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Teachers' Understandings of the Learning Cycle as Assessed With a Two-Tier Test

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The learning cycle is an approach to science instruction gaining increasing favor within the science education community. With its roots in the Science Curriculum Improvement Study (SCIS), the learning cycle is experiencing a revival. Evidence can be found by examining recent curriculum materials whose development was supported by the National Science Foundation. It is reasonable to argue that the widespread inclusion of the learning cycle in these materials represents an endorsement of the instructional approach.

The degree to which the curriculum writers explicitly enacted the learning cycle varies across the projects, yet clear references are made to this approach at some point in all of the programs' descriptions. *Science for Life and Living*, written by the Biological Sciences Curriculum Study (BSCS, 1992), and the INSIGHTS modules, written by the Education Development Center (EDC, 1994), are exemplary elementary science programs that provide clear guidelines to teachers on the use of the learning cycle. The BSCS materials make use of a five-phase learning cycle called "The 5 Es"--Engage, Explore, Explain, Elaborate, and Evaluate. The EDC curriculum relies upon a four-phase learning cycle--Getting Started, Exploring and Discovering, Processing for Meaning, and Extending. Independent of the labels ascribed to the phases, the learning cycle represents an inductive application of information processing models of teaching (Weil & Joyce, 1978). As such, they place a premium upon not only the content students are expected to learn but also emphasize an understanding of the thought processes involved in the construction of new knowledge.

Apart from the prevalence of the learning cycle in a host of curricula, it is unclear how congruent implementation by classroom teachers is with the intent of the model. The direct instruction model is so deeply ingrained in the teaching tradition that resistance is to be expected. Cynics might charge teachers with a general resistance to any change and would suggest the learning cycle is an instructional approach which threatens the tranquility of traditional instruction. Those of us who are a little less pessimistic believe that the resistance is a natural outgrowth of the skeptical nature of humans toward any innovation.

Purpose

The purpose of this article is to describe the assessment of teachers' understandings of the learning cycle. One impetus for undertaking this investigation was an increasing concern by the authors about their effectiveness as science teacher educators with guiding science teachers to understand the philosophy and skills associated with the appropriate execution of the learning cycle during classroom instruction. Many of our preservice teachers in the past have acknowledged support and voiced advocacy of this method of teaching science at the elementary and secondary school level; however, we were without a tool for evaluating the depth of their understanding. In addition, in working in the inservice environment, there was a worry that the learning cycle approach to teaching science was incompletely accepted and understood.

Identification of teachers' understanding of the learning cycle is one step toward improving science instruction where 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 (Barman, 1992; Barman & Shedd, 1992; Marek, 1990), and there are no reports on efforts to develop an objective multiple choice instrument to assess teachers' understandings of the learning cycle. Further, few studies have comprehensively identified teachers' misconceptions about the learning cycle. This research study addressed the situation by: (a) describing the development of a diagnostic test to assess teachers' understandings of the learning cycle and (b) highlighting common misconceptions identified through the administration of the diagnostic instrument.

Overview of Instrument Construction

The development of the Learning Cycle Test followed the procedure modelled after Odom and Barrow (1995) and consisted of three phases: (a) defining the content boundaries of the test, (b) writing multiple choice questions with free response reasons, and (c) writing the final two-tier test items and administering the instrument to obtain information about teachers' misconceptions.

Phase 1

1. Content boundaries were defined with a list of propositional knowledge statements.
2. Content validity of the propositional knowledge statements was determined.

Phase 2

3. Multiple-choice questions with free response reasons were constructed and administered.
4. Free response answers were analyzed and common misconceptions were identified.

Phase 3

5. Final test questions were constructed based on multiple-choice questions with free response reasons.
6. Final test questions were revised and a pilot study was conducted.
7. Final content and face validity of each item were determined with assistance of a specification grid.
8. Final version of the Learning Cycle Test was administered.

Propositional Knowledge Statements

Propositional knowledge statements were used to define the content boundaries of the Learning Cycle Test. The propositions were derived from Barman (1989), Renner and Marek (1988), and Lawson (1995). A list of 17 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 (see Figure 1). The content validity of the propositional knowledge statements was established by 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.

