

A Creative Approach: Teaching Biology Labs through Arts-based Learning

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An experiential learning environment fosters engagement and commitment to process, while arts-based learning incorporates student creativity and involvement. Through the three activities outlined in this paper, designed for undergraduate biology students in the lab or classroom, teachers become facilitators of interactive and aesthetic experiences. The desired outcome is arts-based teaching directly relevant to biological learning outcomes, where students actively engage with and indelibly remember their experience. These activities are complementary to, rather than replacements for, labs or lectures.

Keywords: biology pedagogy, arts-based teaching, active learning, creative learning, embodiment

Introduction

For many students science labs are scary, full of stressful lab reports, difficult concepts, and an intimidating methodology. How can we learn about biological cells, electrophoresis, animal phyla—not to mention how our bodies work—in a fun, accessible, yet still scientific way? Art provides an answer. Through engaging activities, movement, drawing, metaphor and storytelling we can bridge the fear gap and tap into learner creativity (Fels & Belliveau, 2006; Judson, 2015). Creativity is equally important in the arts and the sciences (Bronowski, 1965). Active learning has been shown to increase student performance in science classrooms (Freeman et al., 2014, Haak et al., 2011), although this increase appears to only be relevant when constructivist approaches are used (Andrews et al., 2011; Todd,

Baviskar, & Smith, 2012). Arts-based approaches to learning—including aesthetic/sensory engagement, embodied activities, and role play (Eisenkraft, Heltzel, & Johnson, 2006; Fels & Meyer, 1997; Love, 2013; Marshall, 2014)—present an opportunity for active, hands-on learning that is experiential in nature. Teaching that includes props, drawing, dance and other unexpected surprises are highly interactive and may enhance memory retention (Hardiman, Rinne, & Yarmolinskaya, 2014). In the activities outlined in this paper, learners will make biological drawings of their instructor, embody gel electrophoresis, dance like nematodes, and be part of a lively discussion. I have used these activities the past few years at Kwantlen Polytechnic University (KPU) in teaching both first-year biology students and second-year cell biology and genetics students in a lab setting.

Student Outline

Note: The activities outlined in this paper are not meant to be taught in the conventional manner. The teacher/facilitator will verbally instruct students on what to do; therefore, no handout is required for students.

Learning Objectives

1. Learn how to make biological drawings.
2. Embody gel electrophoresis, and understand how molecules migrate down a gel based on size and charge.
3. Dance nine of the common animal phyla, and understand how movement is connected to feeding habits, habitat, body symmetry, coeloms (body cavity), segmentation, surface area, and support (skeletons).

Notes for the Instructor

First, I will outline characteristics of creative and engaging teaching approaches. Next, the key roles and qualities of a facilitator of learning will be described. Finally, I will provide details on three example activities that utilize arts-based learning to teach biology.

How to Involve Students

When using arts-based teaching, or any experiential approach, the following qualities are of vital importance to ensure student involvement and commitment.

1. **Engage.** Ask questions that you don't provide an answer to, use metaphor to elucidate concepts, and give students a voice throughout the process.
2. **Experience.** Being able to creatively express an experience (through gesture, movement, writing, drawing, etc.) helps integrate learning. Give students a choice as to how they express their experience.
3. **Embody.** Incorporate activities that involve movement and physicality. This is inherently interactive, helps students remember what they have done, and also gives them a reference point for later discussion and integration.
4. **Explore.** Don't be afraid to veer from the prescribed path; you can always return to your intended outcomes later. Zigzagging to your destination is a richer, contextualized, more nuanced experience than simply stating what is to be learned. Unanticipated meanders give greater meaning. Darwin's theory of natural selection would be a different animal if he wrote it prior to island-hopping throughout the Galapagos.

5. **Entertain.** Have fun. Use Humor. Be unexpected. Embrace spontaneity.
6. **Educate.** Keep coming back to the concept at hand, end with reflection and discussion, and/or get students to present what they've learned.

