



BEHAVIORAL
RESEARCH
& TEACHING

Training Module 3

Focus on Teaching
and Learning in
Content Classes

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Goals of the Training Module

This training module is designed to provide you, the content area teacher, with strategies for adapting instruction and assessment to meet the needs of students who may be at risk of failure because they lack skills in reading or writing. The strategies described in the module are based on two premises: (1) many special education students need to and are able to learn content area material; and (2) content area teachers are able to provide instruction that is effective for all students in their classrooms. The following objectives are aimed at assisting teachers as they attempt to accommodate the learning needs of an increasingly diverse group of students. During the training you will have opportunities to learn about and gain practical experience with each of these objectives.

- ⇒ *Distinguish among the characteristics of different forms of knowledge: facts, concepts, and principles.*
- ⇒ *Manipulate information using six different intellectual operations: reiteration, summarization, illustration, prediction, evaluation, and application.*
- ⇒ *Decide which information in your curriculum is the most important for students to learn.*
- ⇒ *Plan instruction that models use of higher order intellectual operations and offers students opportunities to practice using information in critical thinking and problem-solving contexts.*
- ⇒ *Check your students' perceptions about the importance and interrelationship of information you present.*
- ⇒ *Develop assessment tasks that will help you evaluate the effectiveness of your instruction for teaching students to use information in complex intellectual operations.*

Research Basis for the Training

Serving Special Education Students in Content Area Classes

In a review of literature pertaining to teacher competence, Reynolds¹ identified three domains of understanding associated with teacher competence: (a) broad background knowledge and content understanding, (b) general principles of teaching and learning, and (c) content-specific pedagogy. In current models of special education in middle and high school content classes, expertise in these three domains often has been delegated to various individuals including assessment specialists, special education teachers, and classroom content teachers. Among these domains, classroom teachers are most highly trained in content knowledge and pedagogy, while special educators are likely to be most highly trained in principles of teaching and learning. Indeed, expertise in this area defines the job of special education teachers in many settings.² However, special education teachers often assume responsibility for much of the content instruction that special education students receive. For example, in a survey of all state Departments of Education, McKenzie³ found that almost half of the schools in the U. S. use a content approach in their special education programs, and fully 20% of students with learning disabilities received all content instruction from special education teachers. In earlier research Patton, Palloway, and Cronin⁴ surveyed 284 special education teachers from all grade levels and found that between 50% and 70% taught social studies in special education settings, but 43% indicated they had no training in social studies education.

¹A. Reynolds, "What is Competent Beginning Teaching: A Review of the Literature," *Review of Educational Research*, 62(1992): 1-36.

²M. Pugach, "The National Reports and Special Education: Implications for Teacher Preparation," *Exceptional Children*, 53(1987): 308-314.

³R. G. McKenzie, "Content Area Instruction Delivered by Secondary Learning Disabilities Teachers: A National Survey," *Learning Disability Quarterly*, 14(1991): 115-122.

⁴J. R. Patton, E. A. Palloway, & M. E. Cronin, "Social Studies Instruction for Handicapped Students: A Review of Current Practices," *The Social Studies*, May/June(1987): 131-135.

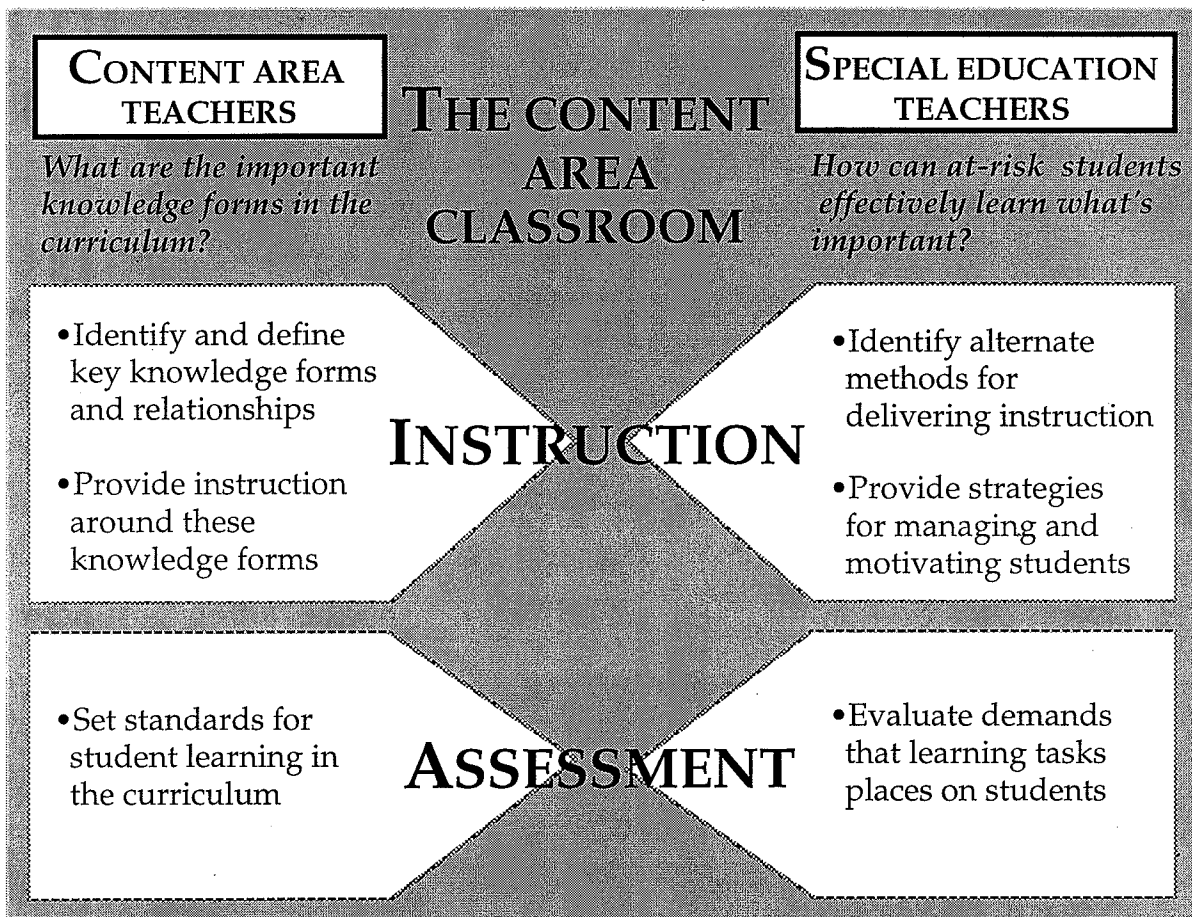
As the Patton, Palloway, and Cronin data suggest, special education teachers may have limited background in content disciplines such as English, science, geography, or history, and few would be expected to have understandings comparable to that of content area teachers in multiple disciplines. Yet content understanding is the primary factor governing student achievement in content classes.⁵ At best, typical special education teachers could be expected to provide adequate content instruction in only one or two of the subject areas typically offered in a middle or high school. Therefore, in many content areas, special education students probably will not receive instruction comparable to that of their peers in mainstream content area classes if they receive it from a special education teacher.

