Living Organisms and The Life Science Class: A Case Study

Cole Entress
Teachers College - Columbia University, New York, NY

Problem

When Darwin memorably described the living world as populated by "endless forms most beautiful and most wonderful" (Darwin, 1859, p. 490) he also alluded to two enduring goals of biology teachers. Biology teachers strive to impart an understanding of the living world to students—but not only an understanding. We also hope to instill in students an appreciation of the delicacy and majesty of this biosphere, to further develop in them the affinity for other life that E. O. Wilson (1984) aptly called *biophilia*. In short, we both want students to get biology and to love it (or, more modestly, to appreciate its objects).

Direct engagement with living organisms, in the lab or the field, can help biology teachers achieve both their cognitive and affective goals (Fleischner, 2017; Herbert & Lynch, 2017; Meyer, Klingenberg & Wilde, 2016). Such engagement also makes biology classes truer to the discipline, as the direct study of living things remains a core activity of practicing biologists. Laboratory research using live organisms, especially model organisms (see Fields & Johnston, 2005), is in fact so central to the life sciences that Kloser (2012) argued for model organism-based reasoning as an aspect of the nature of biology. And yet, especially at the secondary level, the standard biology curriculum has marginalized fieldwork (Fleischner, 2017), natural history (Tewksbury et al., 2014), and even laboratory work using live organisms (e.g., Brown, 1995).

Researchers commonly, and with some validity, attribute this marginalization to changes in the educational and political landscapes. Brown (1995) and the National Research Council (1990) enumerated the now well-known obstacles posed by these changes: a lack of time and resources, curricular change, increased regulation, liability concerns, and pressure from animal rights groups and students. Additionally, high-quality virtual alternatives to live organism or field study—the *Planet Earth* series, webcams in Gorongosa National Park, and videogames based on Mendelian genetics, to name a few—have proliferated in recent years. While digital simulations should not completely displace direct experience with the biosphere—Manz (2015), for instance, found that the unpredictability of instruction featuring live organisms motivates engagement in critical science practices—these easily-accessible alternative tools may render less attractive the effort required to teach biology using live organism study or fieldwork.

Still, the formidable constraints listed above do not preclude engagement with living organisms in the biology class. Some model organism systems have been adapted specifically for use in schools—Wisconsin fast plants (Williams, 1997) and *Halobacterium* sp. NRC-1 (DasSarma, 2017), for instance. Carolina Biological and other supply houses provide free tips on culturing these organisms. Additionally, creatures as common and low maintenance as isopods can be used to teach a number of biological ideas (e.g. Wagler, 2020). Indeed, the pages of *The American Biology Teacher* are routinely given over to novel, interesting laboratory (and sometimes field-based) activities including live organisms both within the model organism canon and beyond it. All this adds up to a lot of low-hanging fruit. That so many biology teachers do not pick it may speak to an obstacle beyond the structural changes to P-16 education.

I fear that this obstacle may be found in the erasure of living organisms from teacher education itself. Aspiring biology teachers rarely have opportunities to do much investigative biology in their content studies (see Windschitl, Thompson & Braaten, 2008) or to learn about live organisms in methods classes. This was not always the case: the biology methods course once included special attention to specimen collection and to the creation of classroom habitats for sundry animals and plants (e.g., Teachers College, 1926; Heiss, Obourn, & Hoffman, 1940). In 1938-1939, the Chicago Public Schools even sent its biology teachers a manual instructing them on the classroom rearing of everything from amoebas to alligators and encouraging regular field work in the area's parks and nature preserves (Daniel, 1938). To anyone familiar with today's methods classes, this sort of thing sounds fanciful, even crazy. Contemporary methods courses include many worthy topics—planning, science standards, the nature of science, and effective teacher behaviors among them (see McComas, Erickson, Burgin & Wissehr, 2020)—but almost nothing about keeping organisms in the classroom or studying them in the lab. The result is a dual problem for biology teachers: a hole in their knowledge base for teaching, and the early formation of a biology teacher identity—which impacts future learning and development (Aavrimadou, 2016; Lave & Wenger, 1998)—divorced from biology's proper objects of study.

