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ABSTRACT

This paper describes the development of a diagnostic test to assess teachers' understanding of the learning cycle and highlights common misconceptions identified through the administration of the diagnostic instrument. The Learning Cycle Test was administered to 28 undergraduate students enrolled in elementary science methods who had received instruction on the learning cycle. This paper describes the misconceptions identified through analysis of items on the Learning Cycle Test in the context of exploration, concept introduction, application, and general questions about the learning cycle. Results indicate that elementary science methods students continue to have alternative conceptions about the learning cycle after instruction on the learning cycle. The most common alternative conceptions were centered around the teacher explaining and/or defining the concept prior to or during exploration. The Learning Cycle Test, which appears to provide a feasible approach for evaluating students' understanding and for identifying alternative conceptions about the learning cycle, is included in the paper with percentage of responses by preservice science teachers with specific misconceptions. Contains 21 references. (JRH)

The Development and Application of a Diagnostic Test to Assess Teachers' Understanding of the Learning Cycle

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INTROL JCTION

The Learning Cycle is an approach to science instruction that is gaining increasing favor within the science education community. With its roots in the Science Curriculum Improvement Study (Lawson, Abraham, & Renner, 1989), the Learning Cycle is finding its way into many science curriculum materials (e.g., Education Development Center, 1994; Lawson,1994; BSCS, 1992; PRISMS, 1985).

The Learning Cycle is a method of teaching that falls within the Information Processing Models of teaching (Weil & Joy, 1978). As such, it places a premium upon not only the content that students are to learn, but also an understanding of the thought processes involved in the construction of new knowledge. The learning cycle as referred to in this paper consists of three phases: Exploration, Concept Introduction, and Application. Although other writers describe the Learning Cycle with anywhere from three to five phases, at their core the approach is essentially the same.

Lawson (1995) distinguishes among three different types of learning cycles. Since this paper describes an objective instrument for assessing educators understandings of the learning cycle, those familiar with Lawson's work need to know that the test does not accurately evaluate his hypothetical-deductive learning cycle.

The Learning Cycle approach has enjoyed successful implementation in secondary instruction(Abraham & Renner, 1986; Schneider & Renner, 1980; Renner, Abraham, & Birnie, 1986) and college science classrooms (Lawson, Rissing, & Faeth, 1990; Zollman, 1990; Allard & Barman, 1994) even though it was initially developed for use in elementary science.Charles Barman has provided guidance to teachers, both inservice and preservice, to this approach to science instruction (Barman, 1989; Barman & Shedd, 1992). Given the widespread appearance of the Learning Cycle in both science curriculum and professional development efforts, development of an assessment tool for measuring teachers understanding of this approach was the goal of the research reported here.

PURPOSE

Identification of teachers understanding of the learning cycle is key to improving science instruction. Tools are needed to assess the effectiveness of teacher education programs designed to teach the learning cycle. Although numerous research studies have investigated teachers misconceptions about science content, there are only a few investigations that describe teachers understandings of the learning cycle (Marek, 1990; Barman, 1992; Barman & Shedd, 1992), and there has been no attempt to develop an objective multiple choice instrument to

assess teachers' understanding of the learning cycle. Further, few studies have comprehensively identified teachers' misconceptions about the learning cycle. This research study helps address the situation by (1) describing the development of a diagnostic test to assess teachers understanding of the learning cycle, and (2) highlighting common misconceptions identified through the administration of the diagnostic instrument.

METHODS

The Learning Cycle Test was developed using procedures that have been utilized in research by Treagust (1985). The development involved three phases: (1) defining the content boundaries of the test, (2) writing multiple choice questions with free response reasons (3) writing the final two-tier test items and administering the instrument to obtain information about teachers' misconceptions. The time line for our study was modeled after Odom and Barrow (1995).

