Teaching Natural History

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Introduction

Imagine a teacher. Do you see a middle aged person standing at the front of a lecture hall facing neat rows of attentive students and spouting their knowledge, transferring information to learners as if they are a blank slate? Now, picture a natural history teacher. Do you see the same person, but perhaps holding a plant? Or do you see someone leading students through a meadow, binoculars around their neck, butterfly net in their hand? Perhaps they stand off at the edge of the meadow, as students explore the variety in species with their field journals. Now, try to expand your definition of a teacher further. What about the interpretive park ranger you saw put on a bird program in Yosemite Valley? Or the raft guide who pulled over her boat to pick wild blackberries and search for river otters with you? Even the child who pulled you down onto your knees to show you a worm. All these people are teachers of natural history, and there are a thousand more. As different as they are, each of these teachers share the ability to inspire curiosity and excitement about the natural world. This is a powerful tool; natural history, and the practices of observation and inquiry, are the foundation of science.

The following chapter will deconstruct some of the methods that have proven successful in the field of natural history education. I aim to make them simple and accessible teaching tools for the reader. I will synthesize professional research, the voices of prominent naturalists and educators, and my own experience as a novice teacher to create a holistic picture of both pedagogical theory and real life experiences of using these theories in practice. Overall, this chapter should serve to uncover some of the mysteries of experiential education by guiding a novice teacher through the steps required to design a successful natural history lesson.

The Importance of Teaching Natural History

"*In fact, hope for the future of the world will increase in direct proportion to the percentage of regular folks who practice natural history--the oldest form of human attentiveness, requiring the skill and humility to examine something larger than ourselves*"-- Thomas Lowe Fleischner, *Natural History and the Spiral of Offering*

Before delving into *how* to teach natural history, it is important to first look at *why* teaching natural history matters. This section will be succinct, as I have already discussed the general importance of natural history in the paper: *What is Natural History?* Natural history education is more specific, and thus it is pertinent to give a more focused outline of its importance.

In public education today, students *do* learn about plants, animals, and the environment, but they typically do so within the confines of a classroom. With the increasing use of technology in younger generations, kids are not visiting natural spaces as much in their free time

either. Richard Louv, author of *Last Child in the Woods*, calls this phenomena "nature deficit disorder" and explains how there has been a shift in society's attitude about nature in the past few decades. Specifically, he explains how "our society is teaching young people to avoid direct experience in nature. That lesson is delivered in schools, families, even organizations devoted to the outdoors, and codified into the legal and regulatory structures of many of our communities" (Louv 2). This is a direct contrast to the childhood that Louv and many older Americans experienced: building tree houses, pulling worms out of the grass, and imagining all the hidden life in the tadpole pond. Louv explains how, beyond just happy childhood memories, exposure to nature is vital for the developing mind of a child: "a widening circle of researchers believes that the loss of natural habitat...has enormous implications for human health and child development. They say the quality of exposure to nature affects our health at an almost cellular level" (Louv 43)**.** Experiential natural history education not only improves the quality of education a child receives, but also improves their mental and physical health. Natural history education can offer solutions to multiple issues in education today, from student understanding to mental health.

Beyond starving young adults of the hands-on experience in nature they need, the current model of indoor, controlled teaching is setting the wrong standards for future researchers. Emphasis on lecture & theory, rather than direct experience, has created a generation of biology researchers who have rarely or never seen the population or natural phenomena that they are studying (Barrows et al. 2016). Anne Bell, in her essay *Natural History from a Learners Perspective*, explains the root of this problem: "nature study has given way to the big-picture approach to environmental education. As a result...students learn about such concepts as "community" without knowing who the community members are" (Bell 133). She argues that it is impossible for a learner to truly understand processes such as food webs, evolution, or geology without first having some connection with and understanding of the players who contribute to these natural phenomena.

These gaps in students' learning do not disappear after grade school; they extend into the world of professional research, and often hinder the greater understanding of the scientific community. Paul Dayton and Enric Sala illuminate this issue in their article *Natural History: the Sense of Wonder, Creativity, and Progress in Ecology*. "Without grounding in the fundamentals of natural history, students will have difficulties in understanding ecology...there are ecologists who have never seen the communities or populations they model or speculate about, and who could not identify the species composing these communities. This is like having the illusion of conducting heart surgery without knowing what a real heart looks like" (Dayton and Sala 200). Natural history--inquiry and observation into the natural world--is the building block of all sciences. The lack of practical application and experiential learning in schools is impacting the greater scientific community.

