Cell organelles and silk batik: A model for integrating art and science.

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All too often, subjects in schools present disjointed phenomena as a compilation of data or facts that seem isolated from students' lives. However, current science education pedagogy clearly emphasizes integration of knowledge and skills in real-world settings (NRC 2007). This integrated instructional approach addresses fundamental process skills as described in A Framework for K–12 Science Education (NRC 2012). This alignment can be observed in practices 4, 6, 7, and 8 (analysis and interpretation of data, constructing explanations, engaging in argument from evidence, and communicating information). To illustrate this, we describe an activity that integrates science and art concepts around the theme of cell organelles, using the exciting and somewhat unusual medium of painted silk batik, which has a "wow" factor of beautiful results beyond typical school-based media.

A combined approach of disciplines like art and science dovetails well with today's required varied literacies. For instance, in science classes, students are expected to read visual images as they interact with the text, a skill that is sometimes overlooked in the school curriculum (Coskie and Davis 2008). Furthermore, both disciplines share common features that promote essential skills such as observation, experimentation,
problem solving, and openness to change (Chessin and Zander 2006). We concur with the belief that visual literacy can be promoted in the classroom when we couple scientific habits of mind like critical thinking with artistic expression as a vehicle to communicate the understanding of natural phenomena, a fundamental skill for scientists, artists, and students (Dambekalns 2005). Visual literacy skills are considered a great mechanism to equip students with the necessary tools to succeed on standardized tests, which contain a considerable amount of graphic information to be “read” and interpreted (McTigue and Croix 2010). In many ways, there is no more appropriate arena for accomplishing this in today’s public schools than a middle school setting. At this level, students are old enough to grasp important concepts, yet they have not landed in the more subject-segregated atmosphere of the high school.

This article explains how to engage students in creative integration of interrelated fields that captures their interests and promotes learning. The challenge presented to students in this activity (depicting organelles’ function through artwork) is based on the well-known assumption that abstract thinking supports a better understanding of nature phenomena (Chessin and Zander 2006).
### Overview of lesson using 5E learning cycle

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<th>Stage</th>
<th>What the teacher does</th>
<th>What the student does</th>
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| **Engage** | • Creates interest and generates curiosity by sharing samples of artist Alex Grey's dynamic and colorful representations of human biology.  
• Raises questions emphasizing the skills/attitudes that both artists and scientists exhibit in their work.  
• Identifies what students know about the topic by having them address the links between the two disciplines in a short video about the work of the scientist who does anatomic representations of the human body. A link to the video can be found at [www.alexgrey.com](http://www.alexgrey.com). Teachers can encourage students to draw a comparison chart in their notebooks between what an artist like Grey portrays and what they already know to be true about biological structures.  
• Asks questions such as the following: How does this artist depict biological systems in a way that changes or enhances our understanding of the body? How are shape, line, and color used to communicate better to the audience? This discussion takes place after watching the video by Grey; students draw from comparison notes they jotted down while viewing Grey's work. |  |
| **Explore** | • Encourages students to work together by having them play the roles of scientists/artists in the completion of an art project.  
• Asks probing questions requiring each group to explain the design of its artwork.  
• Thinks freely by deciding how to meet the challenge.  
• Tests predictions by attempting to obtain intensities and tones to depict organelles' function. Applies preexisting knowledge of color mixing to posit why results appear as they do (often students think they know what will happen but their results on the silk turn out quite differently).  
• Forms new predictions by deliberating about other ways to represent organelles' functions in the painting. |  |
| **Explain** | • Encourages students to bring together the target content (e.g., organelles' functions) and the rationale for the design of their artwork.  
• Asks for justification through group discussion and a peer rubric evaluation in the explanation of the relationship between organelle function and its depiction in the painting.  
• Formally provides definitions of key terms (e.g., organelle, primary colors) through preassigned homework reading with an in-class handout afterward.  
• Uses students' previous experiences as basis for explanations by alluding to cell theoretical analogies, which students have practiced in previous lessons.  
• Listens to teammates' viewpoints.  
• Questions other explanations.  
• Refers to previous activities/lesson content.  
• Consists information sources to explain the design of the artwork.  
• Records teacher's definitions for reference in the project presentation. |  |
## Modeling interdisciplinary collaboration

In keeping with the National Science Education Standards recommendation that teachers collaborate within and across disciplines and grade levels (NRC 1996), two middle school student-teachers, one a teacher in biology, one in art, employed an interactive model in their own classrooms. The science teacher’s students were studying types of cells in her biology classroom, so to reinforce and assess their learning, she had her students create painted silk pieces to represent cell organelles’ functions. Her goal was twofold: cognitively to help students improve their understanding by enticing them to communicate their knowledge in an artistic manner, and motivationally to hook the less-interested students to participate through careful observation. The art student-teacher engaged students in a discussion of work by an example professional artist, Alex Grey, and gave technical assistance. (See a chart of learning goals in Figure 1 and a completed batik in Figure 2.)