Propositional knowledge statements were used to define the content boundaries of Learning Cycle Test. The propositions were derived from Barman (1989), Renner and Marek (1988), and Lawson (1995). A list of 18 propositional knowledge statements required for understanding the learning cycle at a level of sophistication appropriate for elementary and secondary science teachers was identified and constructed (Figure 1). The content validity of the propositional knowledge statements was established by a panel of two science education professors. Final content and face validity of each test item was determined with the assistance of a specification grid and will be discussed in a later section.

Based on the validated list of propositional knowledge statements, a twenty-one multiple choice items with free response were written. The first tier of the test was in multiple choice format with two, three or four choices. The second tier was the statement "The educational reason for my answer is because:" with a blank space provided. Students were asked to explain the reason for their multiple choice selection. Free response data were analyzed and a list of misconceptions was constructed. This test was administered to 19 undergraduate and 15 graduate students enrolled in a science teaching methods course. Each student received instruction on the learning cycle prior to test administration. The free response data provided evidence of misconceptions about the learning cycle.

Items for the learning cycle test were based on the two-tier multiple choice format described by Treagust (1985). The first tier consisted of a content question with two, three, or four choices. The second tier consisted of four possible reasons for the first part: three alternative reasons and one desired reason. The alternative reasons were based on misconceptions detected

during the multiple-choice test with free response reasons. A pilot study was conducted to refine the items on the learning cycle test.

The final version of the learning cycle test consisted of 14 items. The areas covered by the test were: phase 1 (exploration), phase 2 (concept introduction), phase 3 (application), and general questions about the learning cycle. Table 1 offers an example that assesses phase 3 (application), as well as the item analysis.

For the final instrument, a specification grid was constructed to determine the face validity and whether the test questions matched all of the validated content specified by the propositional knowledge statements. Two major questions were addressed while determining face validity: (1) Does the question assess the content as defined by the validated propositional knowledge statements, and (2) Is the question at a level of sophistication appropriate for elementary and secondary science teachers? If the above criteria were not met, the item was dropped. All 18 propositional knowledge statements were matched to the items on the Learning Cycle Test. All of the questions except 1 incorporated more than one of the propositional knowledge statements (Figure 2). Item 2 matched to only propositional knowledge statement 5.

SAMPLE OF POPULATION STUDIED

The learning cycle test was administered to 28 undergraduate students enrolled in elementary science methods. Most of the students were seeking elementary certification (grade 1-8) although a few were working towards developmentally handicapped certification. All of the students were within one to two quarters of their student teaching experience. Each student received the following instruction on the learning cycle prior to test administration. Students participated in learning cycle lessons modeled by the instructor, developed learning cycle lessons, participated in small group and whole class discussions about the learning cycle, and read and critiqued recent research on the learning cycle. As a culminating activity students taught a learning cycle lesson to the class.

SCORING OF THE ITEMS

An item was scored correct on the Learning Cycle Test if both the desired first tier and second tier answers were selected. Items were evaluated for both correct and incorrect response combinations selected. For example, response combinations selected by students in an item dealing with the phase 3 (application) is shown in Table 1. In this item, 53.57% students selected the desired first tier answer, while only 28.57% selected the desired first and second tier answer

combination.

RESULTS AND DISCUSSION

Table 2 summarizes the characteristics of the Learning Cycle Test, and a copy is located in the appendix. The split-half reliability was determined by correlation of the odd and even test questions. The whole test reliability was estimated to be 0.81. The difficulty indices ranged from 0.00 to 0.64, providing a wide range of difficulty items. The discrimination indices ranged from 0.40-0.79.

For the first tier of the test, the range of correct answers was 39.28% to 85.72% (Table 3). When both tiers were combined, the correct response was reduced to a range of 0.00% to 64.29%. The results of the Learning Cycle Test suggest that the students did not acquire a satisfactory understanding of the learning cycle. According to Gilbert (1977), if a multiple choice item has four to five distractors, understanding is considered satisfactory if more than 75% of the students answer the item correctly. With a typical multiple choice test with four possible selections, there is a 25% chance of guessing the correct answer.

