Using a Learning Cycle Approach to Teaching the Learning Cycle to Preservice Elementary Teachers

Deborah L. Hanuscin
Michele H. Lee
University of Missouri-Columbia

The Learning Cycle was developed in 1967 by Karplus and Thier for the *Science Curriculum Improvement Study* (SCIS). This inquiry-based teaching approach is based on three distinct phases of instruction: 1) *exploration* provides students with firsthand experiences with science phenomena; 2) *concept introduction* allows students to build science ideas through interaction with peers, texts, and teachers; (3) *concept application* asks students to apply these science ideas to new situations or new problems. Since Karplus and Thier introduced the Learning Cycle, several variations including different numbers of phases have been proposed; however, regardless of the number of phases they include, "each new version retains the essence of the original Learning Cycle—exploration before concept introduction" (Brown & Abell, 2007). A popular version of the Learning Cycle is the 5-E model--Engage, Explore, Explain, Elaborate, Evaluate (Bybee, 1997). It incorporates the three original Learning Cycle phases while adding two more: the Engage phase of the 5-E is designed to captivate students' attention and uncover their prior knowledge about the concept(s), while the Evaluate phase is an opportunity for the teacher to assess students' progress, as well as for students to reflect on their new understandings.

There has been a large amount of research concerning the Learning Cycle approach since its origins in the 1960's. Much of the research supporting the Learning Cycle approach is discussed in detail in Lawson, Abraham & Renner (1989), and supports the conclusion that the Learning Cycle approach can result in greater achievement in science, better retention of concepts, improved attitudes toward science and science learning, improved reasoning ability, and superior process skills than would be the case with traditional instructional approaches (see, for example, Abraham & Renner, 1986; Gerber, Cavallo, & Merrick, 2001; McComas III, 1992). As a model for planning instruction, the Learning Cycle "can help teachers 'package' important instructional goals into a developing conceptual 'storyline' that accommodates both selection and sequencing of learning opportunities" (Ramsey, 1993, p. 1). In doing so, teachers can avoid the use of episodic and fragmented instructional activities or "activitymania" (Moscovici, 1998).

The Learning Cycle has been embraced in science teacher education as a suitable approach (Rubba, 1992) consistent with the goals of the *National Science Education Standards* (NRC, 1996). Science teacher educators may be disappointed to find, however, that preservice teachers possess a wide range of understandings about the Learning Cycle, even after receiving extensive instruction about the method (see, for example, Settlage, 2000). In our own work, for example, we often encounter the belief that teaching more than one activity related to a single concept is redundant.

Preservice teachers enter their science methods courses following K-12 experiences that may reflect more didactic forms of science instruction. Thus, the Learning Cycle may be a considerable departure from the familiar forms of instruction learned through this apprenticeship of observation (Lortie, 1975). Thus, providing opportunities for preservice teachers to experience this approach *as a learner* can be critical to their understanding of the Learning Cycle. Also necessary, however, is the opportunity to plan instruction using the Learning Cycle *as a teacher*.

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As science teacher educators, we believed that the Learning Cycle itself provided a venue for sequencing learning experiences to help preservice teachers understand and apply this approach. In the sections that follow, we develop a "conceptual storyline" (Ramsey, 1993) that details course activities for each of the five phases of our instruction about the Learning Cycle.

Engage Phase

Consistent with the intent of the Engage phase of the Learning Cycle, our initial activity is intended to elicit preservice elementary teachers' prior knowledge and beliefs about teaching. Drawing on the work of Friedrichsen and Dana (2003) we developed a modified card-sort activity (see Appendix A) in which preservice teachers select and sequence learning experiences. Each set of cards includes 7-10 activities relating to a single topic or concept. The cards range from highly teacher-centered to highly student-centered activities, and also vary in the degree to which one might consider them to be *doing science* (Sullenger, 1999). Working in small groups, our students are first asked to reach consensus on the selection of five activities they feel best relate to the concept(s) or "fit" together. Next, we ask groups to arrange the activities they selected into what they feel would be an appropriate sequence for instruction.