The activity was planned for two science-class periods (with a bit of additional time in art class) and culminated with the display of students’ cellular

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| • Instructs students to perceive the cell artwork as a data set for them to (1) revise previous lesson content, meaning how they perceived cell structure before they had to actually create the art themselves, (2) practice scientific habits of mind (e.g., “development of descriptions, explanations, predictions, and models using evidence” [NRC 2000, p. 19]), and (3) demonstrate conceptual understanding (e.g., being able to “see” the function of the ribosome in the painting, and tying that function to protein-building and transport requirements). | • Applies new labels and definitions while explaining the process applied to tackle the challenge.  
• Draws reasonable conclusions during meaning negotiation with both peers and the teacher.  
• Checks for understanding by sharing her/his interpretation of the artwork (think-pair-share). |
| • During the artwork exhibition:  
  • Assesses students’ knowledge and skills as they use scientific vocabulary in their presentations.  
  • Looks for evidence that students have changed their thinking by (1) having students highlight the progress they made from the pre- to the post-painting discussions, and (2) requiring each student to submit a written interpretation of another group’s artwork. | • Evaluates his or her own progress by highlighting the high and low points of own work.  
• Addresses the following prompts during project presentations (students are provided with the following bulleted objectives in a rubric that they must then fill out while viewing peer work):  
  • Employs visual literacy terminology in the presentation of the artwork.  
  • Provides rationale for the design of the project.  
  • Translates visible details in the painting into oral interpretations.  
  • Highlights analogies and symbols used in the painting.  
  • Uses scientific vocabulary in the presentation of their artwork.  
• Takes notes during group presentations and uses them to prepare and submit a text summarizing an interpretation of another group’s artwork. This is used by the teacher as additional evidence of students’ ability to interpret visual images. |
artworks in the school library. Students began this activity by observing and discussing similarities and differences of iconic animal and plant cell images in their textbooks. They revisited theoretical analogies they had learned in previous classes (i.e., the cell as a city) and debated how to meet the challenge of representing organelle functions with a silk batik art piece. The teacher shared samples of the work of contemporary New York–based artist Alex Grey, who portrays the human body and its systems in a very colorful, vibrant manner. Grey actually worked at Harvard in the human anatomy lab for several years, and thus models a true artist/scientist orientation (see Resources). Class members discussed the relationship between art and science, and then received a technique demonstration of how to paint with the silk. Through guided practice, students tried different strokes and mixtures with the silk-fiber-reactive dyes to see how they might interact with reagents. This activity presented these eighth-grade students with a unique opportunity to practice the critical-thinking skills necessary to conceptualize their knowledge as they created their own representations (see Figure 3), which was reinforced later when they saw how classmates’ renditions portrayed the functions that take place inside animal and plant cells. At the end, as an assessment of learning, the cellular artworks hung in the school library and students gave peer presentations and wrote descriptions to explain how they represented their various cell choices.

**Materials**

Considering the beautiful results, this batik project is really quite reasonable in cost, at approximately $1 per student when spread out across the class. The most comprehensive source for fabric-related art materials (the silk and the dyes) is the online Dharma Trading Co. (see Resources), which also provides good, free how-to instructions. An ideal way to begin is to use pre-stretched silk hoops, 10 inches in diameter, which may be purchased from fiber-arts suppliers. Alternatively, purchasing silk yardage at less than $5 per yard (cut and shared among students) is even more reasonable, but if you use yardage, then you have to deal with stretching it, which can be a little cumbersome, hence the advice to use pre-stretched hoops as we did in this activity. You may choose to use fabric dyes meant for silk or flowable paints meant for fiber art: They have somewhat different characteristics and both challenge students to think about what is going on chemically. We used Dye-Na-Flow brand fabric flowable paint,
which proved easy to heat set. We recommend only giving students the basics of red, blue, yellow, and black to make color mixing part of the learning. Use “habotai/China”-type silk. See the Activity Worksheet for a materials list and student instructions.

Safety
There is nothing inherently dangerous in this activity—the design and preparation of these artistic works require students to manipulate materials typically found in their homes (i.e., salt, vinegar). But in order to prevent accidents, teachers must instruct their students on the proper way to handle these materials and remind them to observe the laboratory safety procedures established in their classrooms. Chemical-splash safety goggles must be worn by students. Remind them to wash their hands thoroughly after handling the chemicals (salt and vinegar). Students should not consume food while handling the art materials and chemicals. The dyes and flowable paint are nontoxic and suitable for classroom use. Also, because the silk hoops require a hot iron to set them, perhaps the best idea is to have the teacher or a classroom aid do this as students bring their completed silk paintings to a separate “ironing station.”