Natural history education is important on multiple levels. Exposure to nature is a key piece in the development of children, encouraging creativity and fostering a connection to all living things. Furthermore, it serves to give future researchers the tools of critical inquiry and observation which, in turn, leads to a deeper and more complete understanding of natural communities and ecological processes. As David Gilligan puts it, "Today, as the disciplines of science and academia continue to diverge and specialize and modern human cultures continue to expand their material infrastructure at the expense of elemental nature, the need for well-trained naturalists is arguably more pressing than ever before. Today's naturalists are translators of scientific and aesthetic vernacular, necessary liaisons between specialists and laypeople, committed practitioners of observation and interpretation of a natural world that is changing perhaps more quickly than we can know" (Gilligan 28).

Learning Methods and Implications

If you have ever taken an education course, or perhaps even if you haven't, you know that people learn in different ways. However, in the history of education, this is a recent discovery; theory on how people learn has undergone multiple tremendous shifts in the past century. Despite research and pedagogical discovery, many aspects of education borne from outdated theories remain in the core structure of modern education. Understanding the flaws in these views of learning is important in understanding the most effective ways to teach.

At the onset of the 20th century, B. F. Skinner's theory of behaviorism was widely accepted. This theory was built on the belief that all children are "blank slates"; they do not have any prior knowledge or experience and can therefore be programmed to learn through conditioning (Hammond 2001). This model was based on research performed on animals in a laboratory, wherein a rat (or dog or pigeon) would be presented with a stimulus and would then be conditioned to respond in a certain way to this stimulus using reward or punishment. Skinner and his colleagues then applied what they learned from these tests to the development of teaching methods.

Despite obvious differences between the psychology of humans and animals, and the later realization that conditioning a child to do something through reward or punishment is not equivalent to learning, behaviorist methods are still used in education. It is common, especially with younger students, for teachers to encourage students with a reward or punishment system. If you finish your multiplication table in under five minutes, you get a piece of candy. If you fail your test, you have to take a red slip home and have your parents sign it. Raise your hand if you want to share your ideas. Furthermore, the idea of children as a "blank slate" led to the belief that knowledge is something that is simply transferred from teacher to student; this idea founded

lecture-style classes (Hammond 2001) where students are expected to copy information off of the whiteboard and paste it into their minds. While behaviorist methods can be an effective and useful tool for teachers, research done since Skinner's time has revealed more impactful methods of learning, many of which are especially applicable in natural history education.

After behaviorism came the constructivist ideas of theorists Lev Vygotsky and Jean Piaget, who made it clear that children are not blank slates; in fact, students construct new knowledge based on prior experience and knowledge, and must actively participate in their learning if they are to truly understand a concept. Vygotsky also found that learning happens in a cultural context and requires social interaction (Hammons 2001). While lecture style teaching paired with note taking can help students memorize facts and concepts, true mastery and application of these concepts requires student interaction and socialization, whether these come in the form of discussion with peers, a hands-on experiment, or a project. This shift in thought from behaviorism to constructivism led to radical large-scale changes in curriculum design, such as the introduction of learner participation and metacognitive activities, some of which have yet to be fully implemented into some education systems.

Researchers and theorists have continued building upon and dissecting constructivist ideas in the past few decades. While there are many ideas about how to put theory into practice in the classroom, Vygotsky and Piaget's findings --1.) students construct knowledge based on their individual experiences and prior knowledge and 2.) learning happens in a cultural context and requires social interaction -- are used as baseline for any new curriculum or learning model development. For example, more recent research has demonstrated that for a student to fully participate in their learning, he or she must be interested and curious about the subject. Researchers at the Beetles Institute, which is within the Lawrence Hall of Science, explain that "A learner's attitude also influences learning. Engagement and motivation are necessary. The more a learner is interested in a topic, the more they are motivated to remain engaged and learn about it. Psychology research shows that people are more able to attend to and grasp the importance of an intrinsic goal for their learning when they feel free to decide for themselves to learn, rather than feeling forced to do so" (Beetles 2015). A lesson incorporating these findings will be much more successful in constructing true understanding than a lecture-style, note taking lesson could ever be.