The clear implication is that while special educators may be most effective in implementing strategies that improve the basic reading, writing, communication and social skills of low achieving students, they may be much less effective at helping students apply those skills at a functional level to specific content. As William Shakespeare reminds us in Hamlet, "the readiness is all," but eventually students need to shift from "getting ready" to "doing." As many special education students reach middle school and beyond, the focus of their educational program must shift increasingly toward acquisition and use of content knowledge. It seems appropriate that they should receive instruction from those teachers who have the most expertise in the content areas. However, just as we should not expect special education teachers to have the expertise required to teach in all the content areas, neither should we expect content area teachers to automatically be able to tailor instruction to fit the needs of every special education student who comes to their class.

We propose a model of special education in which content helps to determine theoretically and conceptually the purpose of curriculum and instruction. This model defines a new relationship between special education and general education teachers. The content area teacher brings to this relationship expertise associated with content knowledge of the particular domain. This discipline knowledge permits identification of key knowledge forms (facts, concepts, principles, and procedures) around which content instruction can be organized. The special education teacher, in turn, brings pedagogical expertise related to methods for designing instruction, classroom management, and motivational strategies effective with at-risk learners. Finally, both need to consider assessment in terms of the standards for learning (from the content teacher's perspective) and the demands made upon students (from the special education teacher's perspective). This model would redefine the working

⁵Reynolds, 1-36.

relationship between special and general educators. While it is assumed that students would receive their primary instruction from the content experts, special educators have a role in helping support students through the curriculum and instruction. They also must become familiar with the demands set by the content area teachers in terms of not only the criterion for success (i.e., performance on the test) but also the content of the assessments. The figure below illustrates this new relationship.



A Model of Special Education for Content Area Classes.

What Our Research Says

In developing this model, we examined a wide range of variables in middle school social studies and science classes, including curriculum materials, teachers' interactive instruction, student perceptions, and students' performance on chapter and end of unit tests. We found that if a term is presented in the textbook, it is likely to be summarized by the teacher during instruction and students are likely to perceive it as important. However, content teachers differentially focus on various aspects of the material contained in the curriculum. Some information that the textbook identifies as important may be only briefly mentioned by the content teacher during instruction, while the teacher may expand greatly on other information that receives little emphasis in the text. This finding is significant when student perceptions are considered.

We asked students to list the most important words and ideas they had learned in a particular lesson and found, not surprisingly, the more frequently the teacher refers to a term during instruction, the more likely students are to perceive it as important. Furthermore, when students perceive information as important, they are more likely to answer multiple choice questions about it correctly on end-of-chapter tests. This finding may imply that simply asking students to list the terms they think are important could be a useful tool for periodically checking their acquisition of the lesson content. Such a quick check could provide a method for a special education teacher to monitor student progress regularly and serve as the basis for content-focused discussions between the special education teacher and general education teacher.

Our research also suggests that it is not only frequent reference to a term that makes students perceive it as important. We found student perceptions about what information is important, as well as their performance on the end-of-chapter test, seem to be associated with the way a concept is used during instruction. When teachers provide instruction that gives students opportunities to observe and practice the use of information in solving problems and making predictions and other complex tasks, students in remedial or special education are more likely to answer selection response items about it correctly on end-of-chapter tests than when the information is only summarized. This result suggests that the use of key information in higher order operations during class could be directly related to improving the achievement of low performing students on curriculum embedded tests. We also found that the performance of special education and Chapter 1 students on objective items correlates moderately well with that of general education students and that low achieving students do not seem to lag that far behind their non-handicapped peers in thinking skills. Rather, their

weaknesses seem to be in the ability to communicate their thoughts on essay type response items. Their lower performance on tasks of this nature may be a consequence of basic skills deficits rather than lack of understanding about the content.