Notes on Being a Facilitator

A facilitator provides a framework and minimal guidance for learners, thereby giving students agency, voice, and the ability to co-create the learning environment. When facilitating experiential and interactive exercises, it is important that the facilitator consider the following sequential steps:

1. **Preamble.** Outline the context for the activity. Provide definitions and explain concepts as needed. Remember that most learning should happen during the activity itself, or during the discussion afterward, so do not over-explain the learning outcomes here.
2. **Set up.** Show students where the required materials are located (you would have set this up prior to the class or lab). Again, do not over explain. Some mystery and spontaneity (Nachmanovitch, 1990) is always important! Ask students: does anyone have any questions before we begin?
3. **Activity.** This is where the facilitator gets out of the way. Students who are confused, or groups that have trouble getting started, may need some guidance or helpful starting pointers. Yet as much as possible the facilitator should be hands off. This can be difficult for teachers, to be the guide on the side rather than sage on the stage, yet it is usually pertinent that students engage in the process with as little help as possible.

1. **Results.** After the activity, give the students an opportunity to share what happened or what they discovered. This is an opportunity for students to have a voice, to articulate what they found interesting or did not understand, or simply to share their experience.
2. **Discussion.** In large labs or classes break students into small groups for discussion. Have students go deeper into what they experienced and what they learned. Invite their questions; if this fails to get a response, the facilitator should have on hand some well thought-out, often open-ended, and perhaps provocative questions to ask.

Activity One: Biological Drawings of Your Instructor

This 10–30 minute activity involves students making a biological drawing of their lab instructor. The instructor will review proper biological drawing etiquette, have students make a drawing (see Figure 1 for an example), and then review anonymous student drawings immediately with the use of a document reader attached to a projector. This activity works well in the first lab of the semester as it helps break the ice, gets students comfortable with drawing, connects directly to laboratory learning outcomes, and sets the stage for a fun and interactive semester.

Required Materials:

blank paper, pencils, document reader attached to projector, powerpoint or handout on biological drawings.

Outline of Activity

1. Instructor reviews proper etiquette for biological drawings. This may include: using a pencil, drawing clear lines, avoiding shading or ambiguous drawing styles, proper location of figure captions, descriptive figure captions, and including scientific name(s), a scale bar, actual size calculation, microscope magnification, and labels and label lines. If using a powerpoint to provide this information, leave a slide up showing an example exemplary drawing.
2. Hand out paper and pencils (if students do not have them already). Tell students they are going to do their first biological drawing.
3. Tell students they are going to draw you (or their lab partner, or their cat, or whatever you deem appropriate). Give students at least 2–3 options. Stick men and stick women are fine! Depending on time constraints, give students 5–10 minutes to complete this task. Students *do not* include their names on their drawings.

4. Collect the drawings. Incomplete drawings are okay; in fact, they are useful for the purposes of this exercise. Review the drawings under the document camera. You do not need to review all of the drawings; usually five to ten is sufficient.
5. As you review the anonymous drawings, ask questions (see below) of each drawing.

Sample Questions to Ask During Post-activity Discussion

1. What important aspects were included on this drawing?
2. What is unclear or missing from this drawing?
3. How could the student improve this drawing?
4. Why do my arms look like twigs?

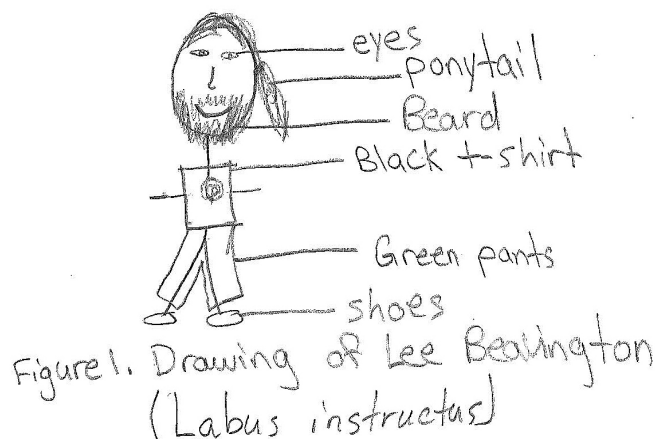


Figure 1. Example drawing, made by a student, of their lab instructor.