Teaching Methods

"*My grandfather taught me that a teacher is not a wise man, but a pointing finger directing our attention to the reality that surrounds us*" --Rachel Naomi Remen, Foreword to *The Five Invitations*

Scenario #1

Student: *Hey, what flower is this?*
Teacher: *That is* Castilleja chromosa*, also known as Indian Paintbrush. I studied it for ten weeks when I was an undergrad. It is part of the Orobanchaceae family and is a hemiparasite, meaning that it taps into other plants and steals some of their nutrients and energy, but not enough to actually harm the host plant. There are many different species in Castilleja, some are tiny, some are huge, some grow by water, some grow in granite scree fields. The flower shape is also really interesting--the parts that you think are petals are actually showy bracts! It's a really beautiful plant, and a good one to remember! Don't you think?*
Student: *Yeah, it's pretty.*

Scenario #2

Student: *Hey, what flower is this?*
Teacher: *Well, let's figure it out. What do you notice about it?*
Student: *Well, it's really bright red and has a purple stem. There are a lot of them right here.*
teacher gets on their belly and looks closer, beckoning for the student to do the same
Student: *Whoa, it's really soft and fuzzy. The petals are also really weird.*
Teacher: *Does it remind you of anything?*
Student: *Well, I saw a clover the other day and this flower is sort of shaped the same. But it's a lot less green. Is that because it's growing in all these rocks and maybe doesn't have as much water?*
Teacher: *That could be! What does the green in a plant usually do? Why might this one not have as much?*
Student: *I guess leaves are the greenest part of trees, and that's where photosynthesis happens. So maybe this plant doesn't photosynthesize as much as other plants?*
Teacher: *It sounds like you're onto something. But then where would it get its energy to grow?*
Student: *Hmm. I don't know. Somewhere else.*
Teacher: *What if I told you it steals some of it from other plants?*
Student: *Whoa, really?! How? With its roots?*
Student begins to dig up a flower in an attempt to expose the roots
Student: *Wow, the root is a lot woodier down here and it connects to more of the flowers. But I can't see if it connects to anything else, there are too many rocks in the way. Are all of these flowers connected to one root system? Do they only grow in rocky areas like this? Could they tap*

into any plant to steal its energy, or does it only steal from one kind of plant? And what's with the petals? Are those even petals….
Student grabs a hand lens and excitedly explores as the teacher fields another students questions

Undoubtedly, each of us has experienced myriad teachers throughout our lives, some of whom may remind us of the teachers in these two scenarios. From a teacher's perspective, there are pros and cons of each style. For example, scenario two takes much more time than scenario one, and also requires a specific setting (an outdoor space). Scenario one could happen in a lecture hall in five minutes, and would still be impactful for those students that are able to learn effectively from this style of teaching. Scenario two, on the other hand, is more interactive and engaging for the student and the teacher.. Furthermore, the student is forced to struggle with the concepts. On the whole, the active learning in scenario two is more effective (Hammond 2001).

Scenario one represents a classic lecture style of teaching. Teacher #1 has spent a lot of time studying *Castilleja*, and is obviously very excited to share their knowledge with the student. While it is important for this teacher to have a deep understanding and background in their field, sharing all she knows with a student in one breath does not guide them to a deeper understanding. How many years and time spent in the field, or paging through field guides, did it take for the teacher to master that knowledge herself? Whereas student one may maintain interest as the teacher talks, the information will likely pass from their mind quickly as they did not have to struggle with the concepts as the student in scenario two did. The departure in these two scenarios comes down to the critical moment when each student asks for the name of the plant.

If a student asks their teacher a question, and they immediately answer it, they take away an opportunity for engaging in further exploration. In the above example,the student asked for the name of the plant, but by giving it to them and not following up with a query for them, they are not encouraged to think harder about the plant. Compare the students in each scenario. Prior to asking, both students gazed upon the mystery flower with a sense of wonder. Because humans have an innate need to name things, and because it is the simplest question to ask, their curiosity manifests itself in name asking. As John Muir Laws puts it: "instead of leading with the name, trail with it." The first student receives what they ask for— *Castilleja chromosa*— and may look upon the flower for a moment thinking that they now know it. They may then move onto the next flower or rock or animal as the name and facts the teacher rambled on about slip back out of their mind and they are left having learned very little.. Ann Brown, in her book *How People Learn*, explains that "research...shows clearly that 'usable knowledge' is not the same as a mere list of disconnected facts. Experts' knowledge is connected and organized around important concepts...it supports understanding and transfer (to other contexts) rather than only the ability to remember" (Brown et al. 2000).