Multiple Choice Items with Free Response Reasons

Based on the validated list of propositional knowledge statements, 21 multiple choice items with free response were written. The first tier of the test was in multiple choice format with 2, 3, or 4 choices. The second tier was the statement, "The educational reason for my answer is because . . ." A blank space was provided for the answer. Students were asked to explain the reason for their multiple choice selection. This test was administered to

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 to 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 actively 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 previously explored.
17. For meaningful learning to occur, students must experience the same concept in different contexts.

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.

Figure 2 shows a multiple choice item prompting a free response reason. The item explores understanding of Phase 3, Concept Application. When answering this type of item the student first selects a multiple choice answer for the first tier. Next, the student writes his or her reasoning for selecting the multiple choice answer.

Figure 2. *Example of multiple choice item and two examples of students' reasoning for their responses.*

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:

Student 1
(A) I feel that new terms (vocabulary) can also be introduced at this time when they become relevant and necessary.

Student 2
(C) As a teacher, you want to extend and expand the new material so that students can see the connection it has with other science concepts.

The most common misconceptions emerging from the free response portions were used to create the choices in the second tier of the subsequent version of the instrument.

Two-Tier Multiple Choice Items

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 questions with 2, 3, or 4 choices. The second tier consisted of four possible reasons for the first part--one desired reason and three alternative reasons. The alternative reasons were based on misconceptions detected during the multiple choice test with free response reasons.

The final version of the learning cycle test consisted of 13 items. The areas covered by the test were Phase 1 (Exploration), Phase 2 (Concept Introduction), and Phase 3 (Application). Table 1 offers an example of an item that assesses Phase 3, as well as the item analysis.

Table 1. *Item 1 on the Learning Cycle Test and students' responses (%).*

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 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 new learning cycle is all inclusive and develops new concepts during each phase.

	Second Tier				
First Tier	A	B	C	D	Total
A	1.8	5.5	0.0	0.0	7.3
B	5.5	3.6	9.0	1.8	19.9
C	10.9	5.5	38.2*	3.6	52.7
D	1.8	0.0	1.8	16.4	20.0

* Desired response combination

For the final instrument, a specification grid was constructed to re-evaluate the face validity and determine 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?
2. Is the question at a level of sophistication appropriate for elementary and secondary science teachers?

If the above criteria were not met, those items were eliminated. All 17 propositional knowledge statements were matched to the items on the Learning Cycle Test, and all of the questions incorporated more than one of the propositional knowledge statements (see Figure 3).

Figure 3. *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	Phase 3 (Application)	13, 17
3	Phase 2 (Concept Introduction)	8, 10
4	Phase 3 (Application)	13, 14
5	Phase 2 (Concept Introduction)	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 Introduction)	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	Phase 3 (Application)	16, 17

Sample of Population Studied

The Learning Cycle Test was administered to 55 undergraduate students enrolled in elementary science methods. Most of the students were seeking elementary certification (1-8) although a few were working towards developmentally handicapped certification. All of the students were within one or two quarters of their student teaching experience. Each student received instruction about the learning cycle prior to test administration. Students participated in learning cycle lessons modelled 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 the Items

An item was considered to be 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 Phase 3 (Application) is shown in Table 1. In this item, 52.7% of the students selected the desired first tier answer, while only 38.2% selected the desired first and second tier answer combination.

Results

Table 2 summarizes the characteristics of the Learning Cycle Test. Reliability was determined with the Kuder-Richardson formula 20 and was estimated to be 0.76. The difficulty indices ranged from 0.127 to 0.727, providing a wide range of difficulty items. The discrimination indices ranged from 0.157 to 0.692.

For the first tier of the test, the range of correct answers was 34.6% to 85.4% (see Table 3). When both tiers were combined, the correct response was reduced to a range of 12.7 % to 72.7%. The results of the Learning Cycle Test suggest that, for this population, the students did not acquire a satisfactory understanding of the learning cycle.

Misconceptions

Twenty-eight misconceptions were identified through analysis of items on the Learning Cycle Test. Selected misconceptions are discussed below.

