



Professional Learning Materials

Teaching & Learning

Learning is active and social. For deep learning to occur, instruction needs to access and connect to prior knowledge and give learners choices and responsibilities in their own learning experience.

This session is designed to explore how people learn, and to model how to prepare lessons and activities that are sequenced in ways that help learners engage with a topic or concept, and build their understanding. Lessons that are highly effective tend to follow a pattern, and in this session we identify that “learning cycle” pattern, so instructors can use it to make thoughtful instructional decisions. It’s worth spending some time becoming familiar with this model, because it can be challenging to apply well, yet can be a transformative backbone for activity planning and instructional decisions.

The learning cycle is a research-based instructional model that focuses on ordering phases of an activity to support learning. The model presented in this session is based on a five-phase cycle: invitation, exploration, concept invention, application, and reflection. The session itself—like all BEETLES sessions—is also based on the learning cycle model, so participants can experience the model at the same time as they are learning about it.

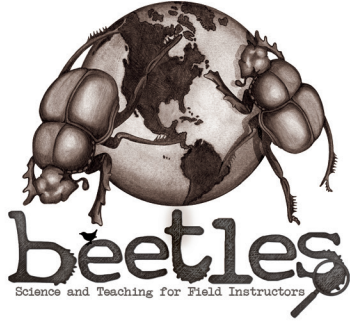
Although all BEETLES professional learning sessions are interconnected and complementary, *Teaching and Learning* has a specific “companion” session, *Constructing Understanding*, that digs more deeply into how people learn.

The goals for this session are:

- Discuss the benefits of sequencing different stages of an activity strategically to achieve engagement, meaning-making, and in-depth learning.
- Learn about an effective model for instruction known as “the learning cycle,” and gain the ability to make learning cycle-based instructional decisions.
- Learn how the learning cycle can be applied to short, medium-length, and longer field experiences.
- Practice implementing the learning cycle by applying it to the planning of a short field experience for students.



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ABOUT BEETLES™

BEETLES™ (Better Environmental Education Teaching, Learning, and Expertise Sharing) is a program of The Lawrence Hall of Science at the University of California, Berkeley, that provides professional learning sessions, student activities, and supporting resources for outdoor science program leaders and their staff. The goal is to infuse outdoor science programs everywhere with research-based approaches and tools to science teaching and learning that help them continually improve their programs.

www.beetlesproject.org

The Lawrence Hall of Science is the public science center of the University of California, Berkeley. www.lawrencehallofscience.org

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Other locations: Balarat Outdoor Education, CO; Barrier Island Environmental Education Center, SC; Chincoteague Bay Field Station, VA; Eagle Bluff Environmental Learning Center, MN; Great Smokey Mountain Institute at Tremont, TN; Wellfleet Bay Wildlife Sanctuary-Mass Audubon, MA; Mountain Trail Outdoor School, NC; NatureBridge, multiple locations; Nature's Classroom, multiple locations; North Cascade Institute Mountain School, WA; Northbay, MD; Outdoor Education Center at Camp Olympia, TX; The Ecology School, ME; UWSP Treehaven, WI; Wolf Ridge Environmental Learning Center, MN; YMCA Camp Mason Outdoor Center, NJ; and YMCA Erdman, HI.

Photos: Pages 1 and 3 by Kevin Beals. *Icons:* Backpack by Rémy Médard; Beetle by Ola Möller; Cut by Nathan Thomson; Outside by Petr Holusa; Park by Antar Walker; &Time by Wayne Middleton all from The Noun Project.

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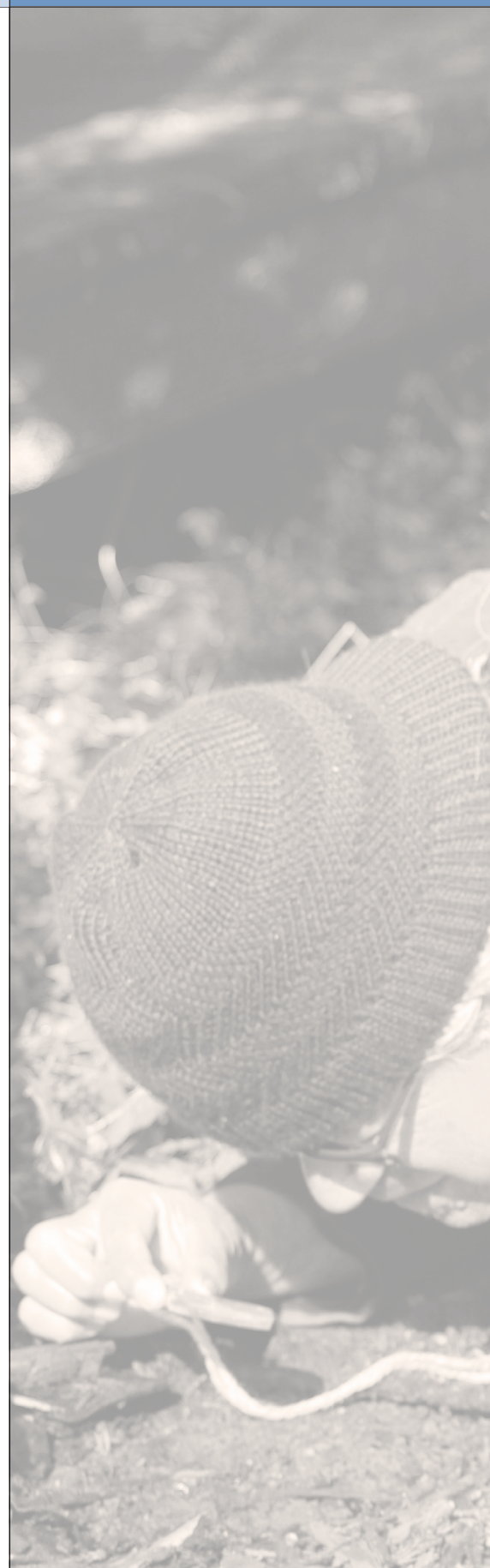
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Teaching & Learning

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TEACHING ABOUT TEACHING



The presentations in this guide have been designed to “practice what we preach.” This session reflects a learning-cycle approach to instruction. In this way, participants experience a version of the learning cycle instructional model while they learn about it. It’s important to structure the session so there are opportunities for participants to experience each phase of the model for themselves. Resist the temptation to shortcut the process and dole out too much information too early. Simply *telling* instructors about the learning cycle goes against the whole idea—they are learners, and, for the sake of their own learning, they should get a full learning-cycle experience on this relevant and important topic that can be challenging to implement.

PRESENTATION OPTION








Want to spend more time outdoors than in? This whole session can be done outdoors. Some slides can be skipped outdoors, but other slide text is important. You and your co-presenter can take turns writing text from slides on white boards, and/or printing some text out using black font on white background on as large sheets as possible. You may want to put these in plastic page protectors.

TIMING TIP



Familiarize yourself with the script and activities and keep things moving, or it might be difficult to stay within the estimated time frame. If you dig deeply into every interesting question and idea during a session, the session will be too long. Be prepared to table a discussion to keep things moving. If a topic seems particularly interesting to your staff, either let the discussion run its course, or consider discussing it more deeply at a later meeting.

Session Overview

	Teaching & Learning	Activity Locations	Estimated Time
Invitation	Introducing Teaching and Learning Participants see a short demonstration modeling how lichen is commonly taught, then discuss pros and cons of the approach. They write about and discuss a time when they’ve learned something really well, and what it took to learn it.		15 minutes
	Sequencing an Activity Pairs sort strips with steps from a lichen activity into what they think is the best order for student learning.		20 minutes
Concept Invention	Discussing the Learning Cycle First, participants read about one phase of the learning cycle in a small group and decide through discussion which step of the lichen activity best matches that phase. Then, as a whole group, the learning cycle is discussed phase by phase. Pairs share what they learned about the goals of each phase and what parts of the lichen activity they think best match that phase.		40 minutes
Application	Modeling a Learning Cycle-based Student Activity: Lichen Exploration The leader conducts a student lichen field activity that models the learning cycle.		60 minutes
	Debriefing the Learning Cycle Participants reflect on how the learning cycle was used in the model student activity. Then, the leader shares some useful tips for implementing the learning cycle as well as some common mistakes that are made.		25 minutes
Reflection	Designing Field Experiences The leader introduces the idea that the Learning Cycle can be applied to field experiences of different lengths: short, medium, and long. Participants apply their learning by designing short learning cycle experiences on interesting organisms students might find in the area.		30 minutes
	Wrapping Up Participants reflect on how the learning cycle was used throughout the session, and discuss how to apply it in their own practice.		15 minutes
TOTAL		~3.5 hours	205+ minutes



PREPARATION

Before the day of the session:

1. **Review entire write-up including background (page 44), sidebars, and handouts.**
2. **Decide if you will present the session partly or entirely outdoors.** If you choose to present outdoors, you'll need to decide which slides to write out on white boards or chart paper, or print in black font on white background (11" x 17" is ideal). Presenting all outdoors works best with a co-presenter.
3. **Set up projection system/review multimedia.** For indoor segments, set up and test in advance the projection system to be sure all participants will be able to see what's projected during the session. Spend a few minutes reviewing these materials.
4. **Read & familiarize yourself with the BEETLES Lichen Exploration student activity guide & assess your ability to lead it.** You may want to ask another staff member who's already done the activity with students to lead this part of the session. To be well prepared, read the entire separate activity write-up, including sidebars and Instructor Support.
5. **Scout/set up outdoor lichen area.** Find a nearby place with a variety of lichen, ideally including the three main types: crusty, leafy, and shrubby (see key in the BEETLES Lichen Exploration student activity write-up). If you don't have an area with the three types, collect and spread out samples in an area or add a little to what's already there. Also check to see if there are examples of lichen succession (leafy growing on crusty, and shrubby growing on leafy). If not, then skip the section "*Finding Evidence of Lichen's Growth Order*" in the model activity. If you don't have lichen in your area, you can substitute another activity that's thoughtfully based on the learning cycle, such as BEETLES activities: *Discovery Swap*, *The Case of the Disappearing Log*, or *Bark Beetle Exploration*. You'll need to make adjustments, including adjusting the Lichen Activity strips handout on page 33.
6. **Prepare copies.** See materials list at right.
7. **Prepare the large learning cycle phase signs.** Write by hand with large felt marker on cardboard or manila folders (or print in large type) the following, on separate signs:
 - **Invitation:** Access prior knowledge; Engage students; Set context
 - **Exploration:** Students explore & become curious; Discussion of discoveries
 - **Concept Invention:** Students invent concepts; Students develop explanations; Instructor provides information about concepts
 - **Application:** Students apply new knowledge
 - **Reflection:** Students reflect on new understandings and how they changed ideas; Students make connections.
 - [optional] You might want to make 5 large arrow signs as well to go between each phase.
8. **Prepare Lichen activity sorting strips.** Make 1 copy for each pair, page 33, and cut into individual strips. Put each set in an envelope, or attach with a clip.
9. **Create large set of lichen activity strips.** Write each step of the activity on a separate sentence strip, cardboard, or manila folder—large enough to be seen from a distance.
10. **Print and cut out Lichen Keys, on page 36, for the model student activity.** Each pair of participants will need one key.
11. **Plan when you might include a break in the schedule.** We recommend a break before and/or after modeling the student activity. You may also want to spread the session over two days, by doing the Designing Field Experiences section on another day.
12. **(Optional) Make Session Overview to post on wall.** You may choose to make a Session Overview to post on the wall during this session. It's not necessary for a workshop like this, but some presenters & participants prefer having it. Overview titles could include: *Introduction*, *Understanding the Learning Cycle*, *Modeling a Student Activity*, *Designing Field Experiences*, and *Wrap Up*.

Immediately before the session:

1. **(Optional) Place lichen examples outdoors.** If you can't find a natural source, or if need to supplement what's there, place collected examples in the area you selected.
2. **(Optional) Hang up agenda poster in the room where all participants can see it.**

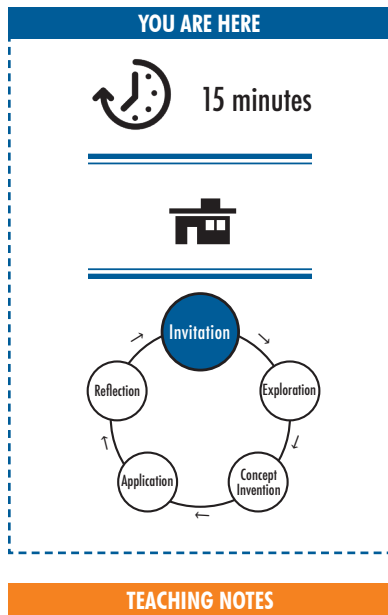
MATERIALS

For the group:

- ☐ Projection system (including computer)
- ☐ Slides
- ☐ Learning Cycle Signs (see Preparation Step 9)
- ☐ Broad-tip felt markers
- ☐ Sentence strips or cardboard for large lichen strips
- ☐ Lichen sample(s)
- ☐ Set of Hand lenses for each participant
- ☐ (Optional) Flip chart paper and marker for agenda

Copies and Printed Materials:

- ☐ Lichen activity strips, page 33 (one per pair)
- ☐ The Learning Cycle Explained, page 34
- ☐ Lichen Key, page 36 (one per pair), for the model student activity.
- ☐ Applying the Learning Cycle Lens to Outdoor Instruction, page 37
- ☐ Brief Background of the Learning Cycle, page 40
- ☐ Short Learning Cycle Skit, page 41 (4 copies total)
- ☐ (Optional) How Learning Happens: Five Foundational Ideas, page 43
- ☐ (Optional) copy of Student Activity Guide for Lichen Exploration (available at www.beetlesproject.org)



Introducing discussion norms. If your staff don't have much experience introducing discussion norms, you may want to model how to do so with students. One suggestion: Tell the group to sit in a circle on the floor, and read aloud each norm, followed by quickly acting out what that might look like, and the opposite of what it looks like. You can also share examples of how to disagree productively, ask people for evidence, or change your mind.