Using their card-sort task in teacher education, Friedrichsen and Dana found "it was not how the teacher sorted particular cards, but what the teacher said during the sorting that offered the most insight into their science teaching orientation" (2003, p. 295). Keeping this in mind, we ask each group to provide a rationale for their selection of each activity, as well as its place in the instructional sequence. Common preconceptions and orientations toward teaching and learning science elicited in this phase of instruction include more teacher-centered and didactic instruction that places the teacher in the role of dispenser of knowledge. Furthermore, in our experience, students tend to draw upon activities similar to those they have experienced as learners. Their own content knowledge also plays a significant role in their decisions about what activities to choose to best develop the concept(s).

Exploration

Because the Learning Cycle differs so greatly from the type of science instruction many of our students experienced as learners, we feel it is critical to provide them with firsthand experiences learning science content through this approach. Over the course of several class sessions, students participate, as learners, in four different learning cycles that focus on content appropriate to the elementary classroom. The lessons are intended for a range of elementary learners, and address a variety of content areas including physical, life, and earth/space science. Following participation in each Learning Cycle, preservice teachers are given access to the written lesson plans as a model for preparing their own lesson plans (see Extend phase of instruction). Though providing such models may evoke concerns that preservice teachers will simply copy or imitate the example, McTighe and O'Connor (2005) indicate that providing multiple models can help avoid this problem. When students see several exemplars illustrating different ways in which the Learning Cycle can be implemented, they are less likely to view this as a cookie cutter approach. Specifically, we highlight the flexibility of the Learning Cycle and the way in which similar activities can be used in different phases of the lesson for different purposes. For example, two of the example lessons include children's literature. In one case, a tradebook is used to Engage learners in considering their own ideas about the concepts, whereas in another, a tradebook is used as an assessment activity in which students critically evaluate the scientific accuracy of the content.

Explanation

The explanation phase is critical for sense-making following the initial activities of the lesson. Course activities in this stage of our instruction focus on identifying the purpose of each phase of the Learning Cycle, based on the model examples in which preservice teachers participated. Following each lesson, preservice teachers work in groups to debrief their experience by completing a two-column chart outlining the specific activities of the teacher and students in each phase of instruction (see Figure 1). Through this process, we emphasize the role of the teacher in facilitating the learning experience and highlight strategies such as productive questioning (Martens, 1999). Additionally, we focus on clarifying the model further through professional readings about this approach, written from the perspectives of science educators and classroom teachers (e.g., Brown, 2006; Lorsbach, n.d.; Moscovici & Nelson, 1998). It is important to note that this is the first time that preservice teachers are provided vocabulary to describe each phase of the Learning Cycle (e.g., “Engage”, “Explore”). This aspect of our instruction is discussed explicitly to illustrate the premise of exploration before concept introduction on which the Learning Cycle is based.

Extension

To apply their new understandings, preservice teachers next plan their own Learning Cycle and conceptual storyline based on a concept/ big idea selected from the *National Science Education Standards* (NRC, 1996). They begin by developing a collection of activities that relate to the concept of focus. Just as in the initial card sort activity, they next select and sequence five activities. Figure 2 illustrates the template we give our preservice teachers to prepare an outline of their lesson idea. Outlines are brought to class, and students work in small groups to provide feedback to one another on the selection and sequencing of their activities in terms of the Learning Cycle model. Following this round of peer review, outlines are further refined and handed in to the instructor for additional feedback.

Next preservice teachers develop a “conceptual storyline” (Ramsey, 1993) for their lesson. Unlike a traditional lesson plan, this storyline provides a rich narrative describing each phase of instruction including specific details about what they and students will say and do, questions that will be utilized to facilitate discussion, how materials will be managed, what criteria they will use to evaluate student work, etc. Finished “lesson plans” are thus usually from 6-10 pages in length. The purpose of this level of detail is to enable the instructor to make a valid assessment of preservice teachers’ instructional decision-making in the design of the lesson; however, preservice teachers consistently report that this is a valuable exercise that helps them realize just *how much* they must consider in designing effective instruction.