Activity Two: Embodying Gel Electrophoresis

This 5–10 minute activity involves students embodying samples to be run on an electrophoresis gel. After a brief introduction to electrophoresis, or having students review this information prior to coming to the lab/class, the facilitator has students act and move as though they are samples being run on a gel.

Required Materials:

small index cards or post-it notes, sharpies, four pre-made signs reading *cathode*, *anode*, *lane A*, and *lane B*.

Outline of Activity

1. Introduce electrophoresis briefly, including using a current to separate samples based on molecular weight.

2. Hand out an index card or post-it note to each student. Ask students to write three things on their cards in large, legible letters and numbers:
 - a. a number from 1–100
 - b. A '+' or '-' sign
 - c. The letter 'A' or 'B'
3. Explain that the number they wrote down represents the size of their sample (e.g., in daltons), that the + or – indicates a positive or negative charge, respectively, and that the letter indicates the lane their sample will be in.
4. Put up the sign for *lane A* and *lane B* somewhere in the classroom or lab, close enough together so that students in lanes A and B will be able to see each other and what they wrote on their cards. The locations of these signs serve as the wells for lanes A and B.
5. Put up the signs for *cathode* and *anode*. The *anode* sign will go some distance from where you put the *lane A* and *lane B* signs (anywhere from 5–20 meters is fine, depending on how many students you have). You can either put the *cathode* sign right next to the *lane A* and *lane B* signs (indicating that the samples are being loaded near the top of the gel), or you can put the *cathode* sign the same distance the *anode* sign is away from the *lane A* and *lane B* signs, but in the opposite direction (indicating that the samples are being loaded in the middle of the gel, which is what I usually do, as then students have to figure out if they should migrate toward the cathode or anode).
6. Remind students about #3 above.
7. Mime holding a giant micropipette, and indicate that they are the samples for the gels to be run. Suck them all up, and place all of the students that wrote an 'A' on their card next to the *lane A* sign, and then place all of the students that wrote a 'B' on their card next to the *lane B* sign. You won't actually physically move them; students can relocate themselves to the appropriate spot.
8. Tell students that the current has been applied, and that they must now migrate to the location they would be after 30 minutes of the current passing through the gel!
9. Let students move and discuss where they should go. Do not interject. Trust the process.
10. Students may ask about the cathode and anode. Which is positive and which is negative? Provide no answer or clues.
11. Once students seem satisfied with where they have ended up, ask questions (see below) about

potential sources of confusion or errors in where they have placed themselves. They never get it right the first time! Don't direct them where to go; rather, have students reorganize themselves based on new information gleaned from the questions you ask.

Sample Questions to Ask During Activity

1. Why is the anode positively charged, and the cathode negatively charged?
2. Why did the smallest molecules travel the furthest?
3. If two separate samples, in lane A and B, respectively, were the same size, where would they migrate to?
4. If all samples were the same size, how would this band look different?
5. How much does an actual protein sample weigh compared to you?

Depending on the type of gel and sample being run, you could also ask questions relating to DNA charge, beta mercaptoethanol, or other relevant topics.

Activity Three: Dancing the Nine Animal Phyla

This 15–45 minute activity involves students using movement to understand myriad characteristics of animals and animal phyla. The facilitator breaks students into small groups, and has each group focus on one animal phylum. That group decides on a movement to represent that animal phylum, and presents it to the class. After all groups have shared their movement, a discussion ensues on feeding habits, body symmetry, coeloms (body cavity), habitat, surface area, and support (skeletons). This activity is intended for 15–40 students, but can easily be adapted for larger classes or labs.

Required Materials:

None!

Outline of Activity

1. Either before class/lab, or at the start, provide information on nine animal phyla (or any other number, depending on your needs). I use Porifera, Cnidaria, Platyhelminthes, Nematoda, Annelida, Mollusca, Arthropoda, Echinodermata, and Chordata.
2. Break students into groups of 2–5, and attach each group to a different animal phylum.