Introducing Teaching & Learning

1. Show slide 1: *Teaching & Learning*. Introduce the guiding question for the session and explain:

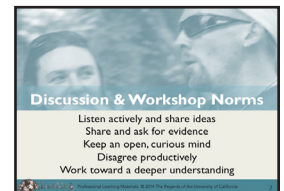
- This is our guiding question for the session:
 - ▶ *How can we use what we know about how people learn to create effective learning experiences?*
- The session goal is to consider how to design deep and effective learning experiences for students.



Slide 1

2. Show slide 2: *Discussion & Workshop Norms*. Explain Discussion Norms:

- We'll be learning a lot through discussion in this session. To make sure conversations are productive, we'll use these discussion norms (which can also be used with students).
- Read aloud the five norms.
- Ask,
 - ▶ *Is anything missing from this list? Does anyone want to talk about any of these norms?*
- Ask: Can we agree to these to keep our discussions respectful and productive?



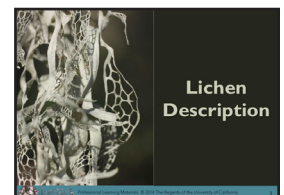
Slide 2

3. Explain: Let's look at a common outdoor science learning experience, then talk about it:

- As an introduction to thinking about how to create effective learning experiences, let's consider a very common outdoor science learning experience.
- Afterward, we'll talk about the benefits and drawbacks of this approach.

4. Show slide 3: *Lichen Description*. Tell the story of Alice Algae and Freddy Fungus.

- Explain: This is a common way of describing lichen you may have seen or used yourself.
- Hold up a sample of a lichen (if you have one). If not, just use the photo in the slide, or pantomime, and tell the story (below) of Alice Algae and Freddy Fungus:
 - ▶ *"This is lichen, and here's a little story about what it is. Freddy Fungus and Alice Algae took a "lichen" to each other, and formed a relationship. Freddy provides the structure, but, being a fungus, cannot make food. Alice is an algae, and is able to make food through photosynthesis. So Freddy Fungus provides the structure, and Alice Algae provides the food in a relationship they both benefit from. And although their relationship is sometimes 'on the rocks,' and sometimes Freddy 'drives Alice up a tree,' they've lived symbiotically ever after."*



Slide 3

TEACHING NOTES

Benefits they may mention: Exposure to vocabulary, such as: symbiotic, lichen, algae, fungus; Students may be able to identify one form of lichen and name the organism; The story may be engaging for students.

Drawbacks they may mention: Students don't get a chance to explore, wonder, and become fascinated with lichen; Lots of new words, and it's hard to know which they will understand or remember; They could have some confusion about the brief mention of the topic of symbiosis; They may not be able to recognize other forms of lichen; If they aren't very familiar with fungi, algae, or photosynthesis, it may not make much sense to them; They would not have the opportunity to touch or observe lichen closely using their senses; A "hetero-normative" understanding/metaphor is used to explain lichen/algae relationship.

Discussion Tip: Accepting Responses.

In order for participants to feel comfortable sharing their own ideas in a discussion on broad questions, it's important for the presenter to be accepting of all responses. The discussion may be much less effective if a hidden agenda emerges when the discussion leader responds in an accepting fashion to some comments but less accepting to others.

5. Ask for ideas about how students might *benefit* from this approach.

▶ What might students get out of an approach like this?

- Listen to their ideas.

6. Ask for ideas about the *drawbacks* to this approach.

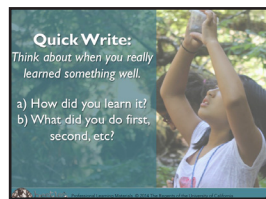
▶ What might be missed with this kind of approach?

- Listen to their ideas.

7. Explain: Let's think about what it takes to learn something well, based on your own learning experiences:

- We've begun talking about pros and cons of one common example, now we'll think more about our own personal learning experiences.

8. Show slide 4: *Quick-Write*. Explain: You have ~3 minutes to write your answers to these questions about when you've learned something well:



Slide 4

- Think back on a time when you learned something really well.
- Instead of thinking about it as instructors, think about it as learners.
- How did you learn it? What was the learning sequence you went through? What did you do first, second, etc.?
- Take ~3 minutes to do a Quick-Write answering these questions.

9. Explain: Turn & Talk about what you wrote with a partner for ~3 minutes:

- Focus on what helped make it a worthwhile learning experience.
- Focus on what the learning *sequence* was.
- Notice similarities and differences between your experiences.

10. Get the group's attention and lead a discussion about common characteristics of enduring learning experiences:

▶ What did it take for you to really learn something?

▶ What was the learning sequence?

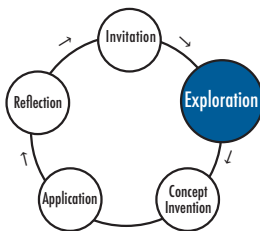
- Summarize and record responses on white board or chart paper.

11. Point out patterns or similarities in what they've said.

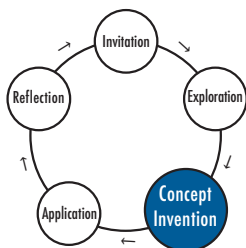
- Point out any patterns or similarities you notice. For example:
 - Creating a desire or will to learn about something
 - Having the chance to practice and extend the learning
 - Not having an answer right away helps keep the learner curious

TEACHING NOTES

YOU ARE HERE:



YOU ARE HERE:



- Sharing thoughts and discussing ideas with others

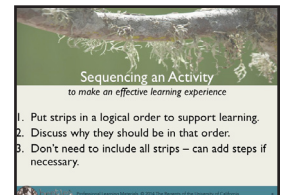
12. Summarize and transition to sequencing with the following points:

- Many of the things you just mentioned from your own experiences are examples of accepted principles for designing effective learning experiences.
- How people learn has been researched for a long time. We're living in an era when we know a lot about how people learn.
- As educators we can use these understandings when we design learning experiences.
- It's useful to think about and plan for the *phases* of learning when we're designing learning experiences for students.
- We'll dive more into what the research says in a few minutes, but for this next activity focus on the ideas and patterns we just discussed.

← Sequencing an Activity

1. Show slide 5: *Sequencing an Activity*. Explain: You'll discuss and sort steps of a lichen activity into an order you think is effective for learning:

- The way you sequence the steps of an activity can make it a more (or less) effective learning experience.
- With a partner, you'll discuss how to sequence the steps of a lichen exploration activity to support learning for students.
- Most important is to share your *reasoning* with your partner, and to be open to their ideas.
- There is no one correct way to sequence the strips, and you don't have to use all the strips, but you do need to be able to explain why you're making the choices you're making.



Slide 5

2. Pass out strips and explain: You have about 5 minutes to discuss and sort.

- Pass out a set of lichen activity strips to each pair.
- Pairs discuss and sort strips for about 5 minutes.

3. Once most have finished, tell each pair to team up with another pair to share their sequence and reasoning for ~5 minutes.

4. After ~5 minutes, focus the whole group back together.

← Discussing the Learning Cycle

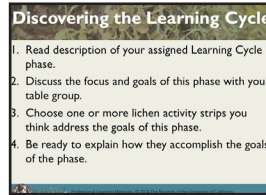
1. Explain that a research-based instructional model called the Learning Cycle has been developed:

- Many researchers have studied what we've just been discussing:
 - How people learn.

- How to sequence activities to support how people learn.

- Based on research, an instructional design model called the Learning Cycle has been developed to help educators design effective learning experiences.

2. Show slide 6: *Discovering the Learning Cycle*. Give instructions for reading about a learning cycle phase, and explain:



Slide 6

- In table (or other small) groups, use the prompts on the slide to discuss the phase assigned to your group.
- Then, each group will present their choices and reasoning to the whole group.

3. Assign phases to table groups, pass out materials, and give ~10 minutes.

- Assign one of the Learning Cycle phases to each table group to read.
- Pass out a copy of *The Learning Cycle Explained* handout to each participant.
- Keep their reading and discussions to ~10 minutes.

4. Gather the whole group in a seated circle, and set out learning cycle phase signs in a circle within the circle.

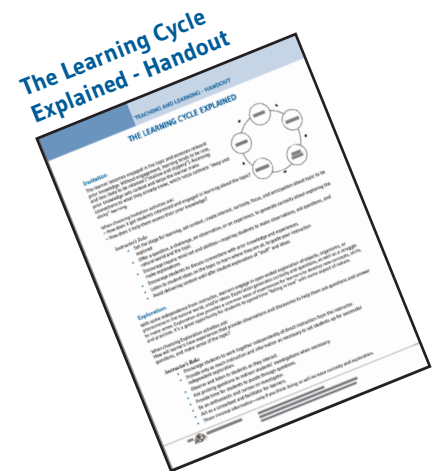
- Set out the pre-made large learning cycle signs as a complete learning cycle on the ground within the seated circle.
- Optional:* If you've made arrow signs, you can put them between the signs to show direction of the cycle.
- Place the large pre-made lichen activity strips in the middle of the learning cycle phases circle.

5. Ask the Invitation group to present the goals of the Invitation phase in own words, as well as explain which lichen activity steps they think best meet those goals.

- Tell the team assigned to the *Invitation* phase to briefly describe the phase and its goals in their *own* words (they *don't* read it).
- Ask a volunteer from the *Invitation* group to place the large sentence strip(s) for the lichen activity step(s) they've chosen next to the *Invitation* sign on the floor.
- Ask them to explain their choice(s) to the whole group:
 - ▶ Which lichen activity step(s) do you think best represent(s) this phase?
 - ▶ Why do you think the step(s) could work well to accomplish the goals of the Invitation phase?

6. Ask follow-up questions on choice(s) of the Invitation group.

- You may want to ask follow-up questions to help the group focus on what students are doing during the Invitation phase.



"I already know about the Learning Cycle/5E's." The good news is that variations on the Learning Cycle have spread widely. (Read more about the relationship between these other models, including the 5E's (one of the most common variations) and the Learning Cycle in the background section.) But not all instructors recognize its deep value, nuances of the phases are often lost, and the tricky part is applying it well. Many instructors are familiar with it, but don't apply it as effectively as they could. That's why the follow-up activities to this session are crucial as part of the application phase for learners. Challenge any staff already familiar with the Learning Cycle instructional model to deepen their understanding and to apply it even more effectively to their instruction.

Some instructors might also get the Learning Cycle confused with Multiple Intelligences or learning styles. The Learning Cycle is not a variation of Learning Styles/Multiple Intelligences. Read more about how the Learning Cycle and Learning Styles differ in the background section.

TEACHING NOTES

Flowing with the Discussion. The beauty of leading a discussion without a hidden agenda is that participants bring up the important points, and the leader merely serves as facilitator of the discussion, making any points they want to make after the discussion. Although the “script” for leading this discussion is provided as a guideline and framework, the session leader should ask broad questions—many of which are suggested in the script—and “flow” with the participant responses and comments, while keeping the discussion generally on track. This kind of dynamic interchange cannot be fully scripted, and depends on the facilitation skills of the presenter.

It’s concept invention, not introduction. It’s called concept “invention” instead of concept “introduction,” to emphasize the idea that learners have to “invent” every concept they learn as they each incorporate it into their own individual brains.

A new context in the application phase might be a new ecosystem or organism to make observations of, a new tool to use, or a provocative question that makes them think in a slightly different way.

- b. For example:
 - How does it get students interested in learning about the topic?
 - How does it help them access their prior knowledge?
- c. Ask for reasoning, encourage participation of all group members, and probe for alternative ideas.
- d. Focus the discussion on the *reasons* behind making different instructional decisions.

7. Add to or clarify their description as needed. For example, you may need to elaborate on the meta-cognitive aspects of the Invitation phase:

- a. Many instructors remember the invitation phase as when learners are engaged in the topic, but forget that it’s also the time for learners to access prior knowledge.
- b. In order for students to access prior knowledge, they need the opportunity to share their thoughts, through writing or discussion.

8. Encourage discussion between groups.

- Ask if anyone has questions for the invitation group, or if there is any disagreement, before moving to the next learning cycle phase.
- ▶ *There are no absolutely correct choices. Do you agree or disagree with their placement? If not, please explain.*

9. Repeat steps 2 and 3 for each of the remaining phases.

- a. Go in order through each phase.
- b. Different groups may choose to use some of the same large sentence strips for their phase.
- c. Encourage discussion, but there’s no need for the group to reach agreement.

10. Elaborate on learning cycle phases as needed, using the following information:

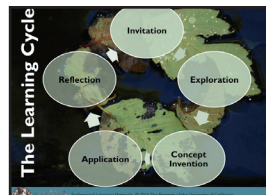
- **Exploration:** This phase is about exploring ideas, not just physical places. Learners might be trying to solve a problem, manipulating and experimenting with new materials, or investigating a particular phenomenon.
- **Concept Invention:** There are two competing misconceptions about this phase: 1) instructors cannot deliver *any* content during this phase because learners should only invent it themselves, and 2) this phase is when instructors should tell content to students. It’s more accurate to say that content from instructors is an important part of learning and this is a good time to provide students with it. Even if the instructor is sharing information, the student still needs to invent it for themselves by incorporating that information into their own prior conceptions and connections.
- **Application:** The application phase must involve a new context for learner’s to use the ideas and concepts they’ve developed.
- **Reflection:** Like the invitation phase, the reflection phase is meta-cognitive. Learners need a chance not just to think about what they

learned, but also how they learned it.

