JOURNAL OF MICROBIOLOGY & BIOLOGY EDUCATION, December 2015, p. 289-291
DOI: http://dx.doi.org/10.1128/jmbe.v16i2.947

Tips & Tools

Moss in the Classroom: A Tiny but Mighty Tool for Teaching Biology†

Erin E. Shortlidge[1]* and James R. Hashimoto[2]
[1]*Arizona State University, School of Life Sciences, Tempe, AZ 85281,*
[2]*da Vinci Arts Middle School, Portland, OR, 97233*

INTRODUCTION

Using live ecosystems in the classroom can help students interact with biology at the systems level (8), thus addressing a core concept of *Vision and Change*'s Systems learning objective: *Living systems are interconnected and interacting.* It furthermore directly meets national calls for students to "do" science in the classroom (1). In this article, we highlight how mosses can present a versatile and novel baseline from which students can interact with a live ecosystem in the classroom and ask a spectrum of ecologically relevant questions. Specifically, we describe a moss-based project developed by a researcher-teacher team for middle school students (6th to 8th mixed grade classes) that meets both national and state science standards (Appendix 1). We advocate that the project has the potential to be scaled up or down, depending upon course learning goals and student cognitive levels.

Why moss? Mosses are the most diverse and widespread group of the ubiquitous bryophytes. They are tractable, complex, globally important, and easy to maintain indoors. In many regions of the world, one can walk outside and grab a small cushion of moss from a yard, a roof, or the sidewalk. Every one of those little moss cushions is a dynamic ecosystem bursting with life—a system that can facilitate classroom activities that address a spectrum of biological questions ranging from fundamental to complex. We employed mosses and their invertebrate inhabitants as an inexpensive platform through which to study individual species to multi-trophic interactions.

PROCEDURE

A moss-based project can be framed by introducing basic biology and natural history

We introduced the system to students through: 1) bringing moss into the classroom for initial investigation via hand lenses, magnifying glasses, and stereomicroscopes, 2) observing mosses in their natural habitats, 3) a PowerPoint presenting basic needs and functions of mosses, invertebrates, and the biotic and abiotic factors that influence them, and 4) excerpts of relevant reading and multimedia material (Appendix 2).

We aimed to build students' confidence and self-efficacy through selective use of scientific literature (4, 11) and simultaneously lay a foundation for students to devise informed research questions on their own in-class moss-microcosms or "mosscosms" (as named by our middle school students). We used excerpts of a journal article and an ebook to outline the roles that mosses and moss-associated invertebrates play in local and global ecosystems, and introduced the term "bryosphere" (9, 12). The students were then asked to define and discuss "bryospheres" in their own words (Fig. 1, Appendix 2). We worked through an in-class mock experimental design lesson using these discussed organisms to distill the basics of experimental design such as replicates, controls, variables, and treatments. We employed these scaffolding activities and subsequent iterative feedback between instructor and student groups on their "research proposals" to prepare students to ask relevant and feasible questions about the moss system, which they would then test in their small groups.

Materials and methods

Moss-microcosms are relatively low-maintenance and inexpensive to set up. A minimal time frame of two months should be allotted for the project, as this provides ample time for microcosm changes to occur (for project details and an example, see Appendix 2). In many regions, mosses are easy to locate and procure as they grow abundantly anywhere from parking lots to forests—instructors and students can likely find mosses growing in their neighborhoods or on school grounds. One wants to leave the majority of the growing moss in a given area in order to bestow environmental stewardship values. We encouraged students to attempt to use the same moss species from the same substrate to ensure reasonable homogeneity among experimental microcosms. Based on the experimental

*Corresponding author. Mailing address: 451 E Tyler Mall, Tempe AZ 85281. Phone: 480-965-0803. Fax: 480-965-6899. E-mail: erin.shortlidge@asu.edu.
†Supplemental materials available at http://jmbe.asm.org