While student two is never given the name of the flower, they are instead given tools to help create 'usable knowledge.' The teacher fields their question in a deliberate attempt to spark their curiosity (Beetles 2005). By the end of scenario two, the student has been guided to their own discovery and understanding of hemi-parasitism, *Castilleja* flower structure and root morphology, and even the texture of the plant. And they are motivated to continue digging! The teacher in scenario two has successfully acted as a "guide on the side" (Beetles 2005). Such interactions create the space for effective meaningful long-term learning.

Teaching Methods, Lesson Examples, and Nuggets of Wisdom

In my paper, "What is Natural History?" I outline the importance of observation, inquiry, and journaling as core practices of natural history. These are also vital tools in natural history education. In the following section, I outline multiple key methods and teaching tactics--compiled from the work of Jon Young, the Beetles Institute, Richard Louv, Ken Norris, and John Muir Laws. Each of these methods serve to build the the skills of observation, inquiry, and journaling in a way that can be paired with most any lesson you are teaching. Thus, students learn how to be naturalists at the same time as he or she is learning about the specific concept you are teaching. I will also rely on The Learning Cycle as a guide to how each lesson, idea, or activity fits in to a students learning process.

The Learning Cycle

In their model on constructing knowledge, The Beetles Institute outlines[1] The Learning Cycle, which offers further insight into learning processes while at the same time offering structure for curriculum design. There are five phases of this cycle: invitation, exploration, concept invention, application, and reflection (Beetles 2005). Each of these phases is based on specific types of questions[2], that should in some way be present in any lesson, whether it is a long term project, or a thirty minute lesson.

- The invitation phase focuses on sparking a student's curiosity through question asking. This phase also "help(s) students connect past experiences to new observations and topics" (Beetles 2005).
- The exploration phase uses specific questions that encourage the students to explore what is around them. This relies on student investigation and observation.

[1] The Beetles Institute did not create the learning cycle; this was created based on the ideas of Jean Piaget (Piaget 1958: see sources) and relies on the research of myriad learning theorists. However, their interpretation of it is most accessible, which is why I cite them for it.

[2] I recommend the Beetles Institute Questioning Strategies Handout (http://beetlesproject.org/resources/for-program-leaders/#1452555182129-c1725c32-7eb4) for a comprehensive list of specific questions for each phase.

- The concept invention phase is when students begin to use what they have found in their exploration to form new knowledge and make connections. While students begin to draw conclusions in this phase, a lesson shouldn't end here.
- The application phase encourages students to generalize their knowledge, which is an important process in building critical thinking skills; students should be able use what they have learned so far in a different context (Beetles 2005).
- The reflection phase solidifies all they have learned as they think back on what they have done throughout the lesson. Journaling is especially important in this phase, as it can allow for long term reflection and serve to benchmark growth.

Observation

In terms of the learning cycle, observation is the core of both the invitation and exploration phases. Whereas we all use our senses every day, good observation in the natural world requires special attention and connection to our senses. Tom Brown, author of *Tom Brown's Field Guide to Nature Observation and Tracking*, explains how "flowers, birds, animals, and changing landscapes all have the power to keep us visually occupied for hours or days on end. The question is whether we are able to realize that power with our own perceptions. Too often we are not, but with practice we can be" (pg 35). The following activities are great ways to welcome your students into the world of their own senses.

Activity: Deer Ears and Owl Eyes

This observation-focused activity comes from a natural history class I took, but can be found more formally in Jon Young's *Coyote's Guide to Connecting with Nature*. It serves to open up the senses, and works well with any age group.I have had success teaching this to college students and second graders alike. It is a short activity, ranging from five to fifteen minutes, and works well to open a class as it grounds students in their senses. No materials are required, and while it is ideal to perform it in a natural space, it can be done anywhere as long as it is outside.

Start by gathering your students into a circle, making sure each person has enough room on either side of them to fully stretch out their arms. Introduce the lesson and its purpose:to sharpen the senses of sound and sight. Then, ask everyone to turn around so that they are facing out from the circle, with a view of their surroundings rather than each other. At this point they can sit down. Start with sight, asking them all to stretch out their arms in from of them, focusing on their fingertips. Ask them to begin wiggling their fingers as they slowly move their arms apart, eventually pausing where they can just barely see their fingers wiggling in their peripheral vision, challenging them to see how much they can be aware of in their field of sight. Explain that their vision should feel soft, unfocused on any one thing, and thus aware of much more.