Phase 1

Understanding of Phase 1 of the learning cycle was assessed by items 6, 7, 11, and 12. On the basis of their responses to these four items, the students had an insufficient understanding of this component of the learning cycle. The percentage of students selecting the desired answer combinations

Table 2. *Characteristcs of the Learning Cycle Test.*

Areas evaluated:	Phase 1 (Exploration) 6, 7, 11, 12		
	Phase 2 (Concept Introduction) 3, 5, 9		
	Phase 3 (Application) 1, 2, 4, 8, 10, 13		
Content:	Validated propositional knowledge statements and concept map		
No. of items:	13		
Recommended level:	Preservice science teachers		
Time:	20-30 minutes		
Discrimination indices:	Mean	Range	Items
	0.51	0.10-0.19	1
		0.30-0.39	2
		0.40-0.49	3
		0.50-0.59	2
		0.60-0.69	5
Difficulty indices:	0.58	0.10-0.19	3
		0.20-0.29	1
		0.30-0.39	2
		0.40-0.49	3
		0.50-0.59	2
		0.60-0.69	1
		0.70-0.79	1
KR-20 reliability:	0.76		

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

Items	First Tier	Combination
1	58.2	38.2
2	49.2	25.5
3	36.4	16.4
4	36.4	12.7
5	85.4	52.7
6	74.5	72.7
7	76.4	67.3
8	34.6	18.2
9	54.6	45.5
10	67.3	52.7
11	52.8	45.5
12	52.8	45.5
13	49.1	34.5

were 73%, 67%, 46%, and 46%, respectively. Item 6 addressed the role of the teacher during exploration. 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." Eleven percent of the students selected this response.

In Item 11, students were asked about the role of the teacher during the first phase (Exploration). The desired response, selected by 46% of the students, was: "During the first phase, the teacher observes, questions, and assists students as they work because the teacher's role is to provide help with equipment and may guide students in their data collection." There were two common alternative responses, selected by 18.2% and 14.5% of the students, respectively. 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." The second was: "Because the teacher has the responsibility of providing the scientific terms when the students are confused." Similarly, on Items 7 and 12, students frequently selected responses describing a more directive role for the teacher during the exploration phase.

Phase 2

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 16% of the student selected the desired response: "The main purpose of Phase 2 is to lead students to build meaningful understanding about their 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 (30%) and Phase 1 (16%).

In Item 5, students were asked to identify what occurs during Phase 2. The desired answer was selected by only 53% of the students: "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 must practice the concepts after exploring them during the hands-on activity" (15%). Another common alternative response was: "Students should be allowed to explore data and terms freely; teacher intervention is not necessary" (16%). Similarly, only 46% of the students selected the desired response for Item 9, indicating confusion about the role of the teacher during Phase 2.

Phase 3

The application phase was examined through items 1, 2, 4, 8, 10, and 13. Item 1 asked, "At what time do students organize the concept they have just learned with other phenomena?" Only 38% selected the desired answer: "Phase 3 because after the concept is presented appropriate activities are provided to apply the concept to a new situation." The most frequent alternative selection was: "This is true for more than one phase because the learning cycle is all inclusive and develops new concepts at each phase" (16%).

In Item 2, 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 26% of the students selected the desired response. The most common alternative responses were: "To extend the concept of metamorphosis to the concept of migration" and "Examine additional phenomena related to metamorphosis because connections among various concepts helps to reinform learning." These represented 20% of the responses.

Many of the students revealed the misconception that Phase 3 is an opportunity for students to extend their understanding of a science concept to a new science concept. The intent of the learning cycle's Phase 3 is actually to serve as an opportunity for students to apply the same concept to a new situation in order to reinforce that concept. The understanding of the purpose of Phase 3 was assessed with Item 4 but only 13% of the students selected the desired response; 47% chose the alternative response: "Is to both expand the lesson into other concepts and extend the previously developed concept into other contexts." Likewise, in Item 8, only 18% of the students selected the desired response, whereas 40% were drawn to select the alternative response that: "The major role of Phase 3 was to explore new science concepts and deepen understanding because students may be exploring new concepts at the same time they are reinforcing other concepts in order to form connections." Similarly, in Item 10, common alternative responses centered around the belief that the function of Phase 3 is to help students learn new concepts (10.71%).