11. Summarize the discussion with these points:

- As we've seen by our various choices and decisions, there are different ways to sequence activities according to the learning cycle.
- Some steps could work at different phases of the cycle. It's an instructor's judgment call, based on the greater context.
- Instead of getting caught up in what phase is what, it's most important to think about what the learners are doing and what the goals for learning are. Ask yourself:
 - What are the learners doing?
 - Is what they're doing meeting the goals of this phase?
 - How can I, as an instructor, support the goals of this phase?
 - How can I facilitate learning during this phase?

12. Show slide 7: *The Learning Cycle*. Provide background to the learning cycle; explain:



Slide 7

- The learning cycle is an instructional design model developed to organize educational experiences to be consistent with what is known about how people learn.
- It has roots in learning theories developed in the early to mid-1900s, as reflected in the work of Dewey, Vygotsky, Montessori, Piaget, and others.
- It was formalized into the Learning Cycle in the 1960s by education researchers and scientists who conducted a comparison study of learning cycle and non-learning cycle-based science instruction. The study found learning cycle-based instruction to be more effective.
- It's been applied in many contexts, and supported by other research in the years since then.
- We'll keep talking about how to use and apply the learning cycle after the following model student activity.

Modeling a Learning Cycle-Based Student Activity

1. Introduce the purpose for the model activity and explain:

- You'll experience a student activity designed with the Learning Cycle in mind and with each phase identified.
- It's one (but not the only!) possible sequence of steps for a lichen activity using the learning cycle model.

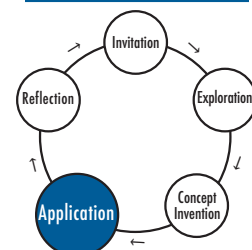
2. Remind participants to think about their learning; explain:

- This is a chance to get a sense of what a learning cycle-based experience feels like from a learner perspective.
- Be meta-cognitive during the activity: notice what you do and discuss in each phase, and how the sequence affects your experience as a learner.

TEACHING NOTES:

YOU ARE HERE:

60 minutes



TEACHING NOTES

How should staff behave during model activities? If you ask participants to behave like children during model activities, they often exaggerate negative behaviors, and the modeling suffers. Tell them to participate as adults, while imagining and considering how students might respond. There may also be times when they might get carried away with adult content to the point that it loses its effectiveness as a model, and as leader you may need to point this out and ask them to tone down the content.

Learning cycle signs. Lichen Exploration is not an entirely smooth trip around the learning cycle. In the case of this activity, the steps are: invitation, exploration, concept invention, application, concept invention, application, concept invention, reflection. It's a good example of the flexibility involved in implementing the learning cycle.

Tell participants who will be holding up the Learning Cycle signs, so they know where to look.

Make sure you bring copies of the Lichen Key outside with you.

The student activity has been embedded in this professional learning write-up for your convenience. In this section, students/ participants are referred to as "learners" in order to help you identify the parts that are taken directly from the student activity. The blue box differentiates the student activity from the rest of the write-up.

3. Remind participants to behave as adults during the activity; explain:

- You'll be participating as adults, following your own curiosity, and discussing discoveries and ideas at your own level.
- The leader will be modeling how to lead it with *students*, so you should support the leader, not derail discussions too far off-topic, and also keep focused on how students might respond to the activity.
- Acting out negative student behaviors is not helpful. Imagining how your students might respond is helpful.
- There will be some questions asked that might seem obvious to you, but are designed for students.

4. Ask a co-presenter to hold up learning cycle signs for each phase of the model activity as it's presented.

- Bring the signs you made for the learning cycle phases.
- The phases of the learning cycle are included in an all caps font in the script, so your co-presenter knows when to change signs.
- The co-presenter prominently holds up the Invitation sign throughout the whole invitation phase .
- The co-presenter does the same with the different signs for each phase of the activity.


5. Take them to the outdoor location you chose, and lead the *Lichen Exploration* activity from the script.

- Use the BEETLES *Lichen Exploration* student script below to lead the activity as closely as possible to how it would be done with students outdoors.

INVITATION (*assistant holds up sign*)

INTRODUCING THIS "WEIRD ORGANISM"

1. Lead a group discussion about "this weird organism":

- Find some interesting lichen and gather your group around.
- Explain: Check out this weird organism.
- Ask,
 -  Have you ever seen anything like this before? What does it remind you of?
- Explain: This is a living organism.

EXPLORATION (*assistant holds up sign*)

EXPLORING LICHEN

2. Tell pairs to check lichen out up close & see how many different types they can find:

- There are over 10,000 different kinds of this organism.



TEACHING NOTES

If you're using hand lenses, pass them out to each participant or pair at this point.

Engage any disinterested learners by directing them to a specific rock, tree, or stick rich with examples, and ask questions that encourage exploration.

- b. Let's see how many different kinds we can find here, and what we can notice about them.
- c. Make comparisons between different kinds you see.

3. Tell learners to explore "weird organisms" in this area.

- a. Give pairs ~10 minutes to find and observe as many different kinds of the stuff as they can.
- b. Emphasize not harming/removing lichen, but observing it where it is growing.
- c. Circulate, troubleshoot, and co-explore with participants.
- d. Check in and ask them what they notice or to compare different kinds of the organism they find.

DISCUSSING LICHEN

1. Lead a group discussion about their exploration discoveries:

- a. Gather learners in a toe-to-toe circle.
- b. Facilitate their discussion using questions such as,
 - What did you notice?
 - How many different kinds did you find?
 - How would you describe one of the most interesting ones?
 - How are the different kinds you saw different or similar to one another?
 - What does that one look like to you? What does it look like through your hand lens?
 - Did anyone else see that too?

CONCEPT INVENTION *(assistant holds up sign)*

2. Write the word "lichen" on a white-board/paper & introduce it to participants; explain:

- a. This weird organism is called "lichen."
- b. It looks like it might be pronounced to rhyme with "kitchen," but it's actually pronounced to rhyme with "hikin'."

INTRODUCING THE SYMBIOTIC RELATIONSHIP IN LICHEN

1. Lead a group discussion about what lichen is:

- a. Explain: Let's talk about what lichen is.
- b. Ask,
 - ▶ What do you know about plants? Do you see any evidence that lichen could be plantlike?
 - ▶ What do you know about fungi? Do you see any evidence that lichen could be a fungus?

Most of your participants will already know that this is lichen. You might want to step out of "field instructor" mode at this point to remind participants that most students will be unfamiliar with lichen.

With adult participants, this discussion can be pretty quick.

TEACHING NOTES

In the student activity, there are optional steps here to introduce the terms “symbiosis” and “adaptations”. We’ve removed them here to save time, but you can decide if you’re staff would benefit from their inclusion. Read the full student activity write-up for more information, notes, and tips.



c. Listen to a few of their ideas and ask follow-up questions to probe deeper into their thinking, such as,

- What’s your evidence for that idea?
- Did anyone else have that idea, too?

2. Explain that lichen is a relationship between fungus & algae:

- Lichens are actually two organisms, a fungus and an alga that depend on each other.
- Some people say, “Freddy Fungus & Andi Algae took a likin’ to each other” to help them remember.
- Freddy fungus, collects water and nutrients, attaches to a surface, and protects Andi alga from the environment.
- By photosynthesizing, Andi alga makes food providing the matter and energy both Andi alga and Freddy fungus use to survive.

3. Explain that the relationship between fungi & algae helps both organisms:

- Earlier in our field experience, we discussed structures and behaviors that might be adaptations that help organisms survive in their habitats.
- In this case, the adaptation is the *relationship* between fungi and algae that helps *both* organisms survive in their habitat.

INTRODUCING AND USING THE KEY

1. Tell learners to Turn & Talk about a lichen they found:

- Think of one type of lichen you saw while exploring & describe it to the person next to you.
- Make sure to take turns describing and listening.

2. Introduce the lichen key with three main types of lichen: crusty, leafy & shrubby:

- Explain: Even though there are thousands of kinds of lichens, most can be grouped into three main types: crusty, leafy, or shrubby.
- Show learners each photo on the key while also holding up (on a stick or rock) or pointing to a real sample of that type of lichen. Add verbal descriptors:
 - Crusty lichen is like a scab or paint that is attached to the surface everywhere it touches.
 - Leafy lichen has little flaps like lettuce and is attached to the surface in one place.
 - Shrubby lichen looks like a bush or beard.

3. Explain that the lichens won’t look exactly like the ones in the pictures:

- Lichens you find might look different than the pictures on the key- there might be differences in color or shape.



- b. Leafy lichen can look “leafy” in many different ways, and there are different ways lichen can look crusty or shrubby too.

APPLICATION *(assistant holds up sign)*

4. Ask learners to explore & identify different kinds of lichen with the key, while also looking for patterns of where lichen grows & what surfaces it grows on; explain:

- a. Go explore and identify different kinds of lichen with your key.
- b. As you do, pay attention to where lichen is growing and look for patterns- scientists often look for patterns to learn more about what’s going on with an organism.
- c. To notice patterns of where lichen grows, look at what surfaces lichen grows on, and what surfaces it doesn’t. Ask yourself questions such as:
 - Does it grow in rocks? On wood? On tops of rocks or on the bottoms?
 - Do different types of lichen grow in different places? For example- does crusty lichen only grow on one kind of surface, and not on others?
 - Do you see more of one kind of lichen higher up in the trees? Where don’t you see lichen?

5. Pass out lichen keys & help learners as necessary to use the key & look for lichen growth patterns.

- a. Pass out one lichen key to each pair.
- b. Reinforce directions as necessary to identify as many lichens as possible and to focus on observing and looking for patterns related to where lichen grows.
- c. Circulate and trouble shoot.

CONCEPT INVENTION *(assistant holds up sign)*

TALKING ABOUT WHERE LICHEN GROWS

1. Lead a whole group discussion about what pairs discovered:

- a. Gather learners in a circle and ask:
- b. Ask questions such as,

▶ What kinds of surfaces does lichen grow on?

2. Then ask other follow-up questions such as the following, to uncover students’ thinking and to move the discussion along:

- Where did you find or not find lichen, or different kinds of lichen?
- Did you notice any patterns of surfaces different types of lichen grow on?
- Did you find different kinds of lichen growing on or near each other?
- What’s underneath lichen?

3. Ask learners to Turn & Talk about possible explanations for why different

If learners struggle, ask- where did crusty lichen tend to grow? What about shrubby?

TEACHING NOTES

Lichen doesn't always grow in this order in every place, so your students may not be able to observe this succession directly. If that's the case in your area, skip steps 5-9.

types of lichen might grow in some places & not others; explain:

- a. Turn and talk with a neighbor about why lichen might grow in some places but not others.
- b. When you discuss with your partner why lichen might grow in some places and not others, share what makes you think that, while thinking about what lichens need to survive. For example, we know lichens need sunlight, so maybe the amount of sunlight affects where lichen grows.
- c. Remember to use tentative language. We are making scientific explanations based on our observations, but we don't know for sure that our explanations are correct.

4. Give learners about 2-3 minutes to come up with explanations, depending on their interest & engagement.

5. Bring the whole group together & listen to a few explanations:

- a. Ask a few learners to share out their tentative explanations.
- b. Encourage learners to use tentative language and share their evidence and reasoning.
- c. Encourage learners to build on each others' ideas, and ask for agreement and disagreement.

6. Explain that each type of lichen (and any organism) has different environmental conditions it survives best in:

- a. Every organism, including lichen, has a different set of conditions or characteristics that meet its survival needs.
- b. Some places meet the needs of organisms better than others, and they survive better in those places.

7. Explain that lichen often grow on surfaces in this order: crusty, leafy, shrubby, sometimes followed by moss, then other plants.

- a. Scientists have noticed a common pattern in lichen growth.
- b. First, crusty lichen colonizes a bare rock, then leafy grows on top of the crusty lichen, which dies in the area beneath it. Then shrubby lichen grows on top of the leafy lichen. After that, mosses can grow, and sometimes even plants with roots or trees.
- c. As each species grows, it changes the environment a little, changing the conditions there. Lichens trap soil, adding a surface other organisms can grow on.

APPLICATION (*assistant holds up sign*)

8. Tell pairs to search for evidence of this order of lichen growth.

- a. Take about five minutes to do another quick exploration.
- b. This time look for patterns of what is growing on top of what?

9. Bring group together & discuss any new findings:

TEACHING NOTES

- a. Ask,
 - ▶ Did you find examples of lichen growing in this order?
 - ▶ Did you find any examples of lichen growing in a different order?
 - ▶ Did you find anything new or surprising.
- b. Listen to a few responses and ask follow-up questions to probe thinking.

WRAPPING UP

1. **Encourage learners to keep looking for lichen on different surfaces (rocks, roads, trees, fences, sticks, etc), & to notice patterns.**
 - a. If you start to pay attention to lichen, you'll start to see it everywhere.
 - b. Try to notice patterns relating to what surfaces lichen grows on, where it is found, and where different types of lichen grow in relation to one another.
 - c. If you find a branch that's fallen from high in a tree, you can see what lichen growth at the tops of trees is like, and compare it with growth of lower branches or on the trunk.

REFLECTION *(assistant holds up sign)*

2. **Walk & Talk: Reflect on Learning.**

- ▶ What did you do today that helped you learn about lichen?