Without breaking this open gaze, how much can they notice? Give them a few moments to sit like this in silence, making silent observations of all they see.

Next, ask them to close their eyes and turn their attention to sound. Give them a moment to simply sit and listen. Then, encourage them to cup their hands around their ears like deer ears. What do they notice now that they didn't before? Did anything grow louder or softer? (Again, have them silently answer these questions to themselves so they can stay present in their own senses). Have them put their hands down again. What is the closest sound they can hear? Your voice? Their classmates breathing? Something sitting on the ground? Now what is the furthest sound they can hear? A bird call? A distant car? Encourage them to try to focus on both sounds and everything in between. Allow them a moment to do this.

Lastly, have them open their eyes and challenge them to practice deer ears and owl eyes at the same time: how much sight and sound can they focus all at one time? You can then ask them to all face back inward and share their experience with others. After this activity, you can encourage them to return to their senses throughout the rest of that lesson, as well as in future classes.

Activity: Full Sense Meditation

The fullsense meditation builds on the ideas of deer ears and owl eyes, and expands our attention to the rest of our senses. You can begin this activity with deer ears and owl eyes, or teach it as a separate, more advanced, installation of sense awareness. Similar to the deer ears and owl eyes activity, you want to slowly draw in each of the senses--sight, sound, smell, touch, and taste--and then conclude with students doing their best to be keenly aware of all five at once.

In Tom Brown's version of this activity, he explains how "the senses are all bound together. Combining the senses is a little like finger painting, in which you allow to colors to blend into an all-encompassing image or emotion" (Brown 59). Be creative in how you bring awareness to the trickier senses: can they feel the wind in their hair? Or the sunshine on their face? Can they smell rain coming, or the day getting warmer? What does the breeze taste like?

After you have led a class through a full sense mediation in a stationary setting (outward facing circle), try having them spread out and slowly walk (across a field, through the woods, across the basketball court) while they focus on all five senses. Discuss how this was different; was it easier or harder? Did they feel as though the noticed more or less by moving? Will this activity change their experience when they walk to their next class?

These two lessons are just the beginning of observational awareness for students. Make sure to follow up these lessons with practice-- have students sit and meditate on their senses

again, or set them loose in a natural space and ask them to journal a list of everything they notice; in the whole forest or in a single flower[3]. Give your students time to settle into their senses, and let them explore and observe without interference. Discussion is also incredibly helpful: have students pair up and talk out loud about all they see in a plant; we all notice different things and it can be enlightening to work with different perspectives[4]. As students gain confidence in their observation skills, help them apply and adapt these skills to more complex ideas that you teach. Remember, one can never truly master observation; as you and your students practice, it will become an ingrained habit; never stop observing!

Questions Lead to Learning

Inquiry and question-based learning are central to the entire learning cycle, but are especially important throughout the exploration and concept invention phases. Questions are everywhere in everyday life and education, but often times we are not conscious of how we ask our questions. Like observation, it takes practice to develop good questioning skills. The following two scenarios offer a brief example of how the structure of a question can change its impact on a student.

Scenario #1

Teacher: *Why is the sky blue?*
Students sit quietly. Eventually, a brave student raises a hand
Student: *I heard that is has something to do with it reflecting the ocean?*
Teacher: *Ah yes, many of you may have heard this. While that is not entirely wrong, it is actually because air molecules scatter more blue light from the sun than red light. So on a cloudless day, we see blue light.*

Scenario #2

Teacher: *Grab a partner! In two minutes, share everything you've heard or know about why the sky is blue.*

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[3] I recommend John Young's *Coyote's Guide to Connecting with Nature* or Tom Brown's *Field Guide to Nature Observation and Tracking* as resources for many more wonderful observational awareness activities.
[4] See the Beetles Walk and Talk activity: http://beetlesproject.org/resources/for-field-instructors/walk-and-talk/