Findings like these have convinced us that not only is it appropriate for at-risk students to receive content area instruction, but it is also reasonable to hold them to many of the same minimum achievement standards that have been set for their peers who are not at risk. Furthermore, these students can benefit most from instruction that is provided by content area experts in a regular classroom setting. The task for the content teacher, working in collaboration with the special education teacher, is to make content accessible and meaningful for students with learning special needs. It's no secret that it's difficult enough to meet this goal for students who do not have special needs. Adjusting your instruction so that the needs of special education students are also met in the content classroom may seem like a lot to ask, especially when you think about the curriculum materials both you and your students must work with. In the pages that follow we offer an approach to instructional planning and delivery that can make the task of interpreting the curriculum more manageable for the teacher. At the same time it can make the task of learning what's important more manageable for all students, especially those who are at risk of failure.

Knowledge Forms

We need to look at both the kind of information that we present to learners and the manner in which we expect them to manipulate this information and with it, demonstrate facility. Information can be organized according to three different types or **knowledge forms**: facts, concepts, and principles. Each of these knowledge forms is defined and illustrated below.

Facts are simple associations between names, objects, events, places, etc. that use singular exemplars. The distinguishing feature of a fact is that the association is very limited and not generalized across a range of names, objects, events, places, etc. The following represent facts from history and literature that were part of a Gallup poll of 686 American college seniors reported in the *Eugene Register Guard* which students noted were either True or False⁶

- William Shakespeare wrote *The Tempest*.
- Mark Twain wrote *The Adventures of Huckleberry Finn*.
- Harry S. Truman was president when the Korean War began.
- Karl Marx stated, "From each according to his ability, to each according to his need."

The overall results from this survey were as follows: For the 49-question history subtest, 39% of the college seniors failed; for the 38-question literature subtest, 68% failed. For the combined 87-question test, only 11% would have received a grade of 'A' or 'B.'

The biggest problem with tests like this, beyond the issue that the results were spread over the front page of the newspaper, is that only facts were tested. Very narrow questions were asked that represented associations between single exemplar objects, events, dates, etc. Facts are very difficult to remember without an organizing scheme to link them. Yet, they are the basic building blocks to more complex information and are necessary, for example, in developing a vocabulary that can be used to work with concepts and principles.

⁶ T. Henry, "Christopher Columbus Did What? Where? When?" *Eugene Register Guard*, Eugene, OR, October 9, 1989.

Concepts are clusters of events, names, dates, objects, places, etc. that share a common set of defining attributes or characteristics. A concept may be thought of as "a category of experience having a rule which defines the relevant category, a set of positive instances or exemplars with attributes and a name (although this latter element is sometimes missing)."⁷ In this definition, rules provide the basis for organizing the attributes of the concept; these attributes, in turn, provide the criteria for distinguishing examples of the concept from nonexamples.

Concepts form the bedrock for a great deal of teaching and learning in all classrooms. In a magazine story for young elementary students entitled *Go, Team, Go!*⁸, the question is asked: "What's it like to be a musher, or sled dog driver?" The same magazine presents a story about the Bermuda Triangle. Both of these terms, "musher" and "Bermuda Triangle," are concepts: the former refers to a particular kind of person and the latter refers to a distinct geographic area. In a high school math class, students may be taught the following examples of the concept "quadrilateral": rectangle, rhombus, trapezoid, square, and parallelogram. In a political science class students may be learning about communism, socialism, and democracy—all of which are complex concepts.

Concepts form a major part of our daily vocabulary, in and out of schools. Consider the many different labels we use with our students: talented and gifted, intelligent, learning disabled, mentally retarded, etc. Many of these concepts are poorly defined—the rules for specifying which attributes should be considered as exemplars and non-exemplars are often vague, containing contradictions. Many objects in our daily life are examples of concrete concepts: trees, stools (when does a stool become a chair?), automobiles (what is the difference between a car and a truck?), desks, computers, etc.

Principles indicate relationships among different facts or concepts, more often the latter. A principle usually represents an if-then or cause-effect relationship, although this relationship may not be stated explicitly. A principle generally involves multiple applications in which the fundamental relationship among the relevant concepts is constant across virtually all examples of the concepts. Principles form the foundation for organizing information into meaningful chunks. Since

⁷P. Martorella, *Concept Learning: Designs for Instruction* (Scranton, PA: Intext Educational Publishers, 1972).

⁸National Geographic, "Go, Team, Go!" *National Geographic World*, 172 (1989): 3-7.

FACT

Definition	A simple association of a name, event, object, date, or place with a specific stimulus. Facts entail only one example or instance.
Examples	<ul style="list-style-type: none">• Pierre is the capital of South Dakota.• The atomic symbol for hydrogen is H.
Nonexamples	<ul style="list-style-type: none">• state capitals• elements

CONCEPT

Definition	<p>A class of events, names, dates, objects, places, etc. that share a common set of defining attributes or characteristics. Concepts involve three components:</p> <ul style="list-style-type: none">(a) a label,(b) the set of defining attributes, and(c) multiple examples or exemplars. <p>At least the name and the defining attributes must be provided in a textbook passage for a concept to be recorded.</p>
Examples	<ul style="list-style-type: none">• A <i>state</i> is one of the fifty internally autonomous territorial and political units comprising the federation known as the United States.• A <i>river</i> is a large natural stream of water that flows from higher elevation to lower elevation and empties into an ocean, lake or other body of water.• An <i>element</i> is a substance made of just one kind of atom.
Nonexamples	<ul style="list-style-type: none">• Mississippi• The Nile• Oxygen