Twenty-eight misconceptions (Table 4) were identified through analysis of items on the Learning Cycle Test. They are grouped under the headings of phase 1 (exploration), phase 2 (concept introduction), phase 3 (application) and general questions about the learning cycle. A description of these misconceptions follows.

Phase 1 (Exploration)

Students understanding of phase 1 of the learning cycle was insufficient as measured by items 6, 7, and 12. For example, only about 60% of teachers selected the desired answer combination in item 6 which related to the role of the teacher during phase 1 of the learning cycle as facilitator and that the concept should be derived from the activity. The most common alternative response was "during phase 1 teachers explain the concept prior to investigation because students should be told why and what they are investigating so they will understand the reason for the activity (17.86%)."

Only 64.29% of the students selected the desired response for item 7 which asked about appropriate teacher behavior during phase 1. The most common alternative responses were "that during the first phase of the learning cycle the teacher demonstrates and explains a basic science concept because the teacher must provide a mental framework for the students before they begin exploring (14.29%)" and "because the teacher has the responsibility of providing scientific terms when the students are confused (14.29%)."

In item 11, students were asked about the role of the

teacher during the first phase (exploration). The desired response(selected by 42.86% of students) was, "during the first phase the teacher observes, questions, and assists the students as they work because the teacher's role is to provide help with equipment and may guide students in their collection of data." There were two common alternative responses and each were selected 14.29% of the time. The first was, "during the first phase the teacher demonstrates and explains a basic science concept because the teacher must provide a mental framework for the students before they begin exploring" and (the second was) "because the teacher has the responsibility of providing the scientific terms when the students are confused."

Item 12 proved to be the difficult for students. Only 42.86% of students selected the desired response which was "during the first phase of the learning cycle the teacher facilitates the process of observing and recording of data because students should be provided materials for which they are to gather data." The most common alternative response was that the teachers role was to keep students on task and manage behavior(25.00%). Another common alternative response was "the teacher is a major informational resource for students because students must have the important concepts defined at the same time that they are working with materials (14.26%).

Phase 2 (Concept Introduction)

Items 3, 5, and 9 examined students' understanding of phase 2 (concept introduction). Item 3 indicated confusion about the function of the second phase. Only 17.86% of students selected the desired response which was "the main purpose of phase 2 is to lead students to build meaningful understanding about there experiences because students are guided to construct knowledge based upon their experiences." The most common alternative responses were that knowledge is constructed in phase 3 (25%) and phase 1 (14.29%).

In item 5 students were asked what occurs during phase 2. The desired answer was selected by only 46.43% of students and was "data are compared and terms are introduced because the teacher acts as a guide, but students must be allowed to verbalize the data and terms for meaningful learning to occur." The most common alternative response was "data are compared and terms are introduced because vocabulary words are key to learning science and students most practice the concepts after exploring them during the hands-on activity (14.29%)." This answer combination is partially true but focuses on learning vocabulary words. Another common alternative response was "students should be allowed to explore data and terms freely; teacher intervention is not necessary (10.71%)." Each of these misconceptions landed on either end of the spectrum of the role of a teacher during

phase 2.

Item 9 asked students to identify the role of the teacher in phase 2. Only 42.86% of students selected the desired response. The most common alternative response was "the teacher helps students investigate phenomena first-hand because the teacher will interpret the data for the students (28.57)." Another common alternative response was "students report data to the class because the teacher will interpret the data for the students (10.71%)."

Phase 3 (Application)

The application phase was examined through items 1, 4, 8, and 10. In item 1 students are asked "at what time do students organize the concept they have just learned with other phenomena." The desired answer was "phase 3 because after the concept is presented appropriate activities are provided to apply the concept to a new situation" and was selected by only 28.57% of students. The most common alternative response was "phase 2 because after the teacher explains the new concept, the students must be given time for free exploration (17.86%)." Approximately 14% of students selected "phase 3 because after the information is given to the students they are given the opportunity to make connections to new concepts."