Debriefing the Learning Cycle Activity

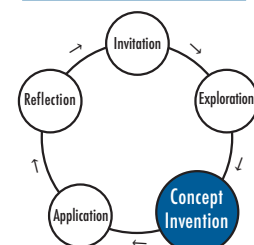
1. **As you return back indoors, continue the *Walk & Talk* with some of the following adult-level reflection questions:**
 - Choose from the following questions to stimulate discussion as seems appropriate:
 - ▶ How does this learning cycle-based experience with lichen compare with the short lichen experience modeled at the beginning of this session?
 - ▶ How did the flow of the activity support learning? How does it compare to other field activities you've seen or taught?
 - ▶ What were the effects of exploring and discovering the different lichens before you were told about the different names?
 - ▶ At what points during the activity were you making meaning or inventing concepts?
2. **Lead a whole group discussion to debrief how the modeled activity supported learning:**
 - a. Ask,
 - ▶ How did the flow of this activity support learning? What did you discuss with your partners?

The student activity write-up has two additional—and optional—sections that are removed here for the sake of time (an investigation about air quality and a debate about moss).

YOU ARE HERE:



25 minutes



Choose 2-3 questions you think your staff will get the most out of, based on previous conversations, questions, and challenges that have already come up. If you have a long walk back to your indoor space or plenty of time, you might ask all the questions.

TEACHING NOTES

This conversation often delves into the pros and cons of withholding and giving information. Read the background section for an anecdote about instructors experimenting with extremes of introducing content. It might be a useful story to share with your instructors, as you encourage them to play with extremes and see what works for them.

Refer to the background section of this session to read more about how people learn, which will help you explain it here to your staff. If your staff seem particularly interested or challenged by some of these ideas, the BEETLES Professional Learning Session, *Constructing Understanding*, delves more thoroughly with how people learn, and works great as a follow-up session to *Teaching & Learning*.

b. Listen to responses and ask for follow-up explanations.

3. Bring up any of the following benefits of learning cycle-based curriculum if participants haven't already brought them up:

- Learner-centered
- More engaging for students
- Experientially-based
- Accesses and builds on prior knowledge
- Opportunities for struggling with ideas
- Learners are given choices and responsibilities in the learning experience
- Sequence matches the way people tend to learn

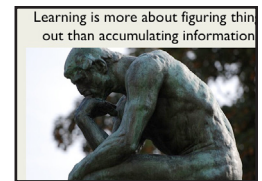
4. Show slide 8: *Deep learning involves challenge & meaning-making. Explain why it's important to provide opportunities for students to struggle with challenges for meaning-making:*



Slide 8

- a. As learners, we thrive on challenges.
- b. The heart of the learning cycle is providing challenges for learners to become curious about and struggle to make sense of discoveries, explorations, and phenomena.
- c. If students are “spoon-fed” information, or are memorizing a “canned” definition without any challenge, there probably isn’t much meaning-making or deep learning going on.

5. Show slide 9: *Learning is more about figuring things out than accumulating information. Explain:*



Slide 9

- a. The key is some kind of learner engagement with questions and ideas, while trying to explain what’s going on, and making connections.
- b. If you are struggling with ideas during this session, that’s probably a good sign of your own deep learning!
- c. In order to really start understanding the Learning Cycle, instructors need the challenge of beginning to apply it by designing activities and trail experiences, with lots of conversations, feedback, and reflection.

6. Explain that the Learning Cycle helps make activities inclusive and effective for all students:

- a. By paying attention to phases of learning and structuring learning experiences around them, more learners benefit.
- b. The Learning Cycle helps create effective and inclusive learning environments for diverse learners.
- c. The Learning Cycle can also address some tendencies toward less effective instructional practices, like falling into a habit of lecturing or not asking meaningful questions.

7. Explain that when applying the learning cycle to your teaching, there are a few keys to doing it successfully.

- Before you start thinking about how to apply the learning cycle to your instruction, here are a few important ideas.

8. Show slide 10: *Keys to Using the Learning Cycle: It's Flexible!.* Explain that the learning cycle is flexible and should be used flexibly:

- The learning cycle should not be seen as rigid or mechanical steps—people and learning are gloriously complex.
- For example, during exploration, learners often begin to invent concepts.
- Some level of exploration, concept invention, application, and reflection can happen during any point in a learning experience.
- All phases don't always take place during an activity. For example, some activities are purely the Invitation phase.
- Effective activities don't always move neatly through the phases. They are sometimes messier, bouncing back and forth, and with overlap between phases.



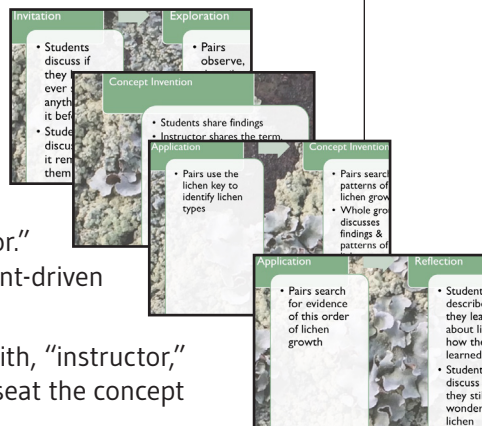
Slide 10

9. Let's reflect on how the steps of the model activity match up with phases of the learning cycle:

- The model activity was an example of how activities can be designed—using the learning cycle—to create effective learning experiences for students.
- Let's look at how different parts of the activity match up with phases of the learning cycle.

10. Show slides 11-14: *The Learning Cycle in Lichen Exploration.* Move through the next 3 slides, giving participants plenty of time to read and process each one.

- When on slide 12, point out that some of the concept inventions begin with the word, "students," and some with "instructor." Those beginning with "students" are student-driven concept invention.
- Remind them that even those that begin with, "instructor," must be invented by each student as they seat the concept within their unique brain.



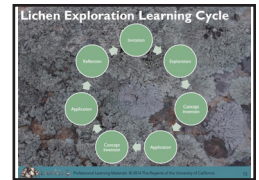
Slide 14

Differing Opinions? Different instructors might break down an activity into the Learning Cycle in different ways. If your participants are confused by or disagree with how the activity is matched up with the Learning Cycle, you may choose to either discuss their ideas or simply acknowledge the difference of opinion and move on. As instructors become more practiced, their sophistication in applying the Learning Cycle to their teaching will grow.

TEACHING NOTES

11. Show slide 15: *Lichen Exploration Learning Cycle*. Summarize the flexible use of the learning cycle in this activity; explain:

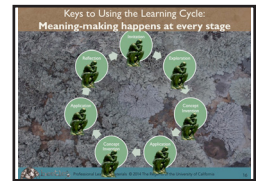
- As you can see, in this activity the learning cycle was used flexibly.
- As is often the case, it did not move through the five phases in the exact order.



Slide 15

12. Show slide 16: *Using the Learning Cycle: Meaning-making happens at every stage*. Explain that:

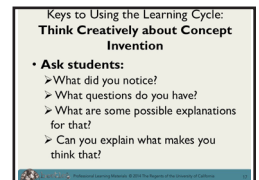
- Meaning making happens for learners at every phase of the learning cycle.
- You want learners continually asking: "I wonder if this is what's going on here?" "Maybe it can be explained like this..."
- The Learning Cycle should be about the learners' experience, not the instructors'.
- Some students can be experiencing different phases of the learning cycle at the same time. For example, one student might be making connections and inventing concepts while another student might be reflecting on their learning.



Slide 16

13. Show slide 17: *Keys to using the Learning cycle: Think creatively about concept invention*. Explain:

- Concept invention can be a challenging phase to guide.
- It's important to think about how to guide students in concept invention. What are their thoughts about the topic? What are they struggling with? How are their ideas evolving? What should the instructor share, when should it be shared, and how should discussion of students' ideas about the topic be guided?
- It can be challenging to come up with engaging questions for students to actively struggle with to test their ideas.



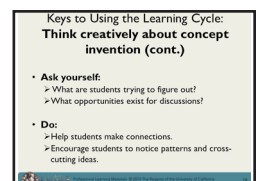
Slide 17

14. Share the following questions to help students with concept invention:

- Ask students: What did you notice? What questions do you have? What are some possible explanations for that? Can you explain what makes you think that?

15. Show slide 18: *Keys to Using the Learning Cycle: Think creatively about concept invention (cont.)*. Explain: Share the following suggestions to help students with concept invention:

- Ask yourself: What are students trying to figure out right now? Is there an opportunity for discussion? Am I asking learners to memorize something or figuring something out?



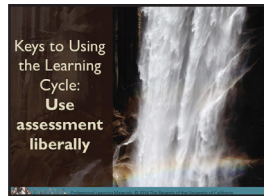
Slide 18



- b. Try to help students make connections to what they already know. This is where an instructors' understanding of common misconceptions is particularly useful.
- c. Encourage students to notice patterns and crosscutting ideas that help them make sense of concepts and ideas.

16. Show slide 19: Keys to using the Learning Cycle: Use assessment liberally. Explain:

- a. Assessment can happen at every phase for instructors.
- b. Instructors should continually be asking themselves: "What are the learners' ideas about the topic now?" "What are they thinking?" "What might they benefit from next?"
- c. Use this information to inform how you conduct the rest of the cycle of your instruction.

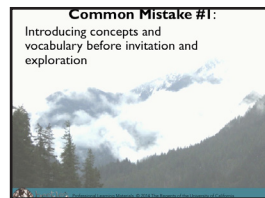


Slide 19

17. Explain that these Learning Cycle tips go hand-in-hand with some common mistakes.

18. Show slide 20: Common Mistake #1. Explain the value of introducing concepts and vocabulary after invitation and exploration:

- a. It's more effective to learn content after you've become curious about something, and have a desire for more understanding.
- b. Concepts and vocabulary are often introduced before students have thought about or explored a topic. Students may be memorizing words and concepts they aren't yet interested in and don't understand.
- c. It's more useful to learn a word when you have a concept to attach it to, which is often (but not always!) *after* exploration.



Slide 20

19. Lead a short discussion about exceptions to introducing vocabulary and content after exploration:

- a. Ask,
 - ▶ When might it be appropriate to introduce vocabulary before exploration?
- b. Listen to their ideas.
- c. Explain: Although in the BEETLES Lichen activity, the decision was made to introduce the word "lichen" after exploration, a thoughtful instructor might alternatively decide to introduce it before, because, in this case, students do have a "thing" to attach the name to right away.

20. Explain why it's important to resist the urge to tell too much, too soon.

- a. As field instructors, we have a lot of knowledge about the ecosystems we're exploring with students, but should resist the urge to share everything we know.

TEACHING NOTES

Common Misconceptions. Many people have done research on common student misconceptions in science, and this research is readily available on the internet. Encourage instructors to research misconceptions of a certain topic before teaching it.

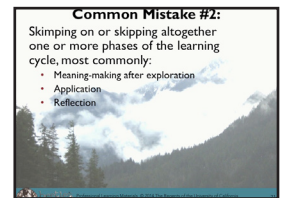
Assessing. Use the BEETLES *Assessing for Learning* session to take a deeper dive into the different types of assessments and how to best use them.

TEACHING NOTES

- b. Even though we're excited about sharing information with students, it doesn't really serve learners if we aren't thoughtful about how we craft the entire learning experience.
- c. This includes thinking about how much content to share, and when to share it, to be most effective.

21. Show slide 21: Common Mistake #2: Explain that it's common for instructors to skip phases:

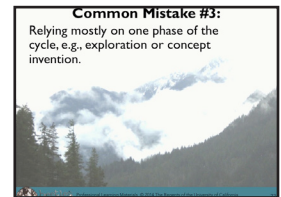
- a. Often, when instructors run out of time, they skip a phase of the learning cycle.
- b. Meaning-making after exploration, true application with a new context for learners to apply their new knowledge, and reflection are the most commonly skipped phases.
- c. These phases are often skipped in order to focus on delivering content.
- d. The research about learning is clear, though, that simply delivering content is not enough. Learners need these other phases to really integrate a new idea.



Slide 21

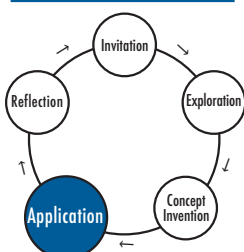
22. Show slide 22: Common Mistake #3: Explain that some instructors sometimes focus only on one phase:

- a. Some instructors mostly focus on just one or two phases.
- b. It's probably most common for instructors to focus on concept invention (or concept delivery!), sometimes referred to as "drag and brag," "concept dumping," or "fact-vomiting."
- c. It's natural for instructors to fall back on how they were taught, especially when under stress.
- d. As students, many of us have mostly had content-delivery-style teaching, and may tend to fall back on that, even if we are making it "fun content."
- e. Alternatively, some instructors over-compensate by mostly staying in the exploration phase, with very little concept invention, etc.
- f. Focusing too much on exploration can result in neglecting or rushing the important meaning-making that exploration can lead towards.



Slide 22

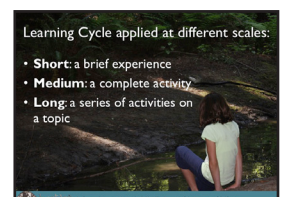
YOU ARE HERE:



← Designing Field Experiences

1. Show slide 23: Learning Cycle can be applied at different scales. Explain how instructors sometimes struggle with how to apply the learning cycle:

- a. Knowing and understanding nuances of phases of the Learning Cycle is only one step.
- b. Versions of the Learning Cycle have spread widely, but often are not reflected in instructional experiences.