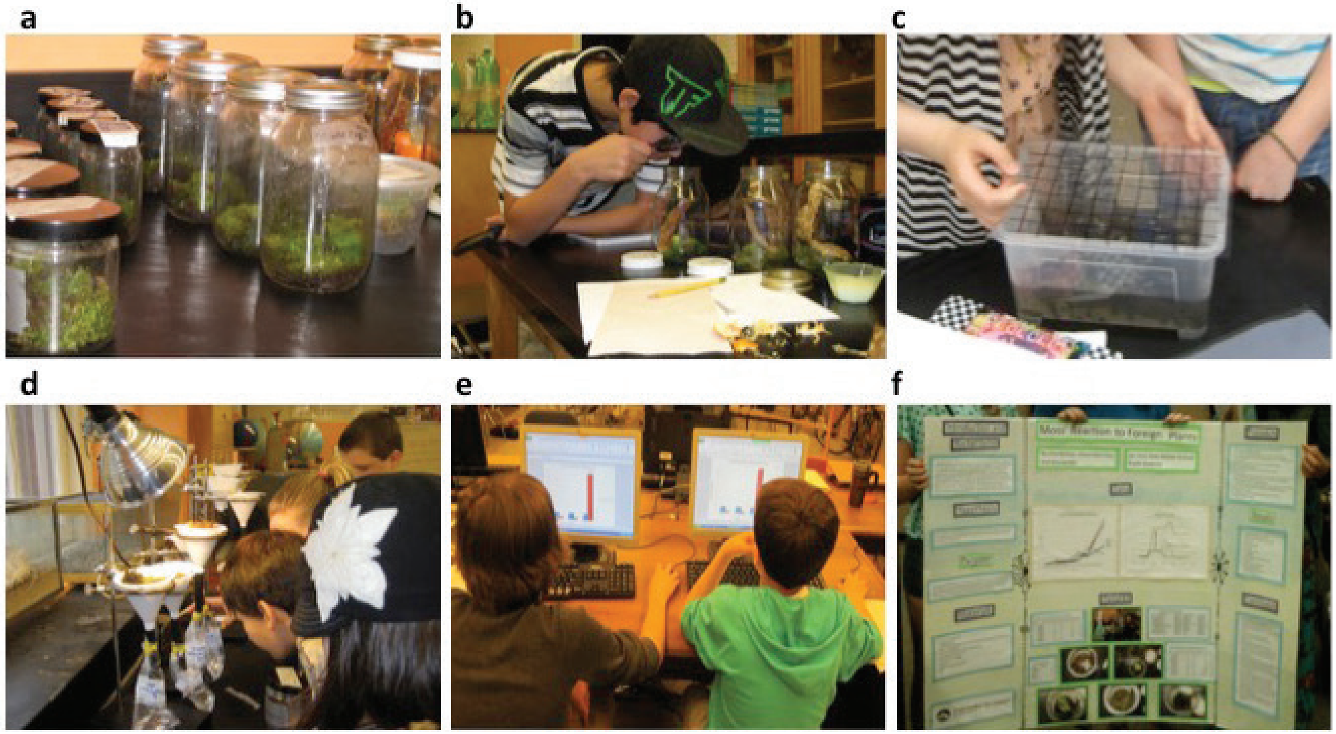

FIGURE 1. Mosscosms in action: a) mosscosms, b) student collecting data on mosscosms, c) subsampling grid technique for counting springtails, d) students observe springtails collected from funnel extractions, e) graphing springtail population growth data, f) student poster: *Moss's Reaction to Foreign Plants.*

design lesson, students discussed the idea that it would be difficult to draw reasonable conclusions from an experiment if they did not use the same species in each microcosm.

Glass or plastic containers such as mason jars can create microcosm habitats. Moss will dry out without regular watering or high humidity; thus water-balance is a key component to success (water needs can be introduced in the framing activities). Moss cushions are home to numerous invertebrates and microorganisms, particularly when collected in a wet season. A stereomicroscope will reveal details of the bryosphere and the resident invertebrates, while wet-mounted specimens examined under a compound microscope can reveal moss leaf and sex organ morphology (including bi-flagellated moss sperm if mature males are present), and leaf-dwelling microorganisms.

Simple moss-based studies can be conducted by providing students a list of abiotic or biotic variables for manipulation such as: relative humidity, light, nutrients, CO_2, substrate pH, other plants, soils, and invertebrates. For example, springtails are invertebrates commonly abundant in leaf litter, soil, and mosses, and have been successfully used for classroom activities (13). Both springtails and mosses can be grown and reared easily in the classroom for testing research questions on moss-springtail relationships.

Basic microbiology experiments can identify moss endophytes or associated surface microbial communities, as has been effectively demonstrated in undergraduate courses investigating vascular plant leaves (2). Multiple levels of ecological complexity can be added to these experiments. For example, students could test invertebrate preferences for various moss-sourced microorganisms (springtails and mites frequently eat fungi and bacteria).

