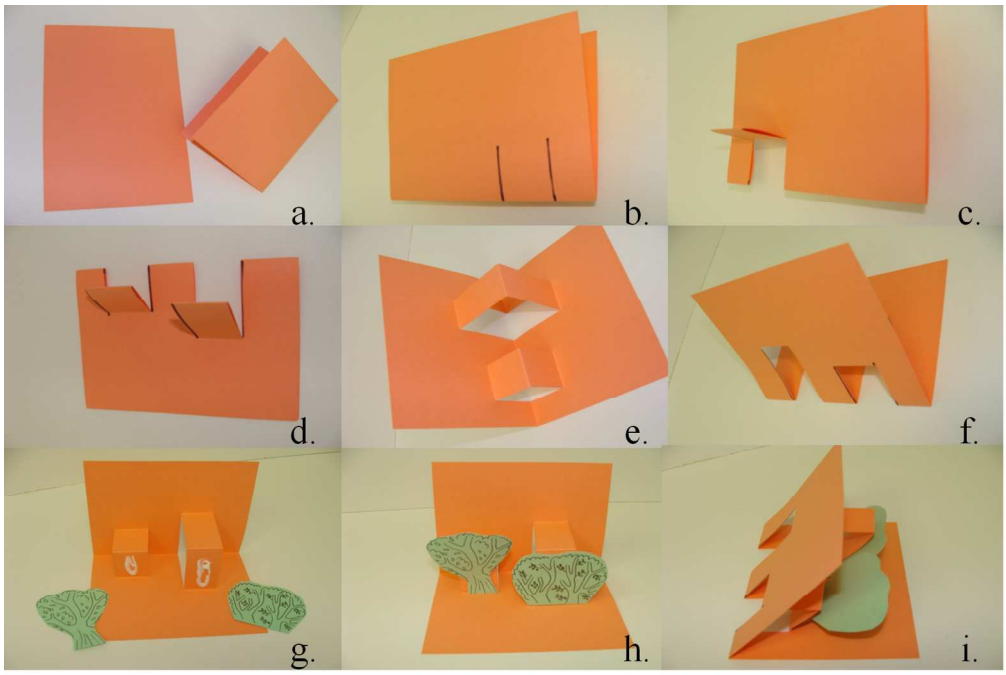

Figure 4. Steps in making a pop-up construction. 4a Fold the paper in half; 4b and 4c Cut a tab in the folded edge and fold back and forth. 4d Cut another tab and fold. 4e Open the folded paper and push the folded tabs into the interior. 4f View of the back side of the pop-up. 4g Put glue on the vertical sides of the pop-ups for adhering images. 4h and 4i Images installed in pop-up that fold down when it is closed.
457x314mm (96 x 96 DPI)

Figure 5. Student-made pop-up constructions. 5a Cover and interior of pop-up made with a folder related to what kids can do to stop littering. 5b Cover and interior pop-up about deforestation.
325x413mm (96 x 96 DPI)

Figure 6. Four interior scenes of student-made pop-ups. 6a scene related to saving the rainforest. 6b pop-up about saving energy. 6c Pop-up construction about planting prairies. 6d Pop-up scene discussing what kids can do to stop hunting and poaching.
306x459mm (96 x 96 DPI)

Figure 7. Pop-up folder about simple machines and where they are found in daily life. 7a and 7b front and back of back-to-back folders. 7c Description of different simple machines. 7d Examples of simple machines in daily life. 7e and f Views of the opened folder pop-up.
313x457mm (96 x 96 DPI)

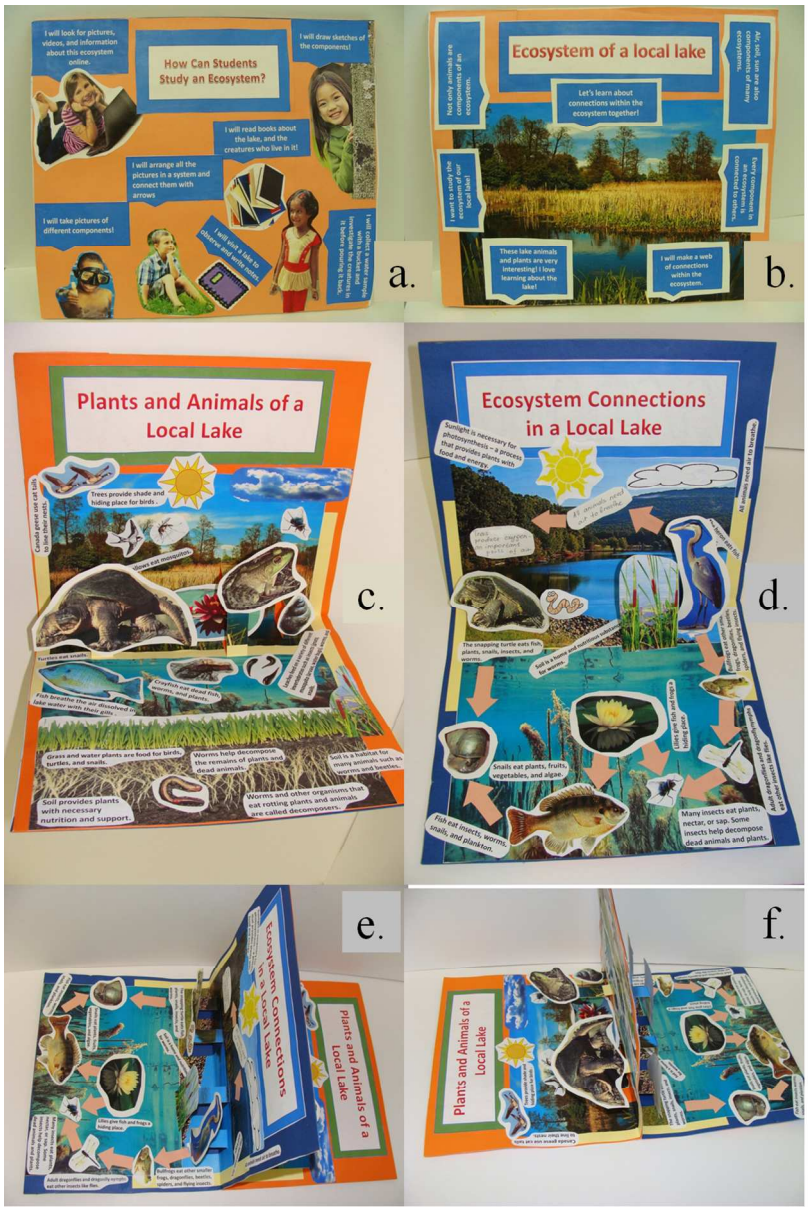

Figure 8. Pop-up folder describing the ecosystem of a lake. 8a and 8b front and back of back-to-back folders. 8c Information about the components of the ecosystem. 8d Relationships between the ecosystem components. 8e and f Views of the opened folder pop-up.
312x456mm (96 x 96 DPI)