Assessment of learning
This art and science project follows the phases of the 5E learning cycle (see Figure 1). The focus of the painting process challenges students to portray cell organelles’ functions by using the batik technique. This challenge is intended to let students practice an unusual but effective format to convey a message to an audience. An additional element is the use of visual literacy skills throughout the project. For instance, students have a chance to use visual literacy terminology when viewing Grey’s work, and again during the exhibition of the final projects in the library. Students...
practice interaction with an audience as they critique their work and others’. This public display models for students how assessment of learning can come in many forms: “Students are so accustomed to writing, often narrative text, that they do not think of drawing as a way to communicate their understandings” (Campbell and Fulton 2003, p. 31).

Concluding thoughts

After final presentations, the teachers queried their students about the activity to gain feedback regarding the benefits of this hybrid instructional model. The cell-representation activity dove deeper than just the reproduction of an already existing image of the cell: It entailed planning the actual representation of the organelle function, and finding the evidence to back up the conceptualization of an organelle function as portrayed in the painting. Central to the project was the practice of visual literacy skills, which became evident during the group project presentation in the library and in students’ written interpretation of their peers’ artwork. The learning in this activity went beyond the biological content of the cells to include curiosity about physical properties of the materials used in the batik process.

Based on student feedback and teacher reflection, extension of learning in the future might include concepts such as the action of reagents on the silk, solutions, concentration, chemical reactions, and the effects of how the dyes/flowable paints and solvents—mixed at different concentrations—interact to produce a desired tone. More puzzles might include the ways in which organic (i.e., alcohol and vinegar) and inorganic (i.e., salt) reagents interact with the silk and the dyes, and whether the same effects can be produced with other painting materials students are familiar with (i.e., watercolors). These and other ideas may emerge during this type of interdisciplinary project. We encourage teachers to take advantage of student-posed questions and use them as springboards for subsequent inquiry when, according to the program, topics like solutions or properties of matter are studied in the classroom.

The silk medium, with its natural translucency, looked stunning as light shown through the library windows and as air currents gently moved the suspended cells (see Figure 4). Because the technique was so new and unusual, even marginally interested students remained excited and engaged over the length of the project. Both teachers were able to observe and record students’ learning during the final presentations and, for students in the audience, their discussion of messages communicated through the batik paintings emphasized learning benefits.

References


Resources

Alex Grey—www.alexgrey.com
Dharma Trading Co. (a comprehensive site for ordering fabric art supplies)—www.dharmatrading.com

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Activity Worksheet: Cell organelles and silk batik

Note: This is intended as a guide for doing the actual artwork; students might jot down notes as they work, but the main emphasis at this point is using time wisely to get the silk hoop painted after experimenting with color and reagent mixing.

Materials

- Chemical-splash safety goggles
- Silk, pre-stretched, on 10” wire hoops (one per student)
- Watercolor-type soft paintbrushes
- Ice cube trays (one tray per two students)
- Resist (gutta) in small, narrow-tipped squeeze bottles (several for students to share)
- Fiber-reactive silk dyes or flowable fabric paints, primary colors only
- Cups with clean water for washing out brushes between colors
- Paper towels for cleanup and scrap paper for trying out mixed-color experiments
- Vine charcoal for lightly drawing image on the silk (it will wash out)
- Salt, alcohol, and vinegar to be used for texture effects on the silk

Procedure

1. After donning your chemical-splash safety goggles, draw out the design on the silk hoops using vine charcoal (this will wash out later if lines are very lightly drawn).

2. Resist the lines by gently squeezing the gutta out of the bottle as you outline the shapes, making sure you close any gaps so the color cannot run together. Make the lines as thin as possible, since thick lines are gooey and take far longer to dry.

3. Typically, thin lines will dry fairly quickly, maybe about 15–20 minutes, and will feel solid to the touch when they're dry. [Note: While lines are drying, this is a good time to review with students what they know about color mixing, what they think might happen when the reagents work with the flowable paint, etc. They can jot down these predictions in their notebooks as they wait to progress to the next step.]

4. Suspend the freshly resist-lined silk hoop so that it is not touching anything below (or else colors will run together and become muddy) and put the flowable paint into ice cube trays. The multiple sections make a wonderful palette for experimenting with color mixing. Have a cup of clean water close at hand, and paper towels for quick cleaning, and scrap paper so you can see what the colors you have mixed look like before you apply them to the silk.

5. Take the brush and slowly and carefully paint the design. Lightly sprinkling salt on the color while it is still wet creates a wonderful dappled textural effect. When the color starts to dry, applying vinegar or alcohol will produce other interesting effects.

6. Allow the painted silk hoop to dry completely (usually takes 20–30 minutes).

7. The silk must be heat set before washing out. To do this, take a hot iron and iron the silk in the hoop so it feels hot to the touch for about a minute [for the sake of safety, this is best done by the teacher or a classroom aid]. Let it sit overnight.

8. Wash out the silk in the sink in room-temperature water, gently massaging with your fingers to dissolve any residual gutta resist. Allow it to dry and you are finished.