Informal assessment

Many of our students reported *mosscosms* as their favorite class activity, and their attitudes toward science at the end of the year were generally positive (Appendix 3). We were interested in understanding the way in which students thought about biology after they participated in *mosscosms*. We obtained a glimpse of their thinking in their written conclusions from the project, and the majority could be considered low-order cognitive skills (expected for grades 6–8), yet some students made higher-order statements that included analysis, synthesis, and evaluation of their projects (3, 6) (Appendix 3). Potentially appropriate assessments of this project would evaluate student understanding of experimental design concepts (e.g., (5, 7)) as well as their perceptions of ownership and investment in their projects (10). Our anecdotal perceptions were that our students began to think deeply about experimental design and the interactive nature of ecology. When they communicated their science projects to others in a poster-session, they were clearly engaged with what they perceived as their *own* microcosms.

CONCLUSION

Mosses provide a uniquely tractable, creative, observable and dynamic system through which to introduce students to the process of science and the discovery-based nature of biology research. We hope that this example framework describing moss-based classroom projects can be adopted, modified, evaluated, and bettered through its integration into more curricula. Moss-based microcosms present a platform for students of all ages to investigate biological research questions as they engage intimately with both singular organisms and entire tiny ecosystems while they "do science" in the classroom setting.

SUPPLEMENTAL MATERIALS

Appendix 1: Moss in the Classroom: Details and suggestions
Appendix 2: Moss in the Classroom: Informal evaluation
Appendix 3: Examples of student conclusions using Bloom's taxonomy

ACKNOWLEDGMENTS

The authors declare that there are no conflicts of interest.

REFERENCES

1. **American Association for the Advancement of Science.** 2011. Vision and change in undergraduate biology education: a call to action: a summary of recommendations made at a national conference organized by the American Association for the Advancement of Science, July 15–17, 2009. Washington, DC.
2. **Bascom-Slack, C. A., A. E. Arnold, and S. A. Strobel.** 2012. Student-directed discovery of the plant microbiome and its products. Science **338**:485–486.
3. **Bloom, B. S., and D. R. Krathwohl.** 1956. Taxonomy of educational objectives: the classification of educational goals. Handbook I: Cognitive domain. D. McKay, New York, NY.
4. **Britner, S. L., and F. Pajares.** 2006. Sources of science self-efficacy beliefs of middle school students. J. Res. Sci. Teach. **43**:485-499.
5. **Brownell, S. E., et al.** 2014. How students think about experimental design: novel conceptions revealed by in-class activities. BioScience **64**:125–137.
6. **Crowe, A., C. Dirks, and M. P. Wenderoth.** 2008. Biology in bloom: implementing Bloom's taxonomy to enhance student learning in biology. CBE Life Sci. Educ. **7**:368–381.
7. **Deane, T., K. Nomme, E. Jeffery, C. Pollock, and G. Birol.** 2014. Development of the Biological Experimental Design Concept Inventory (BEDCI). CBE Life Sci. Educ. **13**:540–551.
8. **Eilam, B.** 2012. System thinking and feeding relations: learning with a live ecosystem model. Instructional Science **40**:213–239.
9. **Glime, J. M.** 2014. The fauna: a place to call home. Ch. 1. *In:* Glime, J. M., Bryophyte Ecology, Volume 2, Bryological Interaction. Ebook sponsored by Michigan Technological University and the International Association of Bryologists. Last updated 29 April 2014 and available at <www.bryoecol.mtu.edu>.
10. **Hanauer, D. I., and E. L. Dolan.** 2014. The project ownership survey: measuring differences in scientific inquiry experiences. CBE Life Sci. Educ. **13**:149–158.
11. **Hoskins, S. G., L. M. Stevens, and R. H. Nehm.** 2007. Selective use of the primary literature transforms the classroom into a virtual laboratory. Genetics **176**:1381–1389.
12. **Lindo, Z., and A. Gonzalez.** 2010. The bryosphere: an integral and influential component of the Earth's biosphere. Ecosystems **13**:612–627.
13. **Moore, J. C., B. B. Tripp, R. T. Simpson, and D. T. Coleman.** 2000. Springtails in the classroom – Collembola as model organisms for inquiry-based laboratories. Am. Biol. Teach. **62**:512–519.