In Item 13, students were asked to select a proper activity for Phase 3 in a lesson about mass. Only 35% of the 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 this phase is when existing and emerging concepts are connected for the first time" (13%).

Conclusions and Implications

This study provides evidence that the learning cycle is a difficult instructional approach for elementary education majors to understand. The high frequency of alternative conceptions that students in this study displayed is especially troubling given that the assessment was administered after they had received instruction about and extensive modelling of the learning cycle. The confusion about the learning cycle was distributed across the three phases, indicating a general uncertainty and/or confusion about the approach and the underlying philosophy.

The most common alternative concepts about the role of the teacher during Phase 1 was that the teacher should explain and/or define the particular science concepts before the students had the opportunity to engage in exploration of the phenomena. It was commonly felt that during Phase 2 the teacher's role is to interpret data for the students and that the emphasis should be placed upon the acquisition of proper scientific vocabulary. Phase 3 was often regarded as the time in which students are presented with additional and new science concepts.

One of the factors that may contribute to misunderstandings about the learning cycle is the prior experiences that preservice teachers have had as students in science classes and within their other instructional methodology courses. The students often remarked that the learning cycle is an approach that departs greatly from the direct instruction approach presented in other courses and reinforced by supervisors during field experiences. Unfortunately, even though the students express fondness for the learning cycle approach as both learners and future teachers, the test indicates that they retain many mistaken notions about the role of the teacher during different phases.

In spite of the low scores, the Learning Cycle Test appears to provide a feasible mechanism for evaluating students' understandings about the learning cycle instructional approach. Furthermore, because of the design of the instrument (i.e., a two-tier test), it allows for the identification of alternative conceptions held by the students. Although the results may be troubling to elementary science methods instructors, the data provided by the test can be used to improve instruction about this topic.

The Learning Cycle Test could become an important tool for assessing practicing teachers' understandings of this method of instruction. Surveys of teaching practices repeatedly demonstrate how few teachers are employing strategies that support students' inquiry as advocated in the *National Science Education Standards* (National Research Council, 1996).

When Weiss (1987) asked teachers to describe their most recent science lesson, three fourths of third-grade teachers acknowledged the use of lectures, half made use of hands-on activities, and only one third of the time was small group work included in the lesson. More recently in the Goals 2000 Report (National Education Goals Panel, 1994), science teachers were asked to indicate the strategies they used with their eighth-grade students. This data revealed that many of the elements of the learning cycle (i.e., group investigation, deliberations about data) did not commonly occur during science lessons. The Learning Cycle Test may guide the efforts of professional development providers working to improve the quality of science instruction.

The existence of a valid and reliable instrument for assessing preservice teachers' understandings of the learning cycle provokes additional questions worthy of additional investigation. We recommend exploration of the following questions: Is the learning cycle method itself an effective method for introducing the learning cycle to educators (Rubba, 1992)? What is the relationship between scores on the Learning Cycle Test and measures of students' self-efficacy or stages of concern about teaching science to children? What is the relationship between scores on the test and actual performance of science lessons by teachers? What are secondary science teachers conceptions of the learning cycle? Is there a relationship between science content background and understanding of the learning cycle?

Although the instrument described here will not answer these questions by itself, it provides a tool for science educators who seek the development of teachers who understand and can successfully implement the learning cycle.

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Appendix A

The Learning Cycle Test, Version 0.4

1. 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 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 new learning cycle is all inclusive and develops new concepts during each phase.

2. If you were properly using the learning cycle to teach students about metamorphosis during the <u>third</u> 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 <u>first</u> 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 <u>third</u> 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.

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 <u>third</u> 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 <u>second</u> 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 <u>first</u> 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 <u>first</u> 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 words 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 predefined vocabulary words in a hands-on setting.

8. A major role of the <u>third</u> 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 are 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 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 <u>second</u> phase of the learning cycle, the teachers 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 <u>third</u> 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 discussion of data is needed to support the presentation of additional vocabulary.

11. During the <u>first</u> 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 <u>first</u> 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. 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.

KEY

1. CC
2. BB
3. BC
4. BB
5. CA
6. BC
7. BC
8. BB
9. CA
10. BC
11. BC
12. BC
13. BA