Evaluation

While preservice teachers’ own learning cycle lessons can serve as a summative assessment for the faculty member to evaluate, it is also important for preservice teachers to self-assess and reflect on their new understandings. To accomplish this, we ask our students to revisit and critique their initial selection and sequencing of the activities from the card sort in the Engage portion of our instruction. In our experience, preservice teachers often change not only the activities they originally selected from among the cards, but also the sequence in which they would use the activities—however, they also recognize that the same activity might be used in different phases of the 5E model depending on the purpose and way in which it is introduced to students.

Though students complete this activity with their original group members, and share their ideas through whole-class discussion, we also encourage students to reflect individually on their new understandings. As one of our students wrote,

> *I really like the techniques we have learned in our class about the Learning Cycle. This technique has created a whole new perspective for me of what it means to teach science. In class during the sequencing activity our group was given a set dealing with electrical circuits. We disagreed over whether one part would be a good idea to teach in our classroom. "The teacher introduces vocabulary terms to students such as "circuit", "conductor" "insulator" and "current". Students create an illustrated dictionary in their lab notebooks, drawing pictures that convey the meaning of each of these terms based on their own observations and investigations". I thought this would be a good idea to use in the classroom. I think there is a time where a teacher needs to build knowledge by teaching students the proper terms of what they are seeing. This knowledge will help add meaning to other things they are seeing. I think that adding pictures at the bottom will help students apply the definitions to what they have witnessed in class.*

As illustrate above, these reflections allow us another means to assess the change in preservice teachers' ideas about teaching and learning science, and the depth at which they understand the purposes of the different phases of the Learning Cycle approach.

Conclusion

Through applying the Learning Cycle model in our own instruction, we have found an effective means for teaching our preservice teachers about this approach. In essence, we are "practicing what we preach" by modeling the same kind of instruction we expect from them. The activities we developed for our own Learning Cycle function together as a conceptual storyline that helps our students develop a deep understanding of powerful ways to select and sequence learning activities for their own instruction. We have been extremely pleased with their ability to develop their own Learning Cycles as a result of this instruction.

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Figure 1. Template for Debriefing Learning Cycle Lesson

The Learning Cycle		
Phase of Instruction	**Activities of the Teacher**	**Activities of the Students**
Engage		
Explore		
Explain		
Extend		
Evaluate		

Figure 2. Template for Outline of a Learning Cycle Lesson Plan

THE LEARNING CYCLE	
Concept of focus: Possible misconception(s) targeted:	
Phase of Lesson:	**Sequence of Activities / Rationale**
ENGAGE :	
EXPLORE:	
EXPLAIN:	
EXTEND:	
EVALUATE:	

Appendix A: Card-Sort Sets of Activities for Learning Cycles

SET #1: The goal of this lesson sequence is to help students understand science as a process of inquiry, and to make connections between the work of scientists and their own classroom science activities. This sequence is part of a broader goal for helping students understand the nature of science.

- Students are asked to draw a picture of a scientist and explain what they think scientists do.
- Students design and conduct their own experiments to investigate plant growth. Their findings are shared in a mini-conference at family science night.
- Students, in pairs, read nonfiction books about the work of scientists, and then share their ideas about what they read in a whole-class discussion.
- Students make a Venn diagram comparing their own work in science class to the work that scientists do.
- The teacher invites a local biologist to visit the class as a guest speaker. Students ask this scientist questions about the work he/she does with corn plants.
- The class takes a field trip to a local farm to hear about ways farmers are trying to increase their crop yield.
- The class adopts a plot of land in their schoolyard and creates a garden to help beautify the school.
- Students read Chapter 5 of their science book, which discusses how plants grow. They compare their ideas in small groups, and discuss how the ideas they read relate to what they have been learning.
- Students bring in different food dishes from home, in which corn is a main ingredient. They discuss the importance of corn to different cultures.

SET #2: The goal of this lesson sequence is to help students understand how shadows are formed, and the factors that influence the size and shape of shadows. This sequence will prepare students for future lessons focusing on the behavior and properties of light.