In item 4, students were asked to determine the purpose of the learning cycle during phase 3. Only 10.71% selected the desired response. The most common alternative response was "the purpose of phase 3 is to both expand the lesson into other concepts and extend the previously developed concept in a new context (42.86%)." Also in item 8 alternative responses were centered around "the major role of phase 3 was to explore new science concepts because the purpose was to make new connections(28.57%)." Only 28.57% selected the desired response for the function of phase 3 which is "to aid students in deepening their understanding because for meaningful learning to occur student must apply previously introduced concepts to new situations." Similarly in item 10 common alternative responses were centered around the function for phase 3 as being to learn new concepts (10.71%).

General Items about the Learning Cycle

Items 2, 13, 14 assessed students general understanding of the learning cycle. Each item explored the relationship of phase 1, 2 and 3. In item 2 zero percent of students selected the desired response, "the first and third phase activities could be alternated because in most cases the sequences of activities is not important." The most common alternative responses were "the sequence of activities could be alternated because applying an existing concept to a new situation is the same as exploring a

new concept(39.29%)" and "because the students go back and revisit the same investigation in more detail a second time (25.00%)." Further, 21.43% selected "the investigation used in the first phase could be repeated with a different concept during the third phase."

In item 13 students were asked "if they were properly using the learning cycle to teach about metamorphosis, what would be an appropriate activity during phase 3?" Only 21.43% of students selected the desired response. The most common alternative response was "to extend the concept of metamorphosis to the concept of migration and examine additional phenomena related metamorphosis because connections among various concepts helps to reinforce learning (25.00%)." Similarly in item 14 students were asked to select a proper activity for phase 3 in a lesson about mass. Only 42.86% of students selected the desired response. The most common alternative response was "an appropriate activity for phase 3 would be to extend the concept of mass into the concept of weight and explore mass with different materials because the purpose is to move the students ahead to consider the more abstract concept of weight (10.71%)."

CONCLUSIONS AND IMPLICATIONS FOR SCIENCE EDUCATORS

This study provides evidence that elementary science methods students continue to have alternative conceptions about the learning cycle after instruction on the learning cycle. The test indicated that students were confused about the role of the teacher in phase 1. The most common alternative conceptions were centered around the teacher explaining and/or defining the concept prior to, or during exploration.

The Learning Cycle Test also indicated that many students believe that the role of the teacher is to interpret data for the students during phase 2. Further, the test indicated that many teachers believe that vocabulary terms are key to learning science.

The test detected major confusion about the role of phase 3 in the learning cycle. Many students indicated that phase 3 is used to explore and learn new concepts and make connections with new concepts. Similarly, the general items on the Learning Cycle Test detected alternative conceptions about the relationship of phases 1 and 2 with phase three. Many teachers indicated that phase 3 could be used to extend concepts learned in phases 1 and 2 into new concepts.

The Learning Cycle Test appears to provide a feasible approach for evaluating students' understanding and for identifying alternative conceptions about the learning cycle. The identification is of direct relevance for science educators because this knowledge can be used to improve instruction.

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Figure 1. Propositional knowledge statements required for understanding the learning cycle.

Exploration Phase

1. During the first phase conceptual understanding is derived from an activity.
2. During the first phase the teacher may describe procedures for students should use.
3. During the first phase lab procedures are given to the students.
4. During the first phase lab procedures are used for guidance about the activity.
5. During the first phase lab procedures are used to enhance data collection.
6. During the first phase the teacher acts as a facilitator.
7. During the first phase students are activity engaged in an activity.

Concept Introduction Phase

8. During the second phase students begin to construct knowledge based on their experiences.
9. During the second phase data are compared and terms are introduced.
10. During the second phase the teacher acts as a guide while data are analyzed.
11. During the second phase students are allowed to verbalize the data and terms.