The class erupts into chaos with many voices and hypotheses. Two minutes pass, and the teacher reins them back in
Teacher: *Okay, what are some ideas that people had?*
Student #1: *Well, space is dark blue just because, and during the day the sun just makes it lighter blue.*
Teacher: *That's a neat thought! Who else had an idea?*
Student #2: *I heard it's because the atmosphere reflects the color of the ocean.*
Teacher: *Who else has heard that?*
Many hands raise
Teacher: *Does anyone have an argument against that hypothesis?*
Student #3: *I don't understand how that would work on land. Because if the atmosphere is reflecting what is below it, wouldn't the sky be brown and green over the continents?*
Teacher: *That's a great question! Let's hold onto these ideas. However, I'm going to throw a new thought into the mix. Remember how we learned about the light spectrum and played with those prisms last week? What if I told you that certain molecules only let certain kinds of light through? Turn to your partner and revise your hypothesis based on this new information.*
Chaos again
Teacher: *Who has a revised hypothesis they'd like to share?*
Student #3: *Do the molecules in the atmosphere affect blue light differently than the other colors of light??*
Teacher: How many people came to this answer?
Many hands raise
Teacher: *Awesome, there is a lot of evidence that supports that hypothesis! Scientists think that as light travels through our atmosphere, more blue light is "scattered" by air molecules in our atmosphere than the other colors of the visible spectrum. When it is scattered in the atmosphere, the sky appears blue. Does this make sense to everyone?*

In scenario one, the teacher asked a narrow question[5], meaning that it only has one correct answer (Beetles 2007). As the scenario shows, this type of question often makes students nervous, as they do not wish to answer the question incorrectly[6]. Thus, their curiosity is quelled. On the other hand, the teacher in scenario two asked a broad question and allowed students to talk in pairs rather than in front of the whole class. This approach can reduce the fear of failure, as there is no correct answer, and opens up the possibility for students to be creative and curious. Notice also that the second teacher does not dismiss incorrect hypotheses, but instead gently steers the discussion towards using evidence to support student's hypotheses. By the time the

[5] I recommend the following BEETLES resource for a guide to broad vs. narrow questions: http://beetlesproject.org/resources/for-program-leaders/questioning-strategies/
[6] Keep in mind that these scenarios are oversimplified extremes. While they are based on truth, they are exaggerated to prove a point: it is important to remember that every teaching situation will be different (ex. while scenario two has more potential for deeper learning, it may totally fail with one group and work perfectly with another).

teacher offers the information about molecules and light absorption, the students are fully engaged in the lesson. As Kevin Beals from the Lawrence Hall of Science explained in an interview about teaching students: "feed them when they're hungry" (2018). The learning cycle puts the exploration before the concept invention phase for a reason; students must first explore their preconceptions before they tackle the new idea.

Beals also explained that "students will learn more if they struggle with the idea--if they're not struggling, they either already know something or they're not learning it" (Beals 2018). This "productive struggle" is necessary for a student as they replace their old ideas about how something works with new ones. If a student has believed their whole life that the sky is blue because it is reflecting the ocean, it is not enough to just tell them they are wrong and why; they must both understand why their previous idea is flawed and why the new idea explains the phenomena better and with more evidence-based support. Then, they must assimilate the new idea into their existing knowledge (Hammond 2001). This process is nearly impossible if the student is expected to either immediately know the correct answer, or try to learn it through a single brief verbal explanation.

I notice, I wonder, It reminds me of…

While the previous section made clear that broad questions are often more useful than narrow questions in kickstarting a lesson, it is challenging to find the right question to ask in a given teaching scenario. There are three core broad questions that are vital in natural history education:

- What do you notice?
- What do you wonder (about something)?
- What does it remind you of?

These are fundamental in Ken Norris's process of spinning the wheel[7], in the Beetles Learning Cycle and model of inquiry, and in John Muir Laws' *Guide to Nature Drawing and Journaling*. Intentionally asking these three questions can be an activity on its own, as the following anecdote illustrates.

Mima Mounds

I was a teaching assistant in ENVS 15, Natural History of UCSC Campus. This class was targeted for incoming freshman, and met for three hours every Friday. We explored different areas of campus and different topics each week. For one of the final classes, once all the students were well into their discovery and practice of observation, inquiry, and journaling, we took them

[7] See a description of this in my first chapter *What is Natural History*?

to visit the Mima Mounds. These mounds are a perfect mystery object to explore; while there are several different compelling hypotheses proposed in the scientific literature, no single definitive answer has been proven.