- The teacher reads *Bear Shadow*, a story about a bear that attempts to escape a shadow that seems to be chasing him. Students are asked to think critically about what aspects of the story could be real or not in terms of Bear's shadow.
- As a class, students go on a "shadow hunt"—identifying different objects that make shadows, where shadows appear, and what light sources are present and their location. They draw pictures to record what they observe.
- In pairs, students make shadows of their own using flashlights and a variety of objects, provided by the teacher. Students record their ideas about what causes a shadow, as well as what causes a shadow to be different sizes or shapes.
- The teacher poses the following problem to students, and asks them to respond individually: *The local puppet show will soon be putting on a shadow play production of The Three Bears. Unfortunately, the three bear-shaped puppets they have are all the same size! How will they ever be able to make Momma, Poppa, and Baby Bear using the same sized puppets? Using what you know about shadows, explain how you think they might solve this problem.*
- The teacher explains to students that the size of a shadow is dependent on the distance of the object from the light source, as well as the distance of the object from the surface on which its shadow falls. The teacher guides students in constructing diagrams to depict these two factors.
- Students draw pictures to illustrate ways to make shadows bigger and smaller. They share their pictures in small groups, and compare their ideas in a whole-class discussion.
- Students work in groups to design investigations to answer the question, *What effect does the distance of the light source from the object have on the size of the shadow that is produced?*
- Using a stuffed Teddie Bear, the teacher demonstrates different ways to change the size of a shadow, by projecting light from the overhead projector. She moves the Teddie Bear closer and farther from the screen, and then moves the overhead projector closer and farther from Teddie. She then brings out a bigger stuffed Bear, and asks the class to predict what she could do to make the shadows of the two bears the same size.

SET #3: This lesson sequence is designed to help students understand how rocks are formed, and to appreciate the diversity of rocks that exist. It is part of a larger unit on the rock cycle.

- Students use Golden Guides™ (kid-friendly field guides) with information about different kinds of rocks - to identify samples of rocks provided by the teacher (or brought from home).
- Students are asked to bring in a rock from home. They share these in a circle, and the teacher closes the sharing session by asking students to write about what they think a rock is and where rocks come from.
- Students are provided a sample of rocks, which they sort based on characteristics they determine such as color, texture, and whether they float/sink. The teacher challenges students to think of criteria that would/would not be useful to classify rocks (e.g., two rocks may be the same type of rock but be different size and shape).
- The teacher teaches students how to sing "The Rock Cycle Song" (to the tune of "Row, Row, Row Your Boat") to help them remember that the three types of rocks are igneous, metamorphic, and sedimentary.
- Students make posters of the rock cycle, using their textbook diagram as a guide, and hang these posters in the classroom.
- Students, as a class, brainstorm a list of ways that people use rocks. Students generate examples ranging from pet rocks and landscaping, to building materials and the basis for sculptures in art.
- The class participates in a "rock exchange" with a classroom in another state—preparing a box with rocks found in their local area to send to them. Once they receive the box from their "rock pals" they compare the properties of rocks they receive to rocks found in their local area, and suggest reasons they might be the same and/or different.
- The class takes a field trip to the nearby state park, where a park ranger gives a talk about the local geology of the area and how it has changed throughout history.
- Students explore an interactive website that explains the various stages of the rock cycle, and how rocks are formed and reformed through this cycle.

SET #4: The goal of this Learning Cycle is to help students understand that each plant or animal has different structures that serve different functions in growth, survival, and reproduction.