Slide 23

- c. The real challenge (and reward) is the next step of **applying** it to your instruction.
- d. You can use the learning cycle to increase effectiveness of different lengths of instructional episodes: Short, Medium, & Long.
- e. You just experienced a medium-length learning cycle field activity (Lichen Exploration).
- f. Here's a skit that is an example of a short-length learning cycle-based experience.

2. Show slide 24: Short Learning Cycle. Choose 4 volunteers to read the script to model how the Learning Cycle can be applied to a short experience with a found organism.

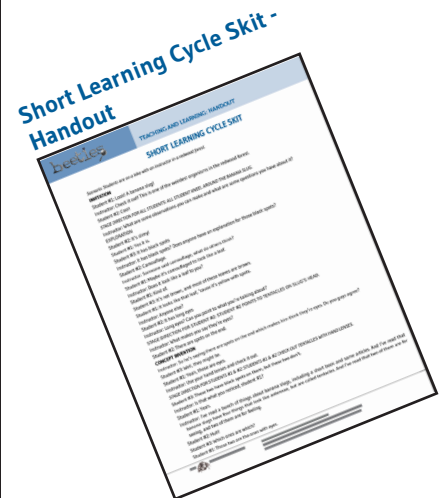


Slide 24

- a. Explain: This script is from an actual learning cycle-based experience with students and a found organism, though it has been shortened.
- b. Pass out scripts to 4 volunteers. Keep one for yourself and one for your co-presenter.
- c. Either use a prop, like a pen, to represent the banana slug, or have the slug be imaginary.
- d. Tell your co-presenter to hold up the learning cycle signs prominently during the phases marked in the script.
- e. Tell your volunteers to begin reading nice and loud.

3. Provide helpful hints for leading this type of shorter investigation and explain:

- a. For short learning cycles with exciting found organisms, the organisms often (but not always) provide their own engagement for students.
- b. The engagement part of invitation often just happens, but enthusiastic adults can help it happen.
- c. Usually it's best to get students immediately making observations. Hold off on asking them to make connections right away.
- d. Resist telling too much information too soon, and only introduce it after exploration has occurred.
- e. What's the right amount of content? It depends! Some general guidelines:
 - If students can figure something out with their own observations, don't tell it to them.
 - Choose 1 or 2 points that are interesting and relate to their observations, and relevant to content topics of your program.
 - Share information you think will stimulate further investigation and curiosity
 - Don't share everything you know about it!

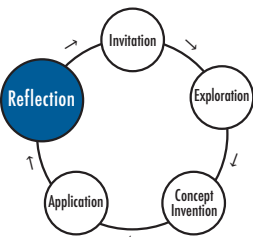


TEACHING NOTES

Applying the Learning Cycle Lens - Handout



YOU ARE HERE:



Read the background section for more information about how we designed this professional learning session with the learning cycle in mind.

4. Explain that pairs will plan a short learning cycle-based experience:

- That was one short learning cycle example. You might have a bunch of short learning cycle experiences during a field program.
- Now you'll try your hand at applying a learning cycle approach to a short experience.
- In pairs, choose an organism (or interesting object), common at your location, that can captivate a whole group's attention, and that you know some interesting content about.
- Map out what you might say and do as instructors to guide the experience to be learning cycle-based.
- You can do more than one, if you have time, including one that you don't know content about, in which case you can focus more on questions you might ask.

5. Pass out the handout *Applying the Learning Cycle Lens to Outdoor Instruction*, which they use to plan short learning cycle-based experiences:

- Pass out a copy of the handout.
- Explain: For now, you should look only at the section titled, Short: Quick Learning Cycle With Exciting Finds.
- Tell them to begin. Circulate and help out as needed.
- After ~ 15 minutes, get the whole groups' attention.

6. Ask a few participants to share their short cycle plans, and make arrangements to have them read one another's.

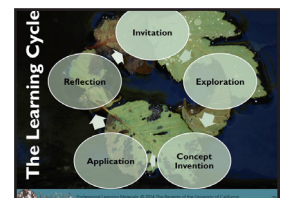
- Ask a few participants to very briefly (about 1 minute or so) share a short learning cycle-based experience they just planned.
- Decide on a location to collect and leave their short cycle write-ups, so they can later read one another's plans.
- Explain: planning like this is very useful, but it needs to be combined with improvisation in the field, where they will probably need to adapt their plan.

← Wrapping Up

1. Show slide 25: *The Learning Cycle*: Ask participants to match up parts of this session with phases of the Learning Cycle.

- Explain: The entire session you just experienced, like every BEETLES learning activity, was designed with the Learning Cycle in mind.

- ▶ Looking back at the entire session, can you identify the different phases of the learning cycle?



Slide 25



TEACHING NOTES

Follow up with your staff! Your staff likely won't implement the Learning Cycle without your help. Look at the suggested follow-up activity section on page 27 for ideas.

- b. Hold up signs for each phase of the learning cycle one at a time (or ask a helper to), and pause at each phase to ask participants which parts of the session might apply to that phase. Listen to their ideas, which may differ.
- c. Explain: there are different ways to apply and interpret the learning cycle with learning experiences.
- d. Explain: the act of applying the learning cycle to this session, as we just did, was an application too.

2. Show slide 26: *Long Learning Cycle*. Explain that their handout describes how to plan short, medium, and long field experiences:

- a. Entire long field experiences can also be more effective when they're learning cycle-based.
- b. A long learning cycle is an extended field experience, with a bunch of medium and short learning cycles within it. It's a series of experiences and activities, planned to fit into the Learning Cycle model.



Slide 26

- c. There's information in your handout on how to plan short, medium, and long learning cycle-based experiences.

3. Challenge participants to apply the Learning Cycle to instruction. Explain:

- a. Pedagogically focused sessions like this are only useful if, as participants, you apply what you've learned to your instructional practice.
- b. This can be challenging, but very rewarding.
- c. There are lots of opportunities for applying the Learning Cycle.

4. Explain some opportunities for participants to apply the Learning Cycle:

- a. Explain: Make a plan for where you'd like to try using the Learning Cycle, such as:
 - Leading an activity or hike that deliberately includes each phase of the Learning Cycle.
 - Reviewing and editing familiar activities with a Learning Cycle lens, or observing another instructor lead a field experience, and looking for a Learning Cycle progression.
- b. Describe any organized follow-ups you've planned for your staff (See follow-ups below), such as collectively planning an existing long experience, and/or making existing activities more Learning Cycle-based.

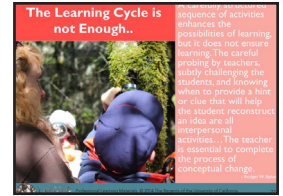
TEACHING NOTES

The 5 Exp's Learning Cycle. The 5 E's are the same phases as the cycle BEETLES uses, but with words chosen partly because they all begin with the letter, "E." But why stop there? Wouldn't it be more cool if they all started with "Ex," or better yet, with "Exp?" Our friend, awesome educator John Erickson did just this. So, here they are. These are the phases of the John Ericksonian 5 Exp's Learning Cycle: Explode, Explore, Explain, Exploit, Expand & Expectorate. Maybe someday someone can come up with the 5 Expl's?!? (No, we're not serious, and yes, this is meant to be silly).

5. Show slide 27: *The Learning Cycle is not Enough.* Give participants time to read the quote.

6. Explain that following Learning Cycle phases is not enough, and instructors need to use social skills:

- It's not enough to follow phases of the Learning Cycle, or any other pedagogical tool, in a formulaic or lockstep way.
- It's got to be done flexibly and with a lot of social awareness on the part of the instructor, paying attention to the students and context.
- The Learning Cycle is an extremely useful tool for thinking about learning activities, but there are other useful tools to consider.



Slide 27

7. Show slide 28: *Reflection for You.* Introduce session reflection. Explain:

- Obviously, this session would not be complete without reflection!
- Reflection depends on you. As with students, the more thoughtfully you reflect on and write about the experience, the more effective a learning experience it will be for you.



Slide 28

8. Participants reflect on the session:

- Give participants a few minutes to quietly reflect on the session, using the prompts on the slide.
- Give them a few minutes to discuss the prompts on the slide with a partner.
- If you have time, ask some participants to share their thoughts with the whole group.

9. Pass out copies of the handout(s): *Brief Background on the Learning Cycle, How Learning Happens: Five Foundational Ideas (optional); explain:*

- These handouts provide some additional information for you to continue reading about and understanding the learning cycle.

How Learning Happens - Handout

TEACHING AND LEARNING: HANDOUT
HOW LEARNING HAPPENS: FIVE FOUNDATIONAL IDEAS

Learning is an active process of acquiring and constructing new understandings, and connections to other knowledge. It is a social process that involves the learner's own experiences, beliefs, and emotions, as well as the influence of others. Learning is a process that is ongoing and continuous, and it is a process that is influenced by many factors, including the learner's own experiences, beliefs, and emotions, as well as the influence of others. Learning is a process that is ongoing and continuous, and it is a process that is influenced by many factors, including the learner's own experiences, beliefs, and emotions, as well as the influence of others.

Brief Background

BRIEF LEARNING CYCLE BACKGROUND

The Learning Cycle is a process that involves the learner's own experiences, beliefs, and emotions, as well as the influence of others. It is a process that is ongoing and continuous, and it is a process that is influenced by many factors, including the learner's own experiences, beliefs, and emotions, as well as the influence of others. The Learning Cycle is a process that involves the learner's own experiences, beliefs, and emotions, as well as the influence of others. It is a process that is ongoing and continuous, and it is a process that is influenced by many factors, including the learner's own experiences, beliefs, and emotions, as well as the influence of others.



APPLYING SESSION TO INSTRUCTION

TEACHING NOTES

The session is not over! A critical phase of learning anything new is application, when the learner takes new knowledge and applies it. The Learning Cycle, in particular, can be challenging to figure out how to apply to instruction. Participants need multiple follow-up opportunities for supported application of the Learning Cycle to different contexts. There is some application included in the session, but with all professional learning for instructors, the rubber meets the road (or trail) when the instructors apply what they've learned to their instruction, and when they keep thinking about it and discussing it with their peers. If you want your instructors to try out "new" activities/approaches, program leader support is crucial. Even if they are excited by new ideas, it is easy for instructors, especially veteran instructors, to keep doing what they have been successfully doing already and not try out new activities/approaches. Below are a variety of follow-up activities and discussions to dig deeper into the topic, and help you facilitate thoughtful implementation.

- **Staff brainstorm of what can be done to encourage incorporation of the learning cycle.** After the session reflection, your staff will have already written ideas they have about implementation into their instruction. You can tap into these, as well as other ideas, through a brainstorm of what they plan to do, and how you can support them in doing it.
- **Discussing Implementation of Lichen Exploration.** Assign your staff to each try Lichen Exploration during their next student program, and write in their journal about how it went. Then, lead them in a discussion of the activity at the end of the program. Here's some suggested questions to focus a reflection or discussion on:
 - **What impact did the activity have on your students' ability to make observations, and to engage with nature?**
 - **What was successful about the activity?**
 - **What might you do differently the next time you lead it and why?**
 - **How did you incorporate the routine into students' other field experiences (e.g., journals, sit spots etc.), and what ideas do you have about incorporating it in the future?**
- **Instructor Observations.** If you do observations of instructors, discuss how you might incorporate elements from this session into the observations.
- **Continuing a discussion.** If there was a topic that came up during discussion that you had to cut off, and it seems like your staff is still interested, set aside some time to continue the discussion.
- **Whole group reflection.** Ask instructors to try out conducting some short Learning Cycle experiences with students, write about their experiences in their journals, then share them in a whole group meeting and discussion.

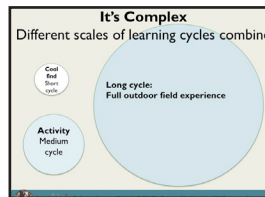
- Have a discussion in pairs and in the whole group of the following questions (or other relevant questions):
 - What might be a Learning Cycle-based approach to studying tide pools? A stream? A pond? What might be a non-learning cycle based approach?
 - What might be a Learning Cycle approach to planning an entire week of program?
 - Which existing activities seem learning cycle-based? Which don't? How might you make an activity more learning cycle-based?
- Have teams of instructors each focus on one student activity, and make it learning cycle-based. Then have them share their plan with others, and try it out with students.
- When your staff has developed some experience in applying the Learning Cycle, ask each to write up a learning cycle-based activity, then share with others for critique and suggestions, then re-write it.
- Lead the following extended application activity, *Planning a Long/ Extended Field Experience (whole hike) Learning Cycle*, on the next page.
- Watch any of the BEETLES Student Activity How-To Videos and discuss how the learning cycle was applied.



Planning a Long/Extended Field Experience (whole hike) Learning Cycle

1. Show slide 1: *It's Complex*. Explain that it's good to start simple with the Learning Cycle, then build up to cycles within cycles.

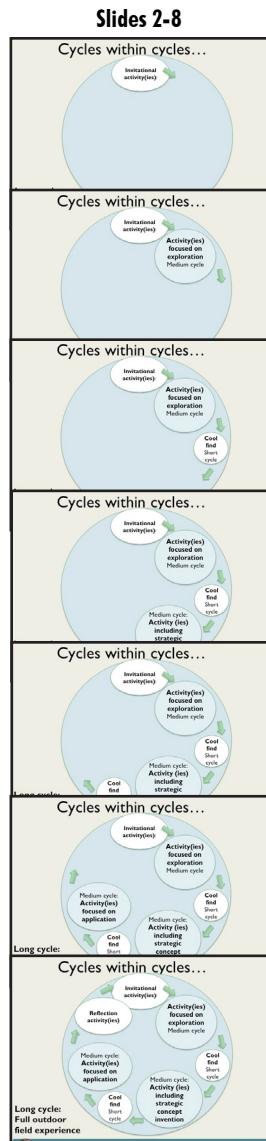
- When you first start applying the Learning Cycle, it's easier to focus on a short cycle, or on a single activity, such as the *Lichen Exploration* activity, or on a cool find.
- But then you can build up to more complex applications.
- There are cycles within cycles.
- During a "long cycle" field experience, such as a hike, each separate activity during the hike may have its own cycle within the greater cycle of the full field experience.