We decided to not tell the students this at first; knowing there is no known answer might take a students drive to find it away if not framed correctly. Thus, we said nothing and broke into small groups, each standing in a circle on one of the mounds. I began by asking everyone to go around the circle and make one new observation (*what do you notice?*). As there were fifteen students in my circle, they were forced to be creative with their observations in order to come up with something new. Next, I asked them to break into small groups and discuss what they were curious about (*what do you wonder?*). After a few moments, we came back together and shared out with the whole group. I repeated this with the question *What does it remind you of?* Then the small groups shared again, each with a different creative memory. (*It reminds me of sand dunes! Of gopher holes! Of the Shire!*) They were curious! They were ready. In their small groups, I set them loose--*Go explore your own mound! Observe all that you can! Talk to each other, and come back in fifteen minutes with as many explanations you can think of.*

The students scattered. Some ran to the top of a mound to look across the field of mounds, while others ran to the base, looking at the low spaces in between. They were on their hands and knees, looking at the vegetation, and then they were on their tiptoes, stretching for a birds-eye view. The exploration and concept invention phase was happening in full force. After fifteen minutes, we regrouped and shared out our thoughts. I had come to class with a list of hypotheses from campus naturalists and researchers and, as each small group of students shared, they collectively mentioned every single one, plus a few more. After everyone had shared and pondered their peers' ideas, there came a moment of silence; I could tell that they expected me to spill the "real" answer. When I told them that it didn't exist, but that in their thirty minutes of exploring they had managed to come up with every pre-existing hypothesis that I had on my official list, they were proud of themselves, and enamoured with the mima mounds[8].

It is important to help your students realize that engaging in the processes of observation, inquiry, explanation-making, and discussion is often much more valuable than arriving at a "right answer." Your aim, as a teacher, should be for your students to apply this concept in all aspects of their life (Lay 2018). While this was a particularly successful experience for me, this activity can be repeated with any type of mystery object, even if it is just a flower that a student doesn't recognize. More often than not, there will be an answer as to what it is, but as long as it is a mystery to the student, you will be able to spark their curiosity and guide them through exploration with well-placed questions.

[8] See the "Could it be…?" activity in *The Laws Guide to Nature Drawing and Journaling* for a potential follow up activity to this one.

Furthermore, you may run into situations in your teaching where you don't have or know the answer to something. This can be an uncomfortable experience for most teachers, and most strive to avoid such a situation. However, as long as you are comfortable guiding the process of inquiry with a group, there is no need for you to have an answer. Chris Lay, head of the UCSC Norris Center for Natural History, explains that in such a situation, you should "engage with your own curiosity and get right in there with your students in the exploration" (Lay 2018). Leading by example is an important method of teaching; don't let an unexpected yet valuable mystery go to waste simply because you are scared to admit that you don't know the answer.

There are a thousand questions beyond the initial three I introduced that a teacher can ask to spark exploration and learning. As you teach, you will gain experience with which ones work, and which ones don't. Beals documents his questions, and explained that if he is teaching and a question fails, he needs to remember that. Later, he will sit down and try to redesign it. The next time he teaches, he will try it out. Eventually, he finds a question that ignites that curiosity. On the other hand, if he ask a question that works immediately, he will write it down then and there. "Good questions are like gold in education" (Beals 2018). A whole lesson, or lesson series, can be borne from a single question. Nature holds a million curiosities; as educators, our job is to get students to notice, ponder, and then explore them.

Journaling

"Think how often you have said to yourself, 'I will never forget this moment.' Sometimes the moments stick, but although it can be hard to admit, we forget many experiences and ideas that were once meaningful to us… but the process of journaling is enough to burn a moment into your memory." --John Muir Laws, *The Laws Guide to Nature Drawing and Journaling*

With all the chaos, exploration, and discovery that erupts from observation and inquiry practice, details are easily lost in the process. Journaling is an essential practice and habit for students to master. If set up correctly, a journal can act as a window into the thought process and growth of a student. A journal is like a container for a student's thoughts--all of their observations, questions, and reflections can be mapped out on the page. Furthermore, the practice of journaling can aid in the practices of observation and inquiry. As Jon Young explains, "journaling is the routine that stretches and etches all of the details a little further into the brain… [it] connects the language parts of the brain to sensory experiences from nature, and both bring each other alive" (p 64). The reflective phase of the learning cycle relies on journaling. Looking back on notes from the day allows one to visualize their learning--misconceptions, new ideas, burning questions--which one can then journal about and reflect on. The journal is the ultimate tool of a naturalist![9]

[9] See *The Laws Guide to Nature Drawing and Journaling* for a wonderful introduction to nature journaling.