Application Phase

12. During the third phase students organize the concept just learned with other related phenomena.
13. During the third phase students apply the concept just learned to a new situation.
14. During the third phase previously learned concepts are extended in a new context.
15. During the third phase new knowledge becomes more meaningful when applied to new situations.
16. During the third phase additional phenomena are discussed and/or explored that involve the same concept are previously explored.

General

17. For meaningful learning to occur students must experience the same concept in different contexts.
18. In many cases an activity can be used in either the first or third phase as long as a new activity involving the same phenomena is used in the other.

Figure 2. Item number, propositional knowledge statement, and topic areas tested by the Learning Cycle Test.

Item Number	Topic area	Propositional Statements
1	Phase 3 (Application)	12, 13
2	General	18
3	Phase 2 (Concept Intro)	8, 10
4	Phase 3 (Application)	13, 14
5	Phase 2 (Concept Intro)	9, 10, 11
6	Phase 1 (Exploration)	1, 7
7	Phase 1 (Exploration)	2, 3, 4, 7
8	Phase 3 (Application)	13, 15
9	Phase 2 (Concept Intro)	8, 10, 11
10	Phase 3 (Application)	12, 13, 14, 16
11	Phase 1 (Exploration)	2, 3, 6
12	Phase 1 (Exploration)	2, 3, 4, 5, 6
13	General	14, 17
14	General	16, 17

Table 1. Science methods students percentage responses to item 1 of the Learning Cycle Test.

1st Tier	2nd tier a	b	c	d	Total
a	0.00	0.00	0.00	0.00	0.00
b	3.57	7.14	17.86	3.57	32.14
c	14.29	3.57	28.57*	7.14	53.57
d	3.57	0.00	0.00	10.71	14.28

During what phase of the Learning Cycle are students given the opportunity to organize the concept that they have just learned with other phenomena related to this concept?

A. Phase One
B. Phase Two
C. Phase Three
D. This is true for more than just one phase.

The educational reason for my answer is because:

A. After the information is given to the students they are given the opportunity to make connections to new concepts.
B. After the teacher explains the new concept the student must be given time for free exploration.
C. After the concept is presented appropriate activities are provided to apply the concept to a new situation.
D. The learning cycle is all inclusive and develops new concepts during each phase.

*desired response combination

Table 2. Characteristics of the Learning Cycle Test.

Areas evaluated:	The exploration or first phase: 6, 7, 11, 12. The concept introduction or second phase: 3, 5, 9. The application or third phase: 1, 4, 8, 10. The learning cycle in general: 2, 13, 14.	
Content based on:	validated propositional knowledge statements and concept map.	
Number of items:	14	
Recommended level:	Preservice science teachers.	
Time to complete test:	20-30 minutes.	
Discrimination indices:	Mean	Range(items)
	0.53	0.40-0.49(3)
		0.50-0.59(6)
		0.60-0.69(2)
		0.70-0.79(2)
		One items had zero Correct responses.
Difficulty indices:	Mean	Range(items)
		0.00-0.09(1)
		0.10-0.19(2)
		0.20-0.29(3)
		0.30-0.39(0)
		0.40-0.49(5)
		0.50-0.59(1)
		0.60-0.69(2)
Split-half reliability:	0.81	

Table 3. Percentage of preservice science teachers selecting the desired first tier and combination first and second tier choice.

Items	First Tier	Combination
1	53.57	28.57
2	85.72	0.00
3	39.28	17.86
4	39.28	10.71
5	75.00	46.43
6	64.28	60.71
7	78.57	64.29
8	49.99	28.57
9	53.57	42.86
10	67.85	50.00
11	57.14	42.86
12	42.86	42.86
13	46.43	21.43
14	60.71	42.86

Table 4. Percentage of responses by preservice science teachers with specific misconceptions detected by the learning cycle test.