PRINCIPLE

Definition	A consistent relationship among events, objects, or behaviors. Principles generally can be stated as "if-then" or "when-then" statements. Principles generally involve multiple applications in which the fundamental relationship is constant across examples. To be coded in a textbook passage, the fundamental relationship must be stated explicitly, regardless of whether or not examples are provided.
Examples	<ul style="list-style-type: none">• When demand goes up, supply goes down.• If vital resources in a region become scarce, the inhabitants will move away.• If a gas is heated, then it expands.• For every action there is an equal and opposite reaction.
Nonexamples	<ul style="list-style-type: none">• The most valuable resource in the Middle East is water (fact).• Many plains Indians were nomadic (fact).• A gas is a substance that disperses evenly throughout any container in which it is placed (concept).

principles sometimes involve complex connections among, objects, events, or other constructs, it is often difficult to recognize when a principle is operating to organize content. In addition, principles are often stated implicitly—if at all—rather than explicitly. As we will see this is very often true in content area textbooks.

Occasionally, principles underlying the organization of content are easily identified. In the physical sciences, for example, the law of conservation of matter, the laws of thermodynamics, the various gas laws, and so on serve as unifying principles for much of the teaching and learning that goes on in lectures and lab activities. Similarly, in social studies, economic principles such as the law of supply and demand and the law of diminishing returns can help students begin to make sense of the operation of a free market economy. In the biological sciences, the nitrogen cycle is a complex principle that is often shown in an intricate graphic display as a way to capture the many relationships present.

The table on the preceding page provides a brief summary of the three knowledge forms, along with a few examples and nonexamples of each form. As the tables suggest, relationships among objects, events, and places get increasingly complex as we move from facts to concepts to principles. However, increasing complexity does not necessarily imply increasing difficulty. Quite the contrary; the relationships present in concepts and principles may actually make them easier to remember and use than facts. For example, which task would you find easier: learning the names of the 50 United States (50 separate facts), or learning the attributes of the concept "state"? Which task would be more useful in helping you understand our country's political structure? Would knowing the names of all 50 states help you understand what a state is?

Is It a Fact, Concept, or Principle?

As you become familiar with these three knowledge forms, you may find yourself thinking about different pieces of information that you know, and trying to determine their form. One thing you may have already noticed is: "It depends."

Fact or Concept? Whether a piece of information is a fact, concept or principle depends on how it is presented. Consider the statement "A dog is a mammal." This is a fact—a simple relationship between two constructs. If we elaborate on the statement to say that, "A dog is a mammal that walks on all fours, barks a lot, usually

has a long tail and is frequently kept as a pet by humans," the fact remains that a dog is a mammal. However, "dog" is now defined as a concept:

- (a) "dog" is the label;
- (b) "a mammal that walks on all fours, barks a lot, usually has a long tail and is frequently kept as a pet by humans" is a set of defining attributes;
- (c) examples of the concept "dog" include collie, poodle, mongrel, etc.

The attributes of the concept "dog" allow us to eliminate "tabby", "opossum", "gray whale", etc. from our list of examples. "Dog" as a concept is far more powerful in helping us make discriminations than are the facts about dogs.

Concept or Principle? Similarly, a piece of information may represent either a concept or a principle, depending on how it is presented. Here is an example from chemistry:

A gas is a substance that disperses evenly throughout any container in which it is placed. (concept label: gas + defining attributes: a substance that disperses evenly throughout any container in which it is placed)

If a gas is placed in a container of any size, then it disperses evenly throughout the container. (principle: if - then relationship that holds across all examples of the concept "gas")

It may seem that the distinction between a concept and a principle is not that important in this example, and it probably isn't. The first description of gas as a concept can be helpful in drawing distinctions between the three states of matter. The second description of gas as a principle provides an explicit lawful relationship that allows us to predict with some certainty how gases will behave. As this example suggests, it is not just the form knowledge takes that matters—what we do with knowledge forms is equally important. In the next section we describe a range of behaviors students and teachers can engage in as they use content information.

Intellectual Operations

While analysis of knowledge forms provides a structure for information that we present in our classrooms, we also need to identify specific behaviors in which we want students to engage. What do we want students to do with the facts, concepts and principles we teach? Write reports? Give speeches? Draw pictures? If we do expect them to engage in these tasks, how do we know if their performance represents learning?

When we use terms such as "higher order thinking," "critical thinking," and "problem solving", we refer to the manner in which information is used. However, one of the problems with terms such as these is that they may mean different things for different people. For example, the term higher order thinking can refer to a variety of activities such as answering questions based about reading passage, writing an essay, or solving a physics problem.

A variety of frameworks have been described pertaining to the tasks a learner performs, the most widely recognized of which is the one proposed by Bloom and his colleagues. The intent of Bloom's taxonomy was to provide a set of educational goals that would define terms such as "really understand," "internalize knowledge," "grasp the core essence," and "comprehend" to facilitate discussion among teachers about curriculum and evaluation using a common vocabulary.⁹ To the extent that the taxonomy has been widely accepted and used by educators, Bloom, et al. have been successful. However, Bloom's taxonomy may be problematic for a number of reasons¹⁰. Contrary to the idea of a range of levels proposed by Bloom, et al. as few as two levels may actually exist.¹¹ Also, because Bloom's taxonomy does not use operational definitions of the operations at each level, inter-rater agreement may be

⁹ B. S. Bloom, M. D. Engelhart, E. J. Furst, W. H., Hill, & D. R. Krathwohl, *Taxonomy of Educational Objectives: Cognitive Domain*. (New York: Longman, 1956).