Despite these obstacles, some biology teachers nonetheless develop the expertise needed to provide their students with direct experiences of the biosphere: they keep snakes, they start water-quality monitoring clubs, they experiment on Fast Plants. It seems reasonable to ask how these teachers attain this knowledge, how it shapes their teacher identity, and whether such knowledge impacts their classroom practice. It may be that these teachers, stubbornly resisting the pressures of policy and formal education, are the keepers of a largely lost art that could (re)vitalize biology lessons and improve student engagement and interest in science.

Study Design

The topics of this study—biology teachers' knowledge of living organisms and how this knowledge relates to teacher identity and practice—form a lonely intersection. While attention to teacher identity as a window into professional development is on the rise (Aavramidou, 2016), studies within biology education to date have focused primarily on college professors (e.g., Aydeniz & Hodge, 2011) or elementary science teachers (e.g., Weinburgh, 2007). Studies about living organisms, like those cited above, focus on student outcomes or the obstacles faced by teachers who wish to use animals in instruction (see e.g., Brown, 1995). Thus, research in this domain must be considered exploratory, a stage which invites the deep analysis of interesting cases in which variables and context cannot be clearly separated (Merriam & Tisdell, 2016).

This instrumental case study (Stake, 1995) focused on Mr. Dewlap, an early-career life sciences teacher working at a charter middle school in a large, urban district in the northeast United States during the spring of 2019. Mr. Dewlap had developed a rare expertise in herpetoculture, plant cultivation, and local ecology, and he made continuing efforts to include the plants and animals he kept in his classroom—and his home—part of his 8th grade, state-required life sciences course.

Through five observations (including follow-up conversations), an informational questionnaire, two semi-structured interviews, analysis of instructional materials, and frequent member checks, the following research questions were investigated:

1. How did Mr. Dewlap learn about live organisms—in teacher education or elsewhere—and how was his knowledge shaped by the manner in which he learned?
2. How did this knowledge impact Mr. Dewlap's identity as a science teacher?
3. How did it impact his biology instruction?

Despite its inability to form generalizations, case study research remains well-suited to issues of identity development (Aavramidou, 2016) and to exploring the meaning-laden process by which teachers put knowledge into practice in a classroom (Merriam & Tisdell, 2016).

Analyses and Findings

All interviews, field notes, and documentary materials including responses from the questionnaire were transcribed and imported into NVivo. Interviews, open-ended questionnaire responses and field notes were initially coded inductively (Kuckartz, 2014) through multiple reads of the data, and codes were grouped with reference to the research questions. Data segments sharing important characteristics—autobiographical stories, or descriptions of memorable lessons—were grouped through categorical aggregation (Stake, 1995) and developed into the assertions below. To improve the credibility and trustworthiness of analysis, I submitted my preliminary report (and some lingering questions) to Mr. Dewlap for his comments and used his input to guide revisions and refinements. In the end, three themes emerged from the data.

Theme 1: Mr. Dewlap's knowledge was situated in his hobbyism

Though he could vaguely recall a few college-level labs involving live organisms, Mr. Dewlap did not attribute almost any of his knowledge of specific organisms or the local ecosystem to his formal education (which included both a master's degree in science education and an undergraduate degree in biology). Instead, Mr. Dewlap reported that an adolescent interest in keeping a fish tank started him on a continuing quest to learn about the natural world from informal sources: exotic pet stores, online message boards, and YouTube channels, to name a few. The knowledge he gained from these resources was both practical and practiced in the hours Mr. Dewlap spent maintaining reef tanks, exploring nearby forests, and the like. That Mr. Dewlap's undergraduate biology studies were bereft of natural history fits neatly into a larger trend (Tewksbury et al., 2014); that his degree in science education also neglected the topic remains surprising, even in light of the many other responsibilities of teacher education.