3. Indicate to students that their group needs to come up with a way to represent their animal phylum using movement. Students need to:
 - a. choose an example organism from their phylum.
 - b. use their body to represent how this organism moves.

Five to ten minutes is usually long enough for this process. It helps if the facilitator wanders around during this time to help groups who are stuck or reluctant to start.
4. Ask all students to stand up. This is critical for participation. Explain that each group is going to demonstrate to the rest of the class or lab their organism's movement. After the current group demonstrates their example organism's movement, then *everyone* in the room will demonstrate this movement. It is important here to emphasize that when you are the only one doing something odd or unusual, then you are the only one looking silly or foolish. However, when *everyone* is doing something odd or unusual, then those people who don't engage are the ones who look foolish!
5. The facilitator must ensure that each group demonstrates their phylum's movement, and that everyone in the class or lab then repeats this movement. Everyone should be standing for this part of the process. You, as the facilitator, keep the energy moving forward. Be confident and dramatic in your movements, and repeat the movement as necessary until everyone present mimics the movement. Some groups will simply use their arm or hands to represent movement, based on their comfort level; this is fine.
6. Remember that the role of the facilitator is not to push students to go where they are not ready to go, but to inspire their involvement. You are the model; the more foolish and engaged you are willing to be, the more they will buy in.
7. Compare the nematodes' movement with that of the annelids, and the echinoderms' movement with that of the chordates (see relevant questions below).
8. After all groups have demonstrated their movement, engage in a discussion (see questions below).
9. Emphasize that through movement we can learn about feeding habits, body symmetry, coeloms, segmentation, habitat, surface area, and support.

Sample Questions to Ask During Post-activity Discussion

1. Porifera: What does their movement, or lack thereof, suggest about their feeding habits?
2. Cnidaria: What does their movement indicate about the kind of habitat they live in? What type of support system would enable them to have buoyancy in this environment?
3. Platyhelminthes: Why do flatworms move this way? Why are flatworms so flat? What does surface area have to do with anything? Is there room for a coelom in a flatworm? What *is* a coelom? Where is *your* coelom?
4. Nematoda and Annelida: How is their movement different? How is it related to segmentation?
5. Mollusca: What characteristics are common to all mollusks? Do they have bones? What type of support system do mollusks possess?
6. Arthropoda: How many legs does your arthropod have? Are arthropods generally small organisms or large organisms? How does this relate to the type of skeleton they possess?
7. Echinoderms and Chordates: What did your notice was different in their movements? How does this relate to body symmetry? What other phyla have radial symmetry?

Concluding Thoughts

The activities described in this paper are meant to be complementary to a lab or lecture. Such active learning breaks up lecture, gets students out of their chairs, gives students a body memory, leads to myriad discussions, serves as a reference point, and often provides an immediate assessment of student understanding. Such rewards are well worth the minimal time required for set up. The more difficult task is switching from the role of teacher to that of facilitator. This takes time and practice. Things never go entirely as planned with activities like these, which is part of the fun, and requires flexibility and spontaneity.

When students engage in activities that require active and embodied involvement their level of participation almost always increases. The teacher, as facilitator, needs to create a safe container for exploration, and introduce students to engaging exercises *slowly*, at a pace that works for both student and facilitator. These activities can be done in a short period of time, if needed; I have managed to compress each of the above activities to 5–10 minutes when time is tight. They help tap into student creativity, make new connections, are fun for student and instructor, and in co-creating their learning environment students learn from each other, which is the ultimate goal of the educator. As a final benefit, the facilitator always learns something new.

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Lee Beavington is a SSHRC scholar and PhD student in Philosophy of Education at SFU. He is also an author, photographer, and instructor for KPU's Amazon Field School, and teaches Ecology, Genetics, and Advanced Cell and Molecular Biology in the lab and field. His interdisciplinary research explores wonder in science education, poetic inquiry, environmental education, and arts-based learning across the curriculum. Find Lee reflecting in the forest, mesmerized by ferns, and always following the river. More about Lee at www.leebeavington.com.

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