¹⁰ G. H. Roid, and T. M. Haladyna, "The Emergence of an Item-writing Technology," *Review of Educational Research*, 50(1982), 293-314; R. G. Williams and T. M. Haladyna, "Logical Operations for Generating Intended Questions (LOGIQ): A Typology for Higher Order Level Test Items," In G. H. Roid and T. M. Haladyna (Eds.), *A Technology for Test-item Writing*, (New York: Academic Press, 1982), 161-186; R. G. Williams, "A Behavioral Typology of Educational Objectives for the Cognitive Domain," *Educational Technology*, 17(1977), 39-46.

¹¹ G. F. Madaus, F. Woods, and R. L. Nuttall, "A Causal Model of Bloom's Taxonomy," *American Educational Research Journal*, 10(1973): 253-262; W. G. Miller, J. Snowman, and T. O'Hara, "Application of Alternative Statistical Techniques to Examine the Hierarchical Ordering in Bloom's Taxonomy," *American Educational Research Journal*, 16(1979): 241-248.

low among educators attempting to classify items with the framework.¹² Finally, Bloom's system pertains to the manner in which the learner acts on information but tells little about the nature of the information itself.¹³

What we need is a characterization of identifiable behaviors, or **intellectual operations**, that allow us to determine whether or not students are able to manipulate content area knowledge forms in meaningful ways. The key here is that the behaviors should be identifiable or observable. That is, there would be a fairly high level of agreement between two skilled observers that a particular observation had occurred.

We use a framework that employs six intellectual operations: reiteration, summarization, illustration, prediction, evaluation, and application. Our classification scheme is based on the work of Miller, Williams and Haladyna¹⁴. This framework can be distinguished from other taxonomies, including that of Bloom and his associates, because each of the operations represents directly observable behavior that can be directly linked to the content and structure of instruction.

Our taxonomy of intellectual operations is described in table on page 17. Each operation represents a different degree of control over information and complexity of interaction. Generally, we view these operations, as increasing in complexity, where reiteration and summarization represent less complex operations while prediction, evaluation, and application represent higher levels of complexity. However, there is no reason to believe that the scale of difficulty or sophistication applies beyond this simple dichotomous cut. The differences in complexity among the last three operations may be negligible: they all represent adequately intricate manipulations of information.

These six intellectual operations interact with the knowledge forms (Facts, Concepts, Principles) described above so that some operations may be more realistic than others with some knowledge forms. Reiteration and summarization can occur with all three knowledge forms—students engage in these forms of behavior when asked to recite facts, recall definitions of concepts, or restate lawful relationships.

¹² G. M. Seddon, "Properties of Bloom's Taxonomy of Educational Objectives for the Cognitive Domain," *Review of Educational Research*, 48(1978): 303-323.

¹³ W. C. Becker, *Applied Psychology for Teachers*. (Chicago: Scientific Research Associates, 1986).

¹⁴ H. G. Miller and R. G. Williams, "Constructing Higher Level Multiple Choice Questions Covering Factual Content," *Educational Technology*, 13(1973): 39-42; Williams, "A Behavioral Typology of Educational Objectives for the Cognitive Domain," 39-46; Williams and Haladyna, "Logical Operations for Generating Intended Questions (LOGIQ): A Typology for Higher Order Level Test Items," 161-186.

Illustration can be used only with concepts and principles since it requires an individual to recognize or generate previously unused examples of a piece of information. A fact cannot be illustrated because it consists of a single simple relationship between constructs.

INTELLECTUAL OPERATION	refers to the behavior employed in using or manipulating knowledge forms.
Reiteration	<p><i>A verbatim reproduction of material that was previously taught.</i></p> <ul style="list-style-type: none"> • The emphasis is on <u>verbatim</u>. The wording in the student's response must be very nearly identical to that presented in instruction.
Summarization	<p><i>Generation or identification of a paraphrase, rewording or condensation of content presented during instruction.</i></p> <ul style="list-style-type: none"> • The emphasis here is on previous presentation of material. Therefore, summarization involves remembering information to a much greater extent than manipulating it.
Illustration	<p><i>Generation or identification of a previously unused example of a concept or principle.</i></p> <ul style="list-style-type: none"> • The emphasis here is on use of an example that was not presented in instruction. In this respect, the student is expected to employ information about the attributes of a particular concept or principle rather than to simply remember whether or not an event exemplifies a knowledge form.
Prediction	<p><i>Description or selection of a likely outcome, given a set of antecedent circumstances or conditions that has not previously been encountered.</i></p> <ul style="list-style-type: none"> • Again, the emphasis is on the <u>use</u> of information in a novel context rather than remembering a response from previous instruction.
Evaluation	<p><i>Careful analysis of a problem to identify and use appropriate criteria to make a decision in situations that require a judgment.</i></p> <ul style="list-style-type: none"> • Evaluation focuses on decision-making. The student must first recognize or generate the options available and then use a set of criteria to choose among them.
Application	<p><i>Description of the antecedent circumstances or conditions that would be necessary to bring about a given outcome.</i></p> <ul style="list-style-type: none"> • Application is the reverse of prediction. The student must use information about a concept or principle to work backwards from the circumstances presented and tell what happened to create it.