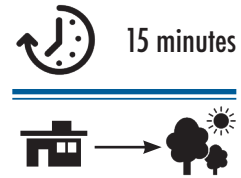
Slide 1

2. Flip through the following slides, explaining the story of how a long learning cycle-based field experience might run:

- Slide 2: You start off with some invitational activities that get students to share their prior knowledge on the topic, and get them engaged.
- Slide 3: Then you do one or more activities. Each one would have its own medium-sized cycle, and would include some concept invention, some application etc., but would be mostly focused on exploration.
- Slide 4: You might run into an interesting find, like an organism, and have a short cycle experience with it.
- Slide 5: At this point, students are probably ready for some deeper concept invention. You might do one or more activities that are full cycles in themselves, but are particularly strong on concept invention.
- Slide 6: Then maybe you run across another interesting find and go through another short cycle experience.
- Slide 7: At this point in the field experience, students are engaged in one or more activities that again, are cycles in themselves, but are strongly focused on students applying what they've learned.
- Slide 8: At the end of the long field experience, they do some kind of reflection activity.



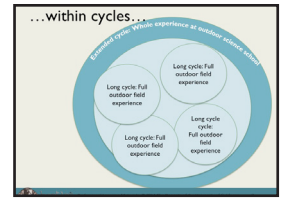
YOU ARE HERE:



Preparation:

- Set up and test in advance the projection system.** Make sure all participants will be able to see items projected during the session. Spend a few minutes reviewing these materials.
- Make sure participants have handouts from main session.** Each pair of participants should have copies of *The Learning Cycle Explained & Applying the Learning Cycle Lens to Outdoor Instruction*.
- Choose a longer field experience you already do at your program to focus on.** Decide on a conceptual focus, e.g., 2-hour creek program focused on ecosystems or 5-hour hike focused on adaptations, that you are interested in redesigning.
- Choose a large flat outdoor area to use for a learning cycle brainstorm.** Alternatively, you can do it indoors with a table for each phase.
- Make Learning Cycle posters.** Get butcher paper or large flip chart paper and at the top of each, write the name of one phase of the learning cycle (one poster will have Invitation on it, one will have Exploration, etc).
- Divide each poster into 2 columns.** Label one column "Activity/Question" and the other, "How it Addresses Goals."
- Prepare the stations.** Each poster will be its own station that participants rotate through. Make sure each station has: a secured poster with nails, stones, or other weights so it doesn't fly away), large sticky notes, broad-tip felt markers. *Note: You can do this without the sticky notes, and have participants write directly on the chart paper, if you have flat backing for each sheet.*

3. Show Slide 9: *Within Cycles*. Explain that the students' entire experience at outdoor science school can also be a big, fat, juicy learning cycle:



Slide 9

- A learning cycle-based overall outdoor science school experience begins with more invitational activities, then moves into exploration-focused activities.
- Then students are ready for deeper concept invention.
- Toward the end of the experience, the focus is on students applying what they've learned to different contexts, such as making connections to their home environment and environmental responsibility.
- The experience ends with reflection back on what they've learned and how they learned it through the whole experience.

4. Show slide 10 *Long Learning Cycle: Extended Field Experience*. Explain the next activity, focusing on a longer field experience:

Long Learning Cycle: Extended Field Experience

- Write activities or questions on sticky notes, and place them on Learning Cycle phases
- Make them learner focused: What are the students doing at this phase?
- Make note of gaps, (e.g., missing "accessing prior knowledge") and attempt to fill gaps by writing ideas.

Slide 10

- If you want a whole field experience/hike to be an effective learning experience, you can use the Learning Cycle to guide your planning.
- Explain: Together we'll be planning a learning cycle-based longer field experience we already do at our program.
- Tell them which program they'll focus on, including conceptual focus.
- Explain: We'll now be thinking of activities that could be used during this field experience.

5. Explain what they'll do at the stations:

- In teams, you'll rotate through a series of posters, each representing a different phase of the learning cycle in this field experience.
- At each poster, you'll brainstorm activities or questions for students to address that phase of learning.
- You should think about:
 - What are the goals of that learning cycle phase?
 - What should students be doing in that phase to support their learning?
 - Which specific activities or questions best support student learning at this phase, and fit into the themed field experience?
 - What might be missing to accomplish the goals of the phase? What activities and/or questions could help here?

6. Take participants outdoors to the learning cycle area. (Can also be done indoors with a table for each phase) and arrange logistics.

- Gather participants in a large flat area.
- Lay out the Learning Cycle phase signs next to pieces of chart paper, along with some large post-its and pens. If necessary, nail or weigh them down so they won't blow away.



- c. Divide the group into five teams to rotate through the phases together, discussing and brainstorming activities and questions at each one.
- 7. Explain the procedure:**
- a. Each group will have about 5 minutes to discuss each phase.
 - b. Each group should write ideas on post-its and stick them to chart paper.
 - c. Groups can also annotate another group's post-its by putting plus signs (+) if they agree and minus signs (–) if they disagree with their ideas.
 - d. There will be time at the end to go back and look at all the phases again, and at the notes of other groups.
- 8. Remind them of the following:**
- a. Consider all activities as part of one extended field experience that helps students understand important ideas related to adaptation (or whatever the main conceptual focus of the experience chosen is).
 - b. What kinds of things should students be doing during the Invitation phase of a field experience? Exploration phase? Concept invention? Application? Reflection?
 - c. At each phase, try to think of: activities you are familiar with and questions you already ask.
 - d. But also think about what goals are *not* being met. Brainstorm new questions that could be posed to students or new activities you think might work, but haven't necessarily been tried or developed.
- 9. Remind them to use the Learning Cycle handouts.**
- a. Use the handouts from the Teaching and Learning session: *Applying the Learning Cycle Lens to Outdoor Instruction* & *The Learning Cycle Explained*.
 - b. On the *Applying the Learning Cycle Lens to Outdoor Instruction* handout, look at the section titled, "Long: Extended Field Experience (whole hike) Learning Cycle."
 - c. When at a poster, such as the invitation poster, you can just read the brief section about the invitation phase to help you think of ideas.
 - d. Do the same for each of the five learning cycle phases.
- 10. Organize the rotation, listen in on conversations, and signal time as groups rotate through each phase.**
- a. Allow ~ five minutes for each group to brainstorm activities for each phase, and tell them the signal for when time runs out.
 - b. Assign a direction for rotation (clockwise makes sense) after completing each phase.
 - c. Listen in on conversations and make sure they are focused on student behaviors and activities that support student learning in each phase. If not, ask questions to help out, such as (at the Invitation station), "It doesn't look like there are many activities or questions that help students access prior knowledge. Can you brainstorm some ideas?"

TEACHING NOTES

Quick discussion. This discussion is just a quick overview while participants can see all the posters together. A more detailed look at an individual poster follows.

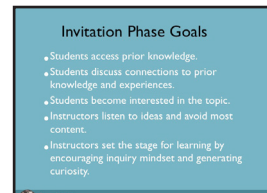
If you have time now, or during a later meeting, you can do a similar debrief of each phase, and make up a chart showing which activities and questions your program has available for each phase—instructors can then use this tool in their program planning.

11. Gather the group together, lead a brief discussion about the results of the brainstorm, and ask:

- Overall, what do you think of the set of activities you laid out? Do they seem to make sense? Why or why not? Do others agree/disagree? Why?
- What's the activity balance? Are there more or less for any phase(s)?
- Return inside.

12. Show slide 11: Invitation Phase Goals. Review the Invitation phase.

- Post the Invitation phase chart paper with the ideas they added to it.
- Lead a discussion focused on the Invitation poster by asking some of the following questions:
 - ▶ *Do these ideas fulfill the goals of this phase of the learning cycle?*
 - ▶ *What goals are not being fulfilled?*
 - ▶ *What's missing?*
 - ▶ *What ideas do you have for filling those gaps?*



Slide 11

LICHEN ACTIVITY STRIPS

Instructions: Make one set per pair of participants in your group. Cut them out into individual strips and put into an envelope or clip together to efficiently handout during the session.



Students discuss what they have discovered or learned about lichen, what helped them learn what they learned, and what questions they still have.

Students listen as the instructor explains how the relationship between fungus and algae helps both organisms survive in their habitat.

Students discuss: Have you ever seen anything like this before? What does it remind you of?

Students use a key to identify three main types of lichen and look at patterns of how lichen grows.

Students spend about ten minutes looking for different kinds of lichen.

Students read the word "lichen" on the white board as the instructor introduces the name of this organism.

Students make explanations for why lichen might grow in some places, but not others.

Students look for evidence of a specific lichen growth pattern.

The instructor shares that scientists have observed that lichen often grow in a certain pattern.

THE LEARNING CYCLE EXPLAINED

Invitation

The learner becomes engaged in the topic and accesses relevant prior knowledge. Without engagement, learning tends to be rote, and less likely to be retained (“shallow and slippery”). Accessing prior knowledge sets context and helps the learner make connections to what they already know, which helps cultivate “deep and sticky” learning.

When planning Invitation phase ask:

- How does it get students interested and engaged in learning about the topic?
- How does it help them access their prior knowledge?

Instructor’s Role:

- Set the stage for learning, set context, create interest, curiosity, focus, and anticipation about topic to be explored
- Offer a question, a challenge, an observation, or an experience, to generate curiosity about exploring the natural world and the topic
- Encourage inquiry mind-set and abilities—inspiring students to make observations, ask questions, and make explanations
- Encourage students to discuss connections with prior knowledge and experiences.
- Listen to student ideas on the topic to learn where they are at, to guide your instruction
- Avoid delivering content until *after* student exploration of “stuff” and ideas.

Exploration

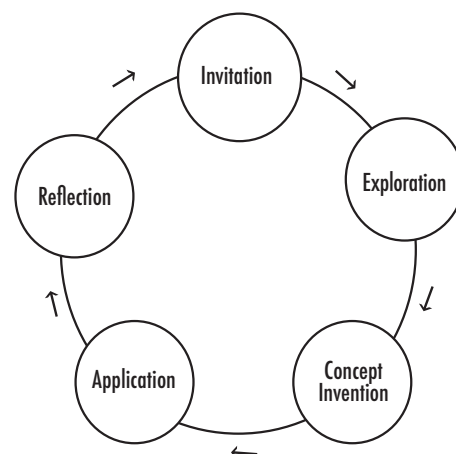
With some independence from instructor, learners engage in open-ended exploration of objects, organisms, or phenomena in the natural world, and/or ideas. Exploration generates curiosity and questions, as well as a struggle to make sense. Exploration also provides a common base of experiences for learners to develop new concepts, skills, and practices. It’s a great opportunity for students to spend time “falling in love” with some aspect of nature.

When planning Exploration phase ask:

- How will learners have experiences that provide observations and discoveries to help them ask questions and answer questions, and make sense of the topic?

Instructor’s Role:

- Encourage students to work together independently of direct instruction from the instructor.
- Provide only as much instruction and information as necessary to set students up for successful independent exploration.
- Observe and listen to students as they interact.
- Ask probing questions to redirect students’ investigations when necessary.
- Provide time for students to puzzle through questions.
- Be an enthusiastic and curious co-investigator.
- Act as a consultant and facilitator for learners.
- Share minimal information—only if you think doing so will increase curiosity and exploration.



Concept Invention

After interest and attention is focused through invitation and exploration, learners make connections and construct new meanings from experiences, often facilitated by an instructor. Ideally, this is largely student-generated, but if there is specific content you want them to understand, this is the time to introduce it. It's crucial to understand that no matter what is "delivered" to them, learners actively generate ideas and concepts, and make sense of the information for themselves. Each learner takes information and fits it into their own conceptual frameworks, and the concepts they walk away with are unique to each individual. What's the right amount of content? It depends! Some general guidelines: 1) If students can figure it out through their own observations, don't tell them; 2) Choose 1 or 2 points that are interesting, related to their observations, and relevant to content topics of your program; 3) Share information you think will stimulate further investigation and curiosity; and 4) Don't share everything you know!

When planning Concept Invention phase ask:

- How will learners be encouraged to struggle with their understanding and negotiate their ideas with others?

Instructor's Role:

- Encourage students to explain ideas, concepts, definitions, and science practices in their own words.
- Ask for evidence, results, and clarification from students, to help guide them to making sense of their experience.
- Provide formal definitions, explanations, and new vocabulary, as necessary, to explain concepts.
- Use students' direct experiences as the basis for explaining concepts.
- Sometimes you have to point out ideas that don't work and help them identify the reasons why.

Application

To truly understand new concepts and ideas, the learner needs to apply them to a different context. Learners apply new knowledge, vocabulary, and skills to solving a problem or meeting a challenge in a new situation, through activity, or through discussion. Learners gain deeper and broader understanding, gather more information, make connections to real-world issues, and develop transferable skills.

When planning Application phase ask:

- How will learners authentically use what they've learned and apply it to a new situation or context?

Instructor's Role:

- Provide opportunities for students to apply vocabulary, definitions, skills, and explanations to new situations or problems.
- Evaluate student progress and understanding and provide feedback.