	Misconceptions	Percent	Item
1.	**PHASE 1 (EXPLORATION)** During the first phase of the Learning Cycle, the teacher should give directions and explain the concept that the students are investigating. This is a TRUE statement because:		
	a. students should be told why and what they are investigating so they understand the reason for the activity.	17.86	6
	b. The concept should be derived from the activity because telling is not as powerful as the actual experience.	14.29	6
2.	During the first phase of the learning cycle the teacher:		
	a. explains the concept that the students will be investigating because students should be given a brief and simplified definition of the concept to a pre-exploration mind set to develop.	10.71	7
	b. describes the procedures the students should use because students should be given a brief and simplified definition of the concept to a pre-exploration mind set to develop.	10.71	7
3.	During the first phase of the learning cycle the teacher:		
	a. demonstrates and explains a basic science concept because the teacher must provide a mental framework for the students before they begin exploring.	14.29	11
	b. demonstrates and explains a basic science concept because the teacher has the responsibility of providing the scientific terms when the students are confused.	14.29	11

Table 4. Continued

Misconception		Percent	Item
4.	During the first phase of the learning cycle the teacher:		
	a. keeps students on task and manages their behavior because student should be provided with the materials from which they are to gather data.	25.00	12
	b. is a major informational resource for the students because students must have the important concepts defined at the same time that they are working with materials.	14.26	12
1.	PHASE 2 **(CONCEPT INTRODUCTION)** During the a.third/b.first (respectively) phase of the learning cycle the main purpose is to lead students to build meaningful understanding about their experiences (this is what Piaget called "accommodation") because:		
	a. students are guided to construct knowledge based on there experiences.	25.00	3
	b. hands-on experiences provide concrete understanding.	14.29	3
2.	During the second phase of the learning cycle:		
	a. data are compared and terms are introduced because vocabulary words are key to learning science and students must practice the concepts after exploring them during the hand on activity.	14.29	5
	b. data are compared and terms are introduced because the teacher should allow students to freely explore data and terms; teacher intervention is not necessary.	10.71	5

Table 4. Continued.

Misconception		Percent	Item
3.	During the second phase of the learning cycle, the teacher helps:		
	a. students investigate phenomena first-hand because the teacher will interpret the data for the student.	28.57	9
	b. students report their data to the class because the teacher will interpret the data for the student.	10.71	9
1.	**PHASE 3 (APPLICATION)** During the a.second/b.third (respectively) phase of the learning cycle student are given the opportunity to organize the concept that they have just learned with other phenomena related to this concept because:		
	a. after the teacher explain the new concept the student must be given time for free exploration.	17.86	1
	b. after the information is given to the students they are given the opportunity to make connections to new concepts.	14.29	1
2.	The purpose of the third phase of the learning cycle is to:		
	a. both expand the lesson into other science concepts and extend the previously developed concept in a new context because of the above are true (see item 4 for the reason).	42.86	4
	b. extend the previously developed concept in a new context because of the above are true (see item 4 for the reason).	17.86	4

Table . Continued.

Misconception		Percent	Item
3.	A major role of the third phase of the learning cycle is to:		
	a. aid students in exploring new science concepts and aid students in deepening their understanding because students may be exploring new concepts at the same time they are reinforcing other concepts in order to help form new connections.	28.57	8
	b. aid students in exploring new science concepts and aid students in deepening their understanding because for meaningful learning to occur students must apply previously introduced concepts into new situations.	14.29	8
4.	During the third phase of the learning cycle:		
	a. new concepts are discussed and/or explored because new concepts are assimilated during the new activity.	10.71	10
	b. slightly different types of activities are used to investigate various concepts.	10.71	10
1.	**GENERAL ITEMS** The hands-on investigation in the first phase of the learning cycle can alternatively be used in the third phase because:		
	a. the students go back and revisit the same investigation in more detail a second time.	25.00	2
	b. the investigation used in the first phase is repeated with a different concept during the third phase.	21.43	2
	c. Applying an existing concept to a new situation is the same as exploring a new concept.	39.29	2

Table 4. Continued.