(How would you illustrate the fact, "Shakespeare wrote *The Tempest*"?) Similarly, none of the other three operations—prediction, evaluation and application—can be employed with facts alone. Prediction of a concept occurs when a student is given some but not all of the defining attributes of a concept, and then uses these attributes to infer other attributes of the concept. Prediction of a principle occurs when a student is given a previously unused description of a situation which has the antecedent conditions (causes) of a relationship embedded in it and is able to use that information to identify the most likely consequences (effects).

Application, the opposite of prediction, is used when a student is given an outcome (effects) and some initial state and then determines the conditions (causes) required to achieve that outcome. Although it is possible to use application with concepts, application works more readily with principles, due to the complex nature of the intellectual operation involved. The same is true of the process involved in evaluation. Evaluation consists of both analysis of a problem that requires a decision or judgment to determine factors that should be considered in making the decision, and weighing of each of these factors. It involves anticipating consequences of an act and then judging whether those consequences are acceptable according to certain criteria. Evaluation tasks require three basic steps: (a) select criteria; (b) operationalize criteria; and (c) make a judgment based on these criteria. The judgment needs to be supported by the criteria.

These interactions are shown in the following diagram:

		Knowledge Forms		
		Facts	Concepts	Principles
Intellectual Operations	Reiteration	Yes	Yes	Yes
	Summarization	Yes	Yes	Yes
	Illustration	No	Yes	Yes
	Prediction	No	Yes	Yes
	Evaluation	No	(Yes)	Yes
	Application	No	(Yes)	Yes

Some examples of the various combinations of knowledge forms and intellectual operations are presented below. In these examples "S" stands for student and "T" stands for teacher.

Some examples of interactions between knowledge forms and intellectual operations:

- Reiteration of a fact:** T: Salem is the capital of Oregon.
-What is the capital of Oregon?
S: Salem is the capital of Oregon.
- Summarization of a concept:** T: An element is a substance made of only one
element kind of atom.
-Who can tell me what an element is?
S: If you have some kind of matter and all of its atoms are exactly the same, that's an element.
- Illustration of a concept:** T: We talked about some examples of energy
energy conservation conservation in the home. Can you think of an example we haven't talked about?
S: We can recycle glass—it takes less energy to make glass from old glass than it does to make it from scratch, so that saves energy.
- Illustration of a principle:** T: I've shown you some examples of this
"For every action principle here in the lab, but can you think of
there is an equal some examples from every day life?
and opposite
reaction." S: How about a bouncing ball—the ball hits the
floor, the floor pushes back, and the ball goes
back into the air.
- Prediction of a concept:** T: Mass production is a system for rapidly
Mass production creating large quantities of one kind of
(Three attributes: product that makes use of the assembly line
and standardized parts. If we want to make a
• assembly line lot of a given product and we want to do it
• standardized parts fast, what would jobs be like in this system?
• division of labor) S: It seems like it would help if every person on
the assembly line only had one kind of job to
do; that way they'd get real fast at it.

Prediction of a principle:

If vital resources in a region become scarce, the inhabitants will move away.

T: The country of Zapland is primarily agricultural, but farming practices have depleted the once rich topsoil. Farmers have come to rely instead on heavy fertilization, which is polluting the region's only reliable water source. What do you think will happen if these practices continue?

S: They'll use up their resources and have to move someplace else.

Evaluation of a principle:

The Law of Diminishing Returns: "As units of a variable factor of production are added to a fixed factor of production, at some point the resulting increases in output will begin to diminish in size."

T: Farmer Jones has decided that if he can't double his profits from his dairy farm, he's going to sell it. Right now he's trying to figure out if he can meet his goal by increasing the milk output of his herd without buying any more cows. If you were Farmer Jones, what factors would you consider in deciding whether to sell or try to increase your cows' productivity?

S: The number of cows is fixed. Obviously the amount of milk a cow produces can't be increased indefinitely, so we'd need to know what they're producing now and how much it can be increased. . .

Application of a principle

If one link in an ecosystem's food chain is broken, the relationship among the organisms may be upset.

T: The owners of vacation homes on Paradise Lake are very upset—in the past couple of years the mosquito population has increased so much that it has become impossible to stay outdoors for very long. They want to get rid of those mosquitoes. How did it get so bad?

S: Well, they shouldn't just run out and get they most powerful bug spray to kill 'em. They ought to try to figure out why the mosquitoes have increased. What eats mosquitoes? Frogs. Maybe something happened to the frogs. . .

☛ Not all of the possible combinations of interactions have been represented here. See if you can create examples to show the following:

- Reiteration of a principle
- Evaluation of a concept

Application to the Curriculum

Curriculum materials determine to a large extent what gets taught in content classes. In particular, the primary textbook for a class may form the basis for the teacher's thinking about how to prioritize content, sequence information, and evaluate student learning. Therefore, we were interested in finding out what kind of information textbooks contain and to what extent curriculum materials can prompt students to use complex intellectual operation such as evaluation and application.

We examined four middle school world geography textbooks currently on the state of Oregon adopted textbook list. Three graduate students in special education were trained to use the taxonomy of knowledge forms presented earlier in an analysis of the main body of text contained in chapters pertaining to three topics: North Africa and the Sahel; The Middle East; and India and Its Neighbors. Concepts and principles were coded only when all aspects were presented in the text. For a concept to be coded, the label, defining attributes, and at least one example were required. For a principle to be presented, both the condition and effect components were required. Inter-rater agreements for coding all three knowledge forms of 95% were maintained consistently throughout the study. The results of the analysis are shown in the table on page 22.