Reflection

Learners reflect on their learning, compare new ideas to alternative explanations, and extend thinking. Through discussion, quiet thinking, writing, and/or drawing, they make connections and construct new conceptual frameworks. They examine and analyze how they arrived at their current understanding to help them understand how they learned what they learned.

When planning Reflection phase ask:

- How will learners think back on the process for learning to help reinforce their understandings, and make them better learners in the future?

Instructor's Role:

- Prompt students to reflect on activities to help them confront their former ideas and evolve new ones.
- Prompt students to solidify conceptual framework connections.
- Prompt students to help build meta-cognitive (thinking about their own learning) skills.

Lichen Key

<http://beetlesproject.org>

Decide if your lichen most closely resembles one of these three kinds:

Leafy
leafy-shaped,
usually attached
to rock or wood
in just one place



Crusty
flat edges, stuck
to rock or wood
like paint



Shrubby
often like a
beard, hangs
down, looks like
a small bush



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APPLYING THE LEARNING CYCLE LENS TO OUTDOOR INSTRUCTION

The learning cycle can be used to improve learning experiences of all lengths in an outdoor context. The learning cycle can be used to plan an extended (day-long or week-long) field experience. A good trail activity can explode into excellence if it is reworked to be learning cycle-based. If your group encounters organisms or other interesting finds during a hike, you can structure your group's encounter as a productive mini-learning cycle. There are many opportunities for cycles within cycles. To help you make sense of how to use this tool and plan for teaching, we are providing suggestions for applying the learning cycle phases at three different grain-sizes:

Short: Quick Learning Cycles With Exciting Finds

Medium: Individual Field Activity Learning Cycles

Long: Extended Field Experience (whole hike) Learning Cycle

As you begin using a Learning Cycle lens to plan and look at instruction, remember that it's often not neat and tidy. For example, applications don't always immediately follow concept invention, and a single cycle may have a series of back-and-forth phases (i.e., concept invention—application, then back to concept invention—application, and moving to reflection). We recommend that you use the Learning Cycle as a lens and a guide for instructional planning, but avoid being rigid or mechanical about how it is applied.

Short: Quick Learning Cycle With Exciting Finds

Invitation. Interesting organisms and phenomena in nature are engaging for students without gimmicks, especially if students find the object or creature themselves, and if the instructor shows enthusiasm along with the students. First make sure everyone can see the organism(s), (form sitting and standing circles, pass an organism around in a container to make it accessible for everyone, etc.). Move quickly into student-generated observations, questions, connections, and explanations. Avoid providing names and/or facts until after students have observed and explored the organism.

Exploration. Ask questions to encourage observations, questions, connections, and explanations (e.g., What do you notice? What does it make you wonder? What does it remind you of? Have you ever seen anything like that? What might be an explanation for that? How might that feature help it survive? Why do you think it's doing that?). Keep everyone involved by asking questions and facilitating student sharing.

Concept Invention. Point out some things students might not have noticed. Don't share everything you know—share names/facts/ideas that help students to understand or describe what they're seeing and stimulate their curiosity.

Application. Students should have a chance to try to apply a new piece of information they've learned about or figured out for themselves (e.g., "Let's see if that's how this creature moves when we set it back down." "Let's see if it raises those things by its head if we move a finger towards it." "Let's gently test and observe the slug's tentacles to see if two of them really are for touch and two for seeing." "Let's test a snail's tentacles to see if it does the same as the slug." "Do its coloring and shape camouflage it where we found it?").

Reflection. Facilitate a brief pair/share (or whole group discussion) about the experience (e.g., "As you walk with a partner, share interesting observations, and questions you have about the organism you just saw," "Describe what you just observed and what you learned from the observations as if to someone who isn't here."). Or you can have pairs discuss an unanswered question about the organism, e.g., "Discuss whether you think its yellow color camouflages this creature or makes it stand out in its surroundings, and use evidence to support your ideas."

Medium: Individual Trail Activity Learning Cycle

Invitation: If you are about to lead an activity on tracks, spider webs, or whatever else, have students begin making observations and talking with each other about the topic before you officially begin the activity (e.g., “Discuss with a partner what kind of evidence animals might leave behind.” “Point out to a partner any spider webs you see along the trail.”). An efficient way to do this while getting to the main activity site is to provide students with prompts so they can talk with a partner while walking along a trail. If the activity focuses on a concept, such as the food web, get students discussing related questions and accessing prior knowledge. Some examples: “Brainstorm what organisms might live here.” “Discuss the possible connections between organisms in the area, and which ones might eat others,” etc.

Exploration: Exploration is perhaps the most important phase of an activity. It’s when students develop their curiosity (and a positive relationship with nature). Give enough structure, guidance, and equipment so students are on task, know how to find organisms, and can explore the environment safely. Provide some autonomy from the instructor by having students work in pairs or teams. Make sure to model enthusiastic exploration yourself, and encourage any other adults present to do so too—and to support students who may be struggling with their involvement in exploration.

Concept Invention: Make sure the activity begins with invitation and exploration before you share or discuss science concepts with students. Try to encourage students to struggle with ideas and build on their understanding. Remember to primarily focus on helping students *invent concepts for themselves*.

- Ask questions such as, “What did you notice?” “What questions do you have?” “What are some possible explanations for that?” “Can you explain what makes you think that?”
- Try to help them make connections to what they already know.
- Encourage them to notice patterns and cross-cutting ideas that help them make sense of concepts and ideas.

Application: If students have discussed a new idea, become excited about an organism or community, or have learned a new skill, give them opportunities to apply these their new knowledge or skills in a new context. Encourage students to continue making new connections throughout their outdoor experience (e.g., “Find a different organism, and compare it with the one we found earlier.” “Now that you have looked at the adaptations of an animal, do the same with a plant.” “We noticed those fungi were growing on wood, so pay attention as we hike to the surfaces that different fungi are growing on.” “Let’s compare the organisms in a grass land with the ones we found in the forest.”).

Reflection: Try to get students to go beyond simply repeating back facts they have heard—“I learned that raccoons blah, blah”). Instead ask questions such as: “What are some skills you used during the activity?” “Describe a new way of thinking about this that you have.” “What other questions about this do you still have?” “How have your ideas changed about this, and what made them change?”

After the activity, encourage students to think/talk/write about new thoughts, ideas, abilities, and feelings the experience brought up for them. A series of thoughtful *Walk & Talk* questions, a guided *Solo Sit*, or some journal writing time can be effective reflections. Also, try to provide opportunities for students to share their reflections with the whole group.



Long: Extended Field Experience (whole hike) Learning Cycle

Invitation: Provide engagement in the topic, help students access their prior knowledge, and encourage an inquiry mind-set. Other possible goals: help students to learn each other's names, encourage them to break out of their shells and/or become energized, help all students feel included, and reduce anxiety about the outdoors. Give students opportunities to think about and share their prior knowledge on the topic. A series of activities, such as an active name game followed by an inquiry tone-setter (such as *I Notice, I Wonder, It Reminds Me Of*), and a series of thematic *Walk & Talk* questions can help achieve these goals. Try to avoid much content introduction. Excite students by sharing the theme of the field experience, but don't go deeply into it yet. Be patient with your students in terms of their curiosity, interest in exploration, and participation in discussion. Use this time to get to know your group. Work up to your content goals later in the field experience.

Exploration: Don't avoid content altogether, but avoid content-heavy activities toward the beginning of the field experience. Instead, focus on activities/routines that are mostly exploration and inquiry-based. Students will be more open to learning and discussing concepts later in the experience if they have exploration time first. This is a great time for activities that lead to "Inquiry Fever."

Concept Invention: Focus on activities or questions that introduce content related to your theme. In order to ensure that students are making meaning of the topic, make sure each full-on concept invention activity is learning cycle-based in and of itself.

Application: This is the time for students to actively try to apply the big ideas of your field experience in some way. For example: "Choose an organism, make observations, and try to figure out which body structures and behaviors are adaptations. Then be prepared to share your findings with other students."

Reflection: A series of thoughtful *Walk & Talk* questions, a guided *Solo Sit*, or journal writing time can provide effective reflections, depending on the mood of the group. If students share their reflections with the group, this can encourage deeper reflections from everyone. For example: "What are some things you got better at during the field experience/hike?" "What are some discoveries you and your classmates made?" "Describe a new way of thinking about this that you have come up with." "What other questions about this do you still have?" "How have your ideas changed about this, and what made them change?" "What helped you to learn today?"

BRIEF LEARNING CYCLE BACKGROUND

- People tend to approach experiences that lead to useful and enduring knowledge in similar ways.
- The Learning Cycle is an instructional design model developed to organize educational experiences to be consistent with what is known about how people learn.
- It has roots in learning theory that was developed in the early 1900s, reflected in the work of Dewey, Vygotsky, Montessori, Piaget, and others.
- It was formalized into the Learning Cycle by education researchers and scientists (Atkin, J.M. & Karplus, R. 1962) who conducted a comparison study of Learning Cycle and non-learning cycle-based instruction that found learning cycle-based instruction to be more effective. It has been said of Robert Karplus: "His work in science education was driven by his fascination with the responses of children to nature. He enjoyed the act of discovery and wanted science curricula to make that joy available to others." (Fuller, 2003)
- The Learning Cycle is supported by ongoing research. It has been transformed and deepened through educational and cognitive scientist research.
- Research has found that a Learning Cycle approach can result in greater achievement in science, better retention of concepts, improved attitudes toward science and science learning, and improved reasoning ability and process skills than traditional instructional approaches (see for example: Abraham & Renner, 1986; Chi, 2008; Duran, et al., 20011; Ivins, 1986; McComas III, 1992; Raghubir, 1979; Renner, Abraham & Birnie, 1985).
- The Learning Cycle has now gained wide acceptance as a useful way to design educational experiences based on how people learn. It has been expanded and utilized in other fields. Many different educators and researchers have designed different Learning Cycles, with various names, descriptions and phases, like the 5 E's, Flow Learning, Coyote Mentoring Natural Cycle, or Experiential Learning. Some of these just have different terms for phases, and others have different intentions behind phases, but at the core, are all influenced by similar research/observations.
- The terms and phases in the Learning Cycle used by BEETLES, and other Lawrence Hall of Science programs, were chosen to reflect current research. The book *How People Learn: Brain, Mind, Experience, and School* is an important summation as of the dawn of the 21st century, even as new brain science, educational research, and the ubiquitous presence of technology in so many aspects of life and education continue to break new ground. A free PDF of *How People Learn* is available online from the National Academies Press at <http://www.nap.edu/catalog/9853.html>

The Learning Cycle we present is one model that can be used to represent phases that support learning. It's of course not the only way! Nor should not be seen as a rigid or mechanical model—people and their learning processes are gloriously complex, and there is no automatic order or sequence in which these phases must take place. That said, a learning cycle approach has been shown to be a solid pedagogical foundation in designing meaningful and effective learning experiences.



SHORT LEARNING CYCLE SKIT

Scenario: Students are on a hike with an instructor in a redwood forest.

Cast: 1 instructor and 3 students

Note: Stage directions are in parenthesis and italics

INVITATION

Student #1: Look! A banana slug!

Instructor: Check it out! This is one of the weirdest organisms in the redwood forest.

Student #2: Cool!

(All students kneel around the banana slug.)

Instructor: What are some observations you can make about it?

EXPLORATION

Student #2: It's slimy!

Student #1: Yes it is.

Student #3: It has black spots

Instructor: It has black spots? Does anyone have an explanation for those black spots?

Student #2: Camouflage.

Instructor: Someone said camouflage, what do others think?

Student #1: Maybe it's camouflaged to look like a leaf.

Instructor: Does it look like a leaf to you?

Student #1: Kind of.

Student #3: It's not brown, and most of these leaves are brown.

Student #1: It looks like that leaf, 'cause it's yellow with spots.

Instructor: Anyone else?

Student #2: It has long eyes

Instructor: Long eyes? Can you point to what you're talking about?

(Student #2 points to tentacles on slug's head.)

Instructor: What makes you say they're eyes?

Student #2: There are spots on the end.

CONCEPT INVENTION

Instructor: So he's saying there are spots on the end which makes him think they're eyes. Do you guys agree?

Student #3: Well, they might be.

Student #1: Yeah, those are eyes.

Instructor: Use your hand lenses and check it out.

Student #3: These two have black spots on them, but these two don't.

Instructor: Is that what you noticed, student #1?

Student #1: Yeah.

Instructor: I've read a bunch of things about banana slugs, including a short book and some articles. And I've read that banana slugs have four things that look like antennae, but are called tentacles. And I've read that two of them are for seeing, and two of them are for feeling.

Student #2: Huh!

Student #3: Which ones are which?

Student #1: Those two are the ones with eyes.

Instructor: Which two?

Student #1: The ones with black spots.

APPLICATION

Instructor: Can anyone think of any quick little investigations we can do with the slug that won't harm it, but will help us test to see if those ones are for seeing, and the others are for feeling?

Student #3: We could move a finger toward them, and see if they react.

Student #1: Yeah!

Instructor: OK, why don't you try doing it, but make sure you don't actually touch the tentacles.

(STUDENT #3 moves finger near banana slugs)

Student #2: Whoa!

Student #1: Those two are the eyes!

Instructor: Which two?

Student #1: The ones with the black dots. They like curled in and got smaller, but the other ones didn't.

Instructor: Student #2, can you try doing the same test, and see what happens?

(Student #2 moves finger near banana slugs to do the same test)

Student #2: Yep, those are them.

Student #3: It's like they're shrinking.