Misconception		Percent	Item
2.	If you were properly using the Learning Cycle to teach students about metamorphosis, then during the third phase an appropriate activity would be to:		
	a. extend the concept of metamorphosis to the concept of migration and/or examine the phenomenon of metamorphosis with an animal different from the one studied during the first phase because the purpose of the third phase is to facilitate the students' making connections among related concepts.	25.00	13
	b. examine the phenomenon of metamorphosis with an animal different from the one studied during the first phase because the purpose of the third phase is to facilitate the students' making connections among related concepts.	17.86	13
3.	Suppose that you were using the Learning Cycle to teach students about the concept of mass. During the third phase of the lesson, an appropriate activity would be to:		
	a. extend the concept of mass into the concept of weight and explore mass with different materials form what were used during the first phase because The purpose is to move the students ahead to consider the more abstract concept of weight.	10.71	14

The Learning Cycle Test, ver. O.3

1. During what phase of the Learning Cycle are students given the opportunity of organize the concept that they have just learned with other phenomena related to this concept? A. Phase One B. Phase Two C. Phase Three D. This is true for more than just one phase. The educational reason for my answer is because: A. After the information is given to the students they are given the opportunity to make connections to new concepts. B. After the teacher explains the new concept the students must be given time for free exploration. C. After the concept is presented appropriate activities are provided to apply the concept to a new situation. D. The learning cycle is all inclusive and develops new concepts during each phase.	2. The hands-on investigation in the first phase of the Learning Cycle can alternatively be used in the third phase. A. This is a TRUE statement. B. This is a FALSE statement. The educational reason for my answer is because: A. The students go back and revisit the same investigation in more detail a second time. B. In most cases the sequence of the activities is not important. C. The investigation used in the first phase is repeated with a different concept during the third phase. D. Applying an existing concept to a new situation is the same as exploring a new concept.
3. During what phase of the Learning Cycle is the main purpose to lead students to build meaningful understandings about their experiences (this is what Piaget called "accommodation")? A. Phase One B. Phase Two C. Phase Three D. This is true for more than just one phase. The educational reason for my answer is because: A. Hands-on experiences provide concrete understanding. B. Schema need to be adjusted so that the principal can be incorporated. C. Students are guided to construct knowledge based upon their experiences. D. Teacher-guided concept construction is essential during each phase.	4. The purpose of the THIRD phase of the Learning Cycle is to: A. expand the lesson into other science concepts. B. extend the previously developed concept in a new context. C. both A and B are legitimate purposes. The educational reason for my answer is because: A. This is when connections to new but similar concepts are made providing cognitive linkage between lessons. B. New knowledge becomes more useful when applied to new situations. C. Old concepts must be integrated with new concepts for accommodation to occur. D. All of the above are true.

5. During the SECOND phase of the Learning Cycle:

A. the teacher explains what happened during the previous phase.
B. students answer questions in writing to reinforce scientific vocabulary.
C. data are compared and terms are introduced.

The educational reason for my answer is because:

A. The teacher acts as a guide, but students must be allowed to verbalize the data and terms for meaningful learning to occur.
B. This is the time traditional instruction plays a role; many labs are complex and the teacher must explain what happened.
C. Vocabulary words are key to learning science and students must practice the concepts after exploring them during the hands-on activity.
D. The teacher should allow students to freely explore data and terms; teacher intervention is not necessary.

6. During the first phase of the Learning Cycle, the teacher should give directions and explain the concept that the students are investigating:

A. This is a TRUE statement.
B. This is a FALSE statement.

The educational reason for my answer is because:

A. Students should be told why and what they are investigating so they understand the reason for the activity.
B. The lesson will not have focus unless the teacher explains the concept they are investigating.
C. The concept should be derived from the activity because telling is not as powerful as the actual experience.
D. The teacher should not introduce the students to the concept but you can tell them the results they should expect.

7. Which teaching behavior listed below is appropriate during the first phase of the Learning Cycle?

A. explaining the concept that the students will be investigating.
B. describing the procedures the students should use.
C. defining the lesson's vocabulary word and giving examples.