Theme 2: Live Organism Study Contributed to Mr. Dewlap's Science and Teacher Identity

Despite its absence from the formal curriculum, Mr. Dewlap saw his learning about living organisms as foundational to his identity as both a science learner and a science teacher. He narrated how the topics covered in his tenth-grade chemistry class serendipitously matched up with the challenges he encountered in maintaining his first home aquarium, allowing him to realize that he liked science—that he was, in fact, using it all the time. This infused science into the developing animal-keeper identity that Mr. Dewlap was practicing outside of school (Lave and Wenger, 1998). Similarly, from teaching others about fish-keeping on message boards to helping students care for classroom animals and plants, from assigning extra credit projects about animal learning, to hunting queens for a classroom ant colony on his walk home, Mr. Dewlap's story of himself as a science teacher was deeply entwined with the living world. Mr. Dewlap saw his role as helping students to find and skillfully learn about the aspects of biology that inspired them most (while, of course, still preparing students to pass the state tests!). This orientation helped sustain the additional effort needed to keep interesting animals and plants on hand and to design lessons featuring living things.

Theme 3: Mr. Dewlap's Knowledge fit the Constraints of School Science Imperfectly

Mr. Dewlap's hobbyist orientation gave him a deep but highly situated knowledge of live organisms. He could credibly claim to know how to keep nearly any organism for display in a classroom or home environment but freely admitted that he had found it difficult, during the semester, to craft biological investigations featuring live organisms or fieldwork. There were some admirable exceptions, like a plankton screen done at the river near the school and a lesson on parthenogenesis in which students debated whether the unfertilized eggs laid by a female chameleon in the classroom terrarium counted. For the most part, however, the organisms Mr. Dewlap kept in his class did not serve as the subjects of the kinds of sustained investigations that the National Academies of Science, Engineering and Medicine [NASEM] (2019) argue should be central to science learning. This is logical enough, on the surface. After all, hobbyists focus on the long-term care and maintenance of their organisms, not the short-term information gathering privileged by investigation. However, while Mr. Dewlap would of course not risk his chameleon to an 8^{th} grader's investigations—the students loved the chameleon, but still—the cockroaches he bred for the chameleon to eat might have made excellent investigative subjects (see Wagler, 2018). This seems like the sort of blind spot that biology teacher education could effectively address, even with teachers who have much less hobbyist knowledge than Mr. Dewlap.

Still, given the constraints of his school, Mr. Dewlap had arguably leveraged his hobbyist knowledge of the living world to the greatest extent possible. To do more might well require more knowledge, but it would certainly also require the school to provide a higher budget for materials (and a room with, for instance, a sink). Intriguingly, when COVID-19 banished Mr. Dewlap from his classroom the following year, the remote classes he streamed from local waterways and natural areas allowed him to make fuller pedagogical use of his expertise than was possible during the year of this study. This testifies to the power of institutional constraints to hamper work with living organisms even among teachers with the right know-how.

Contribution

This study provides an account of a biology teacher who achieved an admirable level of content knowledge and a science identity that kept his teaching practice connected to the living world. Though case studies cannot warrant generalizations—Mr. Dewlap's story is singular—the themes that emerge suggest new and important questions. How often do we biology educators think of herpetoculturists, gardeners, and YouTube streamers as powerful repositories of content knowledge? How can we ensure that aspiring biology teachers have learned—well enough to use them in classrooms—the techniques of field work or organism culture? How can we make the cultivation of students' biophilia a core part of our teacher identities and our classroom practice?

General Interest

In many ways, NABT is the ideal audience for this research. Not only are NABT members accomplished instructors, but they are among the leading current contributors to the practitioner literature on how to study live organisms both within and beyond the classroom walls. Those members who prepare future biology teachers may draw from this research inspiration to augment their methods classes with live organism study (or to share what they already do). Those who do not explicitly prepare teachers might reflect upon the role of direct engagement with organisms in their own courses—and, where applicable, their outreach work. Best of all, the membership is likely to have lots of ideas about where this line of research can and should go next. I would relish the opportunity to hear from them.

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