- Students make a collage using cut-out images from magazines and newspapers that illustrate the diversity of a particular structure among a group of animals, and then writes a paragraph about their ideas. For example, one student creates a collage showing the many different kinds of feet that birds have, and then writes a paragraph that explains how having different types of feet might help birds do things to help them to survive.
- Students use different tools to represent the variety of beaks of different birds (e.g., pliers, a straw, tongs) and explore how much and what kind of "food" these birds might be able to eat in different habitats. The teacher has prepared the "habitats" in advance, and each contains a different variety of foods. Students conclude that their "birds" might not survive well in some habitats, because they would be unable to eat enough food.
- The teacher presents each group of students with a variety of bird feathers (from a single type of bird) and magnifying lenses. Students explore dropping and waving the feathers around, and develop detailed drawings in their science notebooks that illustrate the differences and similarities they observe between the different feather types. Students draw inferences about how having different types of feathers help a bird survive (e.g., down feathers are soft and help keep the bird warm, while flight feathers are rigid and help the bird push the air).
- Students look through Golden Guides™ (kid-friendly field guides) to learn about different species of birds found in their area. Parents are encouraged to help their child birdwatch in their backyard, and identify different species they see.
- Students compare birds found in their local area to birds found in different places around the world. Students use geographical resources to learn more about the environments in which the birds live, and then compare different adaptations the birds have to help them survive in those environments. Each group focuses on a specific pair of birds (one local, one from afar) to compare and share with the class.
- The teacher asks students to imagine what their life would be like if they had a beak instead of a mouth. During circle time, students go around and share something they think would be different, living with a beak.

- A guest speaker from the raptor rehabilitation program brings in several birds and discusses the different adaptations raptors have that help them survive by catching and eating their pretty.
- Students read a chapter in their science book about animal and plant diversity. Afterwards, they discuss factors that affect the survival of different species.
- The class places two bird feeders outside of the classroom with very different kinds of foods. They keep track of the different species of birds that visit one feeder, versus the other.

SET #5: The goal of this lesson sequence is to help students develop an understanding of a simple circuit, and a model for the way electric current travels through a circuit. It is the first lesson in a unit that explores electrical circuits.

- Students, in groups, play the Operation Game. Then, they explain individually in writing how the game relates to what they know about simple circuits. They identify the path of the current as it travels through various parts of the game, as well as why the buzzer sounds and the patient’s nose lights at some times, but not others.
- Students, working in pairs, design their own circuit quiz-boards by following instructions provided by the teacher, and filling in questions and answers of their own choosing. Some students provide words and definitions, while others list math problems and answers. Pairs trade quiz-boards with other groups and try to answer the questions correctly.
- Students are provided a battery, bulb, and wire, and are challenged to find ways to make the bulb light. They keep a list of “ways that work” as well as “ways that don’t work”, then look for patterns in their observations to develop “rules” for lighting the bulb. Students compare their rules in pairs, and negotiate any disagreement by retesting their configurations of battery, bulb, and wire to observe whether the bulb lights.
- Students are provided a flashlight, which they take apart to identify the circuitry found within. They create diagrams and written explanations of how a flashlight works, identifying the path of conductors through which the electric current travels, as well as the insulators through which current cannot travel.
- Students, in groups, design experiments to determine the effect that various factors (number of bulbs, number of batteries, length of wires, etc.) have on the brightness of the bulbs in a circuit. Students use the brightness of the bulbs as an indicator of the amount of current flowing through the circuit.
- The teacher introduces vocabulary terms to students such as “circuit”, “conductor”, “insulator”, and “current”. Students then create an illustrated dictionary in their lab notebooks, drawing pictures that convey the meaning of each of these terms based on their own observations and investigations.
- Students, in pairs, explore a multi-media CD that explains how current travels in a simple circuit. They answer a series of questions at the end of the module to test their understanding.
- Students are given a “mystery box” in which there may, or may not, be an electrical connection. (There may be batteries, bulbs, and wires in any configuration inside). Two wires extend from the side of the box. Students are invited to test their ideas, and explain what they think is inside the box using evidence from their investigations.

SET #6: In this lesson sequence, students consider the question: “What causes sound?” The goal of this lesson sequence is to help students understand that “Sound is produced by vibrating objects.” The mechanism of sound production is an important precursor to understanding other properties of sound such as “pitch” so it is the first lesson in a curriculum unit about sound.