The educational reason for my answer is because:

A. Students must understand the concept before they can investigate it.
B. Students should be given a brief and simplified definition of the concept to allow a pre-exploration mind set to develop.
C. Lab procedures are given in order to provide guidance about the activity and the data that should be collected.
D. The intention is for the students to verify pre-defined vocabulary words in a hands-on setting.

8. A major role of the third phase of the Learning Cycle is to:

A. aid students in exploring new science concepts.
B. aid students in deepening their understanding.
C. both A and B would be appropriate.

The educational reason for my answer is because:

A. Students may be exploring new concepts at the same time they are reinforcing other concepts in order to help to form connections.
B. For meaningful learning to occur students must apply previously introduced concepts to new situations.
C. Integration of old and new concepts is essential to promote higher-order learning.
D. According to learning theory new concepts are explored to prevent false accommodation.

9. During the second phase of the Learning Cycle, the teacher helps with which of the following: A. Additional phenomena are discussed and explored. B. Students investigate phenomena first-hand. C. Students report their data to the class and analyze it. The educational reason for my answer is because: A. Students verbalize what they experienced under the guidance of the teacher. B. The teacher will interpret the data for the students. C. The teacher lets the students work individually to construct meaning about the concept. D. Hands-on activities are essential for those students who have a concrete learning style.	10. During the third phase of the Learning Cycle: A. new concepts are discussed and or explored. B. additional phenomena are discussed and or explored that involve the same concept. C. data are reported to the class and terms are introduced. The educational reason for my answer is because: A. New concepts are assimilated during the new activity. B. Slightly different types of activities are used to investigate various concepts. C. Students continue to use the concept under different circumstances. D. The discussions of data are needed to support the presentation of additional vocabulary.
11. During the first phase of the Learning Cycle, the teacher: A. demonstrates and explains a basic science concept. B. observes, questions, and assists the students as they work. C. introduces the skills and vocabulary that will be practiced during the activity. The educational reason for my answer is because: A. The teacher must provide a mental framework for the students before they begin exploring. B. Students must have a sound understanding of a concept before they are presented with the hands-on materials. C. The teacher's role is to provide help with equipment and may guide students in their collection of data. D. The teacher has the responsibility of providing the scientific terms when the students are confused	12. During the first phase of the Learning Cycle, the teacher. A. is a major informational resource for the students. B. facilitates the process of observing and recording data. C. keeps the students on-task and manages their behavior. The educational reason for my answer is because: A. Students must have the important concepts defined at the same time that they are working with materials. B. The teacher may provide the data to the students for them to analyze. C. Students should be provided with the materials from which they are to gather data. D. Students should be prevented from sharing their ideas with others prematurely.

13. If you were properly using the Learning Cycle to teach students about metamorphosis, during the third phase an appropriate activity would be to: A. extend the concept of metamorphosis to the concept of migration. B. examine the phenomenon of metamorphosis with an animal different from the one studied during the first phase. C. using either A or B or both would be in keeping with the Learning Cycle philosophy. The educational reason for my answer is because: A. The purpose of the third phase is to facilitate the students' making connections among related concepts. B. Students need experience with the same concept in a different context. C. Connections among various concepts help to reinforce student learning. D. Teachers should implement various strategies as they help to extend students' understandings.	14. Suppose that you were using the Learning Cycle to teach students about the concept of mass. During the third phase of the lesson, an appropriate activity would be to: A. extend the concept of mass into the concept of weight. B. explore mass with different materials from what were used during the first phase. C. both A and B would be appropriate. The educational reason for my answer is because: A. during this phase a new activity is supposed to extend the same concept. B. The purpose is to move the students ahead to consider the more abstract concept of weight. C. This phase is when existing and emerging concepts are connected for the first time. D. Both mass and weight should be explored to establish scientific understandings of the relationship between the concepts.