While the journal is a personal creative space, there are certain ways to set this space up that allow for the greatest success. One widely used standard for naturalist journaling is the Grinnell Method, which requires the inclusion of key information, including name, date, time, weather conditions, location, and objective (figure 1.1). Start by becoming familiar with this method yourself, and take the time in your class for it to become a habitual practice for students. John Muir Law explains how "it only takes a few seconds... to convert any journal page to a scientific record...the foundation of natural history is careful and specific observation with rigorous and exact note taking. Much of what we know about the natural world today comes directly from the journal entries of naturalists and scientists" (20). A well-kept journal is not only a tool for learners and teachers, it can also become a tool for environmental protection and advocacy, as historical records on species can illuminate important change over time.

While simply encouraging your students to go through the steps of *I notice, I wonder, It reminds me of,* plus whatever else they wish to include, leads to a full-blown journal entry, there are, of course, a multitude of journaling activities to help you and your students dive in deeper.

C. Hartley *Always include your name at the top of the page! While it may not seem important to you in the moment, a name is important if your journal needs to be referenced*	**23 Jan 2018** *Written dates this way to avoid confusion with international dates*

USA; CA; Santa Cruz Co; Santa Cruz; UCSC; Upper Campus Natural Reserve; North Remote Parking Lot; East along fire road about 100 ft.
Make sure to include as much broad to specific information as possible in your locality description. The goal of this section is so that you, or someone else, could locate the exact place where you made this journal entry.

Conditions: **9:13 am, mostly clear skies with a few scattered clouds, approx. 60 degrees F, slight breeze (<10 mph)**
Include a description of the conditions, as it can impact what you may or may not observe that day!

Objective: Casual bird walk and observation journaling session in Upper Campus, hoping to see a Pileated Woodpecker

This section should be a brief description of what you journaling about/ the objective of your day.

Time *Make sure to continually keep track of what time of day it is as you journal in the left margin of your page!*	**Observations/Inquiries/Sketches** *With all the above information written down, you can begin the meat of your journaling: the observation, inquiry, and drawings!* **Reflection/ Species List** *It can be helpful to end your journal entry with a reflection of what you learned, lingering questions, and/or a detailed species list of all you saw. This both solidifies all you learned throughout your journaling, and makes it easy to refer back to in the future.*

Figure 1.1: Journal Page Formatting Example

Drawing and Journaling

John Muir Laws, master scientific illustrator and author of multiple field guides, teaches nature sketching as a way to improve observation and journaling skills. By taking the time to draw the organism at hand, you are forced to notice individual details with more attention. It does not matter if you are an expert artist or a novice; simply attempting to draw something forces a deeper and different perspective. For example, if you are looking at a bird, you may not notice the exact shape of its bill. However, if you are sketching it out in your notebook, you are forced to look carefully at the bill in order to draw it correctly, and might realize at that point that its bill reminds you of a flycatchers bill. Or perhaps you decide to sketch out a flower, and realize as you draw the parts that it is lacking leaves. Going through the steps of sketching allows our minds to settle into whatever we are looking at, and thus notice more about it. Muir's book *The Laws Guide to Nature Drawing and Journaling* is a wealth of knowledge on drawing and journaling activities, and a wonderful resource for both students and teachers.

Practice and Consistency

While there are many more activities, the most important aspect of journaling is to be consistent; activities are a tool to help keep students engaged in the process. Encourage your students to keep a journal starting on the first day--the more often they write in it, the more of a resource it will become. Eventually, students will begin to love journaling and fall into the habit. This is the true mark of a naturalist; there are many naturalists who value their old journals more than any other material object. Just like observation and inquiry, journaling must be practiced; eventually it becomes habit, and the world is opened up.

Conclusion

This essay offers the smallest slice of the natural history teaching process; it is a start to a fire that must be built upon with practice, failure, and more practice. As many of my own favorite instructors have told me, learning how to teach never ends. The second you think you have mastered teaching is the second you are no longer a true teacher. Every lesson, every moment, can be seen as an opportunity to reflect on your teaching style and continue improving it. Try someone else's approach to a lesson. Then try designing your own. And always, always seek as much student feedback as possible. Never forget that it is all about the student! And, finally, remember: be humble. "At the end of your lesson, do you want the kids to think 'Wow, my instructor is so cool!' or 'Wow, nature is so cool!'" (Beals 2018). Go out there and try, fail, and try again, all the while making your beautiful impact on the minds of others as you connect them to the wonder that surrounds us all.

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