- Students partner together to design and build an instrument. The whole class listens as each pair shares their instrument and presents how it produces sound.
- The students make sounds by using different materials that the teacher has placed at several stations around the classroom. They pluck rubberbands, blow into bottles of various shapes, and try out various percussion instruments while recording ideas and observations in their science notebooks.
- The teacher reads aloud the children’s book *Very Quiet Cricket* by Eric Carle. Here is a brief synopsis of what the book is about: A cricket is born who cannot talk! A bigger cricket welcomes him to the world, then a locust, a cicada, and many other insects, but each time the tiny cricket rubs his wings together in vain: no sound emerges. In the end, however, he meets another quiet cricket, and manages to find his "voice." "And this time . . . he chirped the most beautiful sound that she had ever heard."

- Students make and use "string telephones" out of tin-cans and string. Their recorded observations and ideas about what they think is happening to the sound become the focus of a class discussion.
- Students watch a video entitled: "What is Sound" and fill out a worksheet that the teacher created to go along with the video.
- Students are given the challenge to "Make the Sound Stop!". Each group has a buzzer and a limited amount of materials and time to figure out a way to stop the sound. . . without turning off the buzzer, of course!
- Students are given a bag of materials: a tuning fork, small rubber hammer to strike the tuning fork, a jar of water, ping-pong ball. The teacher encourages students to find different ways to use the materials to make sound.
- Students write down three things that they know about sound on post-it notes. Groups of students compare and contrast their ideas with each another, noting that they don't all agree. This leads to a whole class discussion about students' ideas.

SET #7: The goal of this lesson sequence is to help students understand that almost all kinds of animals' food can be traced back to plants. This lesson is within a unit focused on the interdependence of organisms to each other and to their environment.

- The teacher shows a metal chain with links to students. She uses this as a model to represent what a food chain is. Students then use strips of paper, writing organism names and linking them to create their own "food chain". The teacher staples all of the food chains onto a bulletin board with a large sun in the center.
- Students choose a group of animals that interested them: pets, sea creatures, insects and spiders, etc. The teacher (with support from her school librarian) helps students find books and Internet resources so they can find out what their chosen animals eat. When students present their findings, the class constructs a Venn diagram: two overlapping circles labeled 'animals that eat animals' and 'animals that eat plants' to consider food resources.
- Students are given signs that have different plant and animal names and pictures on them. Students consider different relationships of who eats what, physically representing relationships by joining hands. At the conclusion, the teacher asks students to fill out an exit ticket:
- Your friend's younger brother says: "Almost all kinds of animals can be traced back to plants." Do you agree or disagree? Why do you think so? Explain and then draw an example to support your answer.
- The teacher asks students to sort common food items (pictures, toys, or real) into three categories: Comes from a plant, Comes from an animal, or Both. Students work in small groups to discuss and sort the foods. Students write names of food items on a large chart drawn on the class chalkboard. The whole class then discusses whether plants and/or animals are needed as food.
- Students write responses to the following questions:
  What would happen to an owl living in a forest if all of the mice could not find food? Why?
  What would happen to the bees in an area if all the flowering plants died? Why?
- The teacher reviews the definitions of a carnivore, omnivore, and herbivore. Students look in old magazines to find pictures of each type of animal to place on a poster board.
- Students want to know what foods like marshmallows, candy, and mayonnaise are made of because the source isn't obvious to them. Students bring in food labels and work in groups to figure out if the ingredients can be traced to plants or not.

Appendix B: Learning Cycle Assignment and Rubric

Rationale:
Research shows that simply doing isolated hands-on activities (Activitymania) is not sufficient to promote deep conceptual understanding of science content. The Learning Cycle is an effective method for building conceptual understanding by progressing from the concrete experiences with materials to formation and application of concepts to new situations. This assignment is designed for you to develop your skills for adapting and sequencing learning experiences for elementary students using this method.