As the table shows, the textbooks differed considerably with respect to the amount of print devoted to each of the topics and the manner in which different aspects of the topics were prioritized. For example, the MacMillan/McGraw-Hill textbook devotes an entire chapter to the physical geography of North Africa and the Middle East, unlike the other texts. However, the most important aspect of the table can be found in the two columns on the right. Notice that all of the curriculum programs contained many facts, but taught very few concepts and almost no principles. As you recall from the discussion of intellectual operations, this state of affairs does not bode well for teaching students to engage in complex thinking. Remember, all you can do with a fact is memorize it and reiterate it. Imagine the memory load required to "learn" the material presented in these curricula.

Clearly, for students to engage in complex intellectual operations, the teacher must play an integral role in identifying the most important information in a body of content and then formatting it in the form of concepts and principles that can be operated upon. The next section provides you with the opportunity to practice these steps.

Facts, Concepts, and Principles Contained in Selected Chapters from
Four World Geography Textbooks

<i>Textbook</i>	<i>Chapter Topic</i>	<i>Total Pages</i>	<i>Facts</i>	<i>Concepts</i>	<i>Principles</i>
Merrill © 1989	North Africa and the Sahel	22	673	10	0
	Southwest Asia	25	890	6	0
	India and Its Neighbors	17	763	5	0
	<i>average per chapter</i>		775	7	0
Heath © 1989	South Asia (India and Its Neighbors)	22	557	2	0
	North Africa and the Middle East	23	1098	1	0
	<i>average per chapter</i>		827	1.5	0
Scott-Foresman © 1988	South West Asia (Middle East)	10	209	0	0
	South Asia (India and Its Neighbors)	9	256	0	0
	North Africa	10	152	0	0
	<i>average per chapter</i>		206	0	0
MacMillan/ McGraw-Hill © 1991	North Africa and the Middle East: Physical Geography	18	317	8	1
	Middle East	17	479	5	1
	North Africa	18	460	2	1
	South Asia (India and Its Neighbors)	17	695	1	0
	<i>average per chapter</i>		487	4	1

Identifying Knowledge Forms in Curriculum Materials

Here is a passage from a chapter about the Indian subcontinent found in the Scott-Foresman middle school world geography textbook. As you know, textbooks often contain many graphics, maps, and photos. However, the value of these graphical additions often is questionable and they usually depend on the text for descriptions. Therefore, the primary source for information often is the material students are expected to read and comprehend.

South Asia's four greats South Asia has a complicated landscape that is easier to learn about if you think of it as having four greats. It has great mountains, great rivers, a great plateau, and a great wind.

You have already read something about the great range of the Himalayan mountain system. This highest of mountain ranges joins others to form a giant wall that separates the Indian subcontinent from the rest of Asia. The Pamir (pa mir') Knot, in north India, is a place where many mountain ranges meet. It is sometimes called the roof of the world.

These giant mountain ranges are a barrier to the masses of air that move north onto the Asian continent. Warm air from the seas to the south is forced up by the high mountain wall. As it rises, it grows colder and loses its moisture. The moisture falls on the southern side of the mountain ranges. This creates the second of the region's greats, the great rivers.

Great river systems High in the eastern Himalayas, the Brahmaputra (bräm a pu' trü) River carves a slow and winding route to the sea. Follow the Brahmaputra's route on the map on page 371. It is 1,800 miles (2,897 km) long.

In Bangladesh the Brahmaputra joins another great river, the Ganges (gan' jez) which has followed a route almost as long in its journey from north-central India. Most of Bangladesh is made up of the delta land of these two rivers.

The other great river of South Asia, the Indus, also begins in the Himalayas. It flows southwest into the Arabian Sea. Locate the Indus on the map on page 371. Through what countries does it flow?

Much of Pakistan is dry, but the Indus River provides water for irrigation. The Indus River plain joins with the Ganges Plain across northern India, and farther east is joined by the Brahmaputra Plain. About half of the people on the Indian subcontinent live in the densely settled valleys of these three great rivers. The plains of these rivers and their tributaries form the world's largest alluvial plain. Often this

area is simply called the Indus-Ganges Plain. It is a wide plain that stretches from Pakistan across northern and eastern India and south through Bangladesh.

The great plateau South of the Indus-Ganges Plain, the Indian Peninsula rises to a great plateau. The southern part of the plateau is known as the Deccan (dek' en) Plateau. The western edge or ridge is called the Western Ghats (gots). The somewhat lower ridge on the eastern of the plateau is low mountains and hills known as the Eastern Ghats. Between the Western Ghats and the Arabian Sea and between the Eastern Ghats and the Bay of Bengal are the Indian coastal plains. They are rich farming areas.

Most rivers on the Deccan Plateau flow from west to east. The longest river, the Godavari (ga däv'e re), begins in the Western Ghats and flows across India to the Bay of Bengal. Its wide, fertile delta is one of India's main rice growing areas. Plateau lands with enough moisture are used to grow rice, cotton, and grains.


The great wind Each year the people of the Deccan Plateau and the river basins of South Asia wait for a great rainstorm. This storm has high winds that are so strong that they sometimes knock down houses.

Rain pours down so heavily and quickly that entire villages are sometimes washed out to sea. The storm lasts for 4 or 5 months. It is a once-a-year super storm that brings water, and therefore life to the Indian subcontinent. The storm is brought by the monsoon (mon sün'). The monsoon is a seasonal wind. It blows from sea to land from roughly April to October. It blows the opposite direction the rest of the year. This gives most of South Asia a climate of two seasons, wet and dry.