Application (continued)

Instructor: Has anyone else seen banana slugs before or heard anything about banana slugs?

Student #2: Oh, yeah, I think raccoons eat them, but they have to roll it in dirt first.

Instructor: You heard that? What's your source?

Student #2: I was at a camp and the counselor said it.

Instructor: So student #2 heard from a counselor that raccoons can eat them if they roll them in dirt.

Student #2: Yeah, because they have this covering and its like protective and it will like numb up anything that touches it.

REFLECTION

Instructor: O.K., we're going to move along the trail now. Everyone be careful not to step on our little slug buddy.

Student #3: Big slug buddy!

Instructor: Yeah, it's pretty big for a slug. Everybody grab a partner near you, and take turns telling each other everything you can think of that you observed and learned about the slug, just now. And share questions you still have about banana slugs.

(Students #1 and #2 partner together; student #3 partners with the instructor. Students #1 & #3 both start talking at the same time.)

Student #1: I learned that they're slimy, and they have antennae. I mean, tentacles.

Student #3: I learned that they camouflage with black spots. And they have tiny black spots on the end of their thingies that are like eyes for seeing. And you can see it, cause they turn in when you get close to them, but the other ones don't...

Student #2: And two of them are for seeing and two are for touching.

Student #1: Yeah, and the seeing ones have black eyes.

Student #2: Black dots on the ends that are eyes...

HOW LEARNING HAPPENS: FIVE FOUNDATIONAL IDEAS

The Five Foundational Ideas on Learning is a framework developed by Lynn Uyen Tran and Catherine Halversen for *Reflecting on Practice: A professional learning program for informal science educators* (Lawrence Hall of Science, University of California Berkeley). For more information, please go to reflectingonpractice.org or contact lynn.tran@berkeley.edu.

1. Learning is an active process of engaging and manipulating objects, experiences, and conversations in order to construct a mental picture of the world (Dewey, 1938; Piaget, 1964; Vygotsky, 1986) Learners build knowledge as they explore the world around them, observe and interact with phenomena, converse and engage with others, struggle to make explanations, and make connections between new ideas and prior understandings.
2. Learning builds on prior knowledge, and involves enriching, building on, and changing existing mental models, where “one’s knowledge base is a scaffold that supports the construction of all future learning” (Alexander, 1986).
3. Learning that is situated in an authentic context, not in the abstract, provides learners with the opportunity to engage with specific ideas and concepts on a need-to-know or want-to-know basis (Greeno, 2006; Kolodner, 2006) and leads to deeper understanding.
4. Learning occurs in a complex social environment, and thus should not be limited to being examined or perceived as something that happens on an individual level. Instead, it is necessary to think of learning as a social activity involving people, the things they use, the words they speak, the cultural context they’re in, and the actions they take (Bransford et al., 2006; Rogoff, 1998); knowledge is built by members in the activity (Scardamalia & Bereiter, 2006).
5. Learning complex ideas deeply involves considerable mental effort and persistence, which requires learners’ motivation and cognitive engagement to be sustained, i.e., for learners to be engaged in, or actively committed to, the experience, task, or activity (Fredricks, Blumenfeld, & Paris, 2004). Engagement is multi-faceted and malleable, and affected by interactions between individuals and the context.

note: For full citations, see the References on page 47-48.

BACKGROUND INFORMATION FOR PRESENTERS

There has been much research, particularly in the past 15 years, concerning the processes involved in how people learn. An awareness of some of the main findings from this research is useful to anyone involved in designing or presenting educational activities. This session is designed to open the door on the topic of how people learn, and suggest ways to craft learning experiences that reflect this understanding. It's clear from research that learning is not about passive transmission from instructor to student. If an instructor tells (or even chants or acts out) a piece of information, the information is not passed directly from the instructor's brain to the student's. The instructor must translate an idea into language, then the student interprets that communication. The student may then just memorize it, or actively compare or combine the new idea with their prior ideas. Our brains are designed to interpret new information based on previous experiences and ideas we've encountered. Ideas can be altered through this process. The understanding a student walks away with is not necessarily the same idea the instructor has presented, and may even be radically different or inaccurate. In order to create lasting conceptual understandings, students need active experiences, such as discussing with peers, interacting with the natural world, and testing their ideas and interpretations.

The Learning Cycle

The Learning Cycle model introduced in this session has been developed by researchers and educators and refined and deepened in recent years by newer findings in neuroscience and cognitive psychology. The model is built upon what is known about how to support learning, and takes place in specific phases—invitation, exploration, concept invention, application, and reflection—which eventually lead the learner to begin the cycle once again. This model for instruction also takes into account the learner's prior understandings and recognizes their need for firsthand experiences. Lessons or activities designed according to the Learning Cycle are learner-centered, access and connect to learners' prior knowledge, provoke questions and explanations from the learners, provide opportunities for learners to talk about their ideas with peers and those with more knowledge, and consequently enable the learner to conceptually integrate and apply new ideas and information. All the learning activities in the BEETLES materials have been designed with the phases of the Learning Cycle in mind. Familiarity with this instructional model can help participants begin to understand how students can benefit from carefully designed activity plans, and supports the instructor's ability to make thoughtful instructional decisions while leading science activities.

While its roots go back to forerunners such as Dewey, Vygotsky, Bruner, Piaget, and others, the contemporary idea of the Learning Cycle grew out of a breakthrough in science education in the early 1960s, as scientists and educators wrestled with more effective ways to help students acquire, retain, and apply important concepts. In 1962 Robert Karplus and J. Myron Atkin described a three-phase cycle: exploration, invention, and discovery, termed the "guided discovery" approach to learning. The model was further developed in the 1970s as it was applied toward developing more effective science activities for the elementary classroom. The research on the effectiveness of the Learning Cycle has been quite extensive, (for a summary see Lawson, Abraham, & Renner, 1989; Lawson, 1995). The Learning Cycle has been instrumental in helping curriculum developers design materials and in assisting teachers in presenting educational experiences that are consistent with what is known about how people learn. Other learning cycle models have evolved including similar phases, although they may be named differently. Some of these instructional models maintain the three main stages of the Atkin/Karplus model, others involve four or more phases such as the 5 Es Model, which was developed by Roger Bybee in the 1980s (Bybee, *Achieving Scientific Literacy*, 1997). Some other variations on "learning cycles" include:

- **5 E's:** Engagement, Exploration, Explanation, Elaboration, and Evaluation
- **Flow Learning:** Awaken Enthusiasm, Focus Attention, Direct Experience, Share Inspiration
- **Coyote Mentoring Natural Cycle:** Inspire, Activate, Focus, Take a Break, Gather and Share, Reflect, Integrate, Open and Close – Listen for What's Next
- **Experiential Learning:** Concrete experience, Reflective observation, Abstract conceptualization, and Active experimentation



These learning cycle-based instructional models share a common vision of how learning takes place and are grounded in a constructivist theory of teaching and learning. Constructivist ideas rely on the assumption that learners must internalize and transform information for themselves and with others in order to create deeper understandings. As summarized in the National Research Council's 2000 report *How People Learn: Brain, Mind, Experience, and School*, the most recent cognitive research supports the view that learners are active agents in their own construction of knowledge and delineates three key findings that relate closely to phases of the Learning Cycle.

- **Key Finding #1 states, "Students come to the classroom with preconceptions about how the world works. If their initial understanding is not engaged, they may fail to grasp the new concepts and information, or they may learn them for purposes of a test but revert to their preconceptions outside the classroom."** This finding explains why the Invitation phase of the Learning Cycle is so crucial and why teachers should take the time to uncover and try to understand students' prior knowledge of a subject before beginning an instructional sequence. The Invitation phase often provides a significant motivating factor for learning science by engendering student interest and generating a need to know and understand. Learning builds on prior knowledge, and involves enriching, building on, and changing existing understanding, where prior knowledge is "a scaffold that supports the construction of all future learning." Prior knowledge and experiences direct how new information and knowledge is processed and organized in working memory. If prior knowledge is organized poorly or ineffectively, new information may or may not fit. This situation, in turn, also strains working memory to process and organize new information into existing mental models.
- **Key Finding #2 states, "To develop competence in an area of inquiry, students must (a) have a deep foundation of factual knowledge, (b) understand facts and ideas in the context of a conceptual framework, and (c) organize knowledge in ways that facilitate retrieval and application."** This finding highlights the importance of the Exploration, Concept Invention, and Application phases of the Learning Cycle. Students should have a variety of opportunities to explore various scientific phenomena and data sets to acquire factual knowledge, and must also consider how this new information fits into larger conceptual frameworks. In this way, the knowledge of facts and an understanding of overarching conceptual ideas both play a significant role in helping students learn about science. Students also need multiple opportunities to apply what they've learned and "test out" their new conceptual frameworks in different situations. According to current research, the ability to easily access and transfer knowledge and understanding is key to developing expert knowledge in a discipline.
- **Key Finding #3 states: "A metacognitive approach to instruction can help students learn to take control of their own learning by defining learning goals and monitoring their progress in achieving them."** Meta-cognition involves learners in considering their learning path and taking note of experiences and ideas that have led to their personal understanding. This type of internal self-monitoring exemplifies the Reflection phase. As students acquire scientific knowledge and understandings, it's critical that they spend time discussing how they arrived at these concepts and explain their thinking. Through reflecting on their learning processes, they develop the ability to think flexibly and acquire new understanding as needed.

It's important to be mindful of the fact that the Learning Cycle we present is one model that can be used to represent, organize, and categorize main phases that support learning. It's not the only way to conceptualize learning. It should not be seen as a rigid or mechanical model—people and their learning processes are gloriously complex, and there is no automatic order or sequence in which these phases must take place. That said, the Learning Cycle model of instruction can be powerful and enormously helpful in stimulating thinking about how people learn and in designing lessons that succeed in conveying concepts to students in meaningful and effective ways.

Sometimes, the Learning Cycle model is conflated with Howard Gardner's work on Multiple Intelligences or other writing about learning styles. Research on learning styles shows that different individuals often have different preferences for teaching approaches. These preferences may have to do with identified learning styles or with their exposure to various teaching approaches in the past. Formerly, it was thought that one's preferred learning style(s) was the primary way one could learn. However, the latest research on cognition synthesized by Reiner and Willingham (2010) has not supported the idea that individual learners learn better from a particular style of teaching. Their findings support the idea that everyone learns through a variety of different teaching approaches, despite their preference or learning style. Instead, the

research suggests that learners learn best through the opportunity to engage with the material through multiple modalities—reading, writing, talking, doing, etc., structured within the Learning Cycle instructional model.

The Learning Cycle and this Session

Of course, this professional learning session was also designed with the learning cycle in mind:

- **Invitation:** An initial question was posed at the beginning of the session, “How can we use what we know about how people learn to create effective learning experiences?” Participants experienced the Freddy Fungus/Alice Algae story, and discussed the pros and cons of that approach for learners. Participants accessed their prior knowledge as they discussed and shared an example of when they learned something well, and what made it an effective experience
- **Exploration:** In small groups, participants struggled with how to sequence a series of steps of a lichen activity, while discussing the reasoning for their sequence.
- **Concept Invention:** Each team read about and then in the whole group explained the phases of the learning cycle, then discussed which steps of the lichen activity might match up with the goals of their assigned phase. Then the instructor added more information about the learning cycle model.
- **Application:** Participants experienced a model learning cycle-based student activity. The group discussed how the learning cycle applies to the structure of the student model activity and the whole session. Groups came up with plans for short learning cycle-based experiences.
- **Reflection:** Participants spend time thinking quietly, discussing with a partner and writing about their thoughts on the learning cycle, and describe specific things they can do to make their instruction more learning cycle-based.

Experimenting with Extremes (a Lichen example)

While experimenting with how withholding information might increase curiosity, one field instructor testing BEETLES approaches took it to an extreme. She played up the engagement factor by—over a full week—never actually telling students the formal definition of lichen. She reported, “Those kids were on the edge of their seats by the end of the week, after we’d noticed, wondered, built new frames of reference, and pieced together evidence for what it reminded us of, as to what the green lacy stuff on twigs really was. Never have I had children so excited about lichen and figuring out what it was!” She also told us that she even succeeded in helping the same group of students invent the concept of a mutualistic organism—still without telling them what lichen is.

In contrast, another field instructor, who was intrigued by and knowledgeable about lichen herself, told students information about lichen and even created a special lichen “museum” for them to look at on the trail, with different species, names, and information on index cards. It was *all* concept delivery. Without an invitation and an opportunity for her students to explore before introducing content, they never became truly interested in the organism or the related information. The approach she used did not follow the Learning Cycle. Adding invitation, exploration, application, and reflection stages could have made the lesson into a much more meaningful experience for her students.

Leading Discussions

This session includes a significant amount of discussion and discussion leading. We recommend that leaders review the background section of the *Promoting Discussion* session and the *Tips for Promoting Discussion* handout (which, although designed for instructors leading discussions with students, is also useful for those leading discussions with other adults). Instructors implementing the Learning Cycle might also be challenged by the significant amount of discussion involved. Setting up discussion norms both within a staff and a group of students is critically important to having good discussions. This session includes a quick conversation around five discussion norms that research shows are useful to create a culture of discussion (Michael & O’Connor, 2012). If your instructors don’t have much experience with introducing discussion norms to students, consider spending more time with this part of the session and model one way these norms might be introduced to students. One suggestion is to have the group sit in a circle on the floor, and read aloud each norm, followed by quickly acting how what that looks like and the opposite of what it looks like. You can also share examples of how to disagree productively, ask people for evidence, or change your mind.

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