Procedure:
I. Select a Science Concept to Teach

- Decide the grade level for which you would like to plan a lesson (your choice!). Consult curriculum standards documents (*Benchmarks*, *National Science Education Standards*, *Show-Me Standards*) to find out what concepts, skills, and topics are taught at this level.
- Select **one concept** or idea on which to focus teaching in-depth, rather than trying to "cover" everything about a topic in one learning cycle.
- Research your concept to gather background information for your lesson plan. You should provide an explanation of the concept of the lesson as well as examples of typical student misconceptions about the concept (Refer to *Children's Misconceptions about Science).*

II. Locate Activities to Help Students Understand this Concept

- Find out what other teachers have done to teach this concept—ask real teachers, or read about their lessons in the NSTA journal *Science and Children* or the book *Seamless Assessment* on reserve in the Reflector.
- Consult elementary science curriculum materials, teacher resource books, children's literature, and other resources in the Reflector or Boone County Public Library.
- Peruse the Web Resources in the NETwork for lesson plans, sample assessment tasks (PALS), and online access to *Connect: A Magazine of K-8 Teachers' Innovations in Science and Math.*

III. Select and Sequence the Activities

- Look through the activities you found—which would best help students understand the concept of the lesson? (As you did earlier this semester, you will most likely have to adapt the activities you found, rather than using them as is.)
- Outline your sequence of activities, following the Learning Cycle model (use the form provided). You will bring this to class on the designated date, and will have an opportunity to receive feedback from both your peers and your instructor.

IV. Write Your Lesson Plan

- "Lesson plans" take on a variety of forms and purposes. As a preservice teacher, you audience is your instructor, who must make evaluations of your knowledge and abilities. For this reason, the level of detail in your lesson plans should be such that I can envision the lesson as it would occur, step by step, in your classroom, including what you and students will be doing throughout.
- Specific elements that should be included in your lesson plan are outlined in the evaluation criteria (next page). Please refer to the sample lessons provided for examples of each.

V. Communicating Your Instructional Decisions

- Along with your lesson, you should provide a brief commentary on your lesson that explains your decisions about what activities to do in each phase of the lesson. This commentary should describe how each activity "fits" with the Learning Cycle model, and why you chose and/or adapted the activities. Your decisions should be supported with your own beliefs about teaching, and your professional knowledge about teaching and learning science.

Rubric/ Evaluation Critera		
Element	**Expectation**	**Points/Possible**
Rationale	The lesson provides a clear indication of why the concepts are appropriate and/or important for elementary students to learn.	/5
Teacher Background	The lesson includes a complete and accurate explanation of the science concepts involved in the lesson, as well as typical student misconceptions about which teachers should be aware.	/10
Link to Standards	The lesson identifies the science standards, benchmarks, or grade-level expectations that the lesson is designed to teach. The match between the lesson and standards is clear.	/5
Materials	The lesson provides a list of all necessary materials and the amounts of each which are needed for the lesson. Materials are appropriate for use in the elementary classroom.	/5
Goals and objectives	The lesson provides clearly define goals and objectives related to the knowledge, skills, and understandings about science that students will develop. There is a clear match between the evaluation and objectives.	/5
Engage	Appropriate activities are selected to engage students in the lesson by activating their prior knowledge about the topic and stimulating curiosity. The initial activities rely on students' existing ideas.	/10
Exploration	Appropriate activities are selected to allow students to explore the concepts through first-hand experiences. Activities are student-centered, rather than teacher-centered.	/10
Explanation	Appropriate activities are used to help students develop explanations based on their explorations. New vocabulary is introduced, where appropriate. The teacher leads students in making sense of their experiences, rather than dispensing information to students.	/10
Extension	The activity(ies) invite students to apply what they learn to a new, but related situation or real-world context. In order to be successful in the activity, students must understand the concept(s) of the lesson.	/10
Evaluation	Opportunities for formative assessment of student ideas are embedded throughout the lesson, and a final (summative) task is designed to assess students' achievement of the goals and objectives of the lesson at the conclusion of the cycle. Specific criteria are provided (e.g., a rubric) to enable the teacher to evaluate students' progress.	/15
References	A complete and accurate list of references for all materials and resources consulted in designing the lesson is included. The author of the lesson appropriately attributes credit to the source of information.	/5
Level of Detail	The lesson plan is clearly communicated in sufficient detail to enable the reader to understand what will occur in each phase of the lesson. Information about what the teacher will say/do (including questions that will be asked) is provided for each phase of the lesson.	/10
	Total Points / Possible	/100
Comments:		