The dry season is at its worst just before the monsoon arrives. The land is parched. Wells and streams have dried up. Many families have run out of food from the last harvest. Yet new planting cannot begin until the rains come. If the monsoon is late or does not last as long as it should, people can starve.

As you can see, this passage contains many pieces of information that would qualify as facts according to the definitions we have been using. Here is a list of the facts contained in just the first section of the passage, "South Asia's four greats":

1. South Asia has a complicated landscape.
2. South Asia has great mountains.
3. South Asia has great rivers.
4. South Asia has a great plateau.
5. South Asia has a great wind.
6. The Himalayan mountain range is the highest of all mountain ranges.
7. The Himalayan mountains and other mountains form a giant wall that separates the Indian subcontinent from the rest of Asia.
8. The Pamir Knot is in north India.
9. The Pamir Knot is a place where many mountain ranges meet.
10. The giant mountain ranges are a barrier to masses of air that move north onto the Asian continent.
11. Warm air flows from the seas in the south.
12. Warm air is forced up by the mountains.
13. As the warm air rises, it cools.
14. As the warm air cools, it loses its moisture.
15. The moisture falls on the southern side of the mountains.
16. (This region) has great rivers.

 See how many facts you find in the rest of the passage.

As we discussed earlier, the problem with facts is that you can only do one thing with them to demonstrate learning: memorize and then reiterate. For example, there is only one range called the Himalayan Mountains. Any attempt to use the fact that the Himalayas are the tallest range in the world likely would result in a classroom version of the game show Jeopardy:

T: In the category mountains, for \$40. 'This is the tallest mountain range in the world.'

S: What are the Himalayas?

Remember, though, information that is presented in one form often can be transformed into a more powerful format. Clearly, the single case of the Himalayas exemplifies the broader concept of "mountain range." It may be a reasonable assumption that most students in a middle school geography class would be familiar with the attributes of the concept "mountain range," but other concepts may not be so familiar.

The problem content teachers must grapple with is this: How much can I assume my students already know and how much do I need to teach? The prospect of learning hundreds of discrete pieces of information (i.e., facts), in each chapter, throughout an entire year is daunting even for students who have no learning problems. Imagine the challenge faced by the lowest achieving students in your class.

Unfortunately, curriculum materials offer little assistance. As you can see the geography passage contains many concept labels but few are defined explicitly and rarely is a range of examples provided. For example, can you assume your students recognize the attributes of terms such as "plateau," "delta," "plain," or "river basin"? Yet none of these are defined in the passage. The concepts in the passage for which attributes and examples were presented are described in the table below.

Notice that even these concepts have not been described fully in the passage. For example, the chapter referred only to the specific Pamir Knot but described the key attributes of the more general case "knot." Furthermore, the concepts that are summarized may not be ones you would think are important to target during instruction. If you were teaching this content, what concepts would you emphasize?

CONCEPT DESCRIPTIONS

<i>Concept</i>	<i>Attributes</i>	<i>Examples /Non Examples</i>
1		
subcontinent	A large part of a continent that is set apart from most of it.	The Asian subcontinent
		no non examples
2		
knot	A place where many mountains meet	The Pamir Knot
		no non examples
3		
great rainstorm	A storm with high winds	the once-a-year storm associated with the monsoon
	heavy rain	no non examples
4		
monsoon	a seasonal wind that blows from the sea to land (in summer)	the monsoon that affects India
	from land to sea (in winter)	no non examples
5		
dry season	land is parched and streams dry up	no examples
	many families run out of food	no non examples
	occurs in the winter	
6		
wet season	it rains for 4 or 5 months	no examples
	occurs in the summer	no non examples

Use the concept recording form below to describe three concepts that you would choose as the most important in this passage. Use your own knowledge of the content to generate key attributes and examples if they are not included in the text.

CONCEPT DESCRIPTIONS

<i>Concept</i>	<i>Attributes</i>	<i>Examples / Non Examples</i>
1		
2		
3		

Clearly, you can make the content of a textbook take whatever form you like. The key determiner is your expert perception of the importance of any piece of information and the manner in which you think it should be taught. Although no principles were taught directly, a number of relationships are implied in the passage. Here are two examples:

<i>Passage Statement</i>	<i>Principle</i>
Plateau lands with enough moisture are used to grow rice, cotton, and grains.	IF an area has enough moisture, THEN the land can be used to grow crops (rice, cotton, and grains).
If the monsoon is late or does not last as long as it should, people can starve.	IF weather patterns change, THEN people can be affected drastically.

A wide variety of examples that illustrate each of these relationships can be found in addition to the one presented in the passage. For example, the recent famine in Ethiopia and five-year drought in the western United States both exemplify the relationship noted above: IF weather patterns change, THEN people can be affected drastically. One principle is presented implicitly in this chapter and it has to do with the concept "rain shadow." The relationships associated with rain shadows might be described as follows:

When warm marine air encounters mountains, it is pushed upward. As it is pushed upward, it cools and loses moisture. The windward side of the mountains receives large amounts of precipitation and the leeward side is very dry.

☛ Use the relationship recording form below to identify the components of this principle. Think of some examples you might use to teach the principle.

RELATIONSHIP RECORDING FORM

"If" Component	"Then" Component
Examples	

Designing Instruction for Higher Order Thinking

Curriculum Analysis

As the content expert, you must make two decisions: (a) what information needs to be learned and (b) how it should be organized and framed (which eventually will guide how it should be presented and used). Designing instruction for higher order thinking involves two major steps, which are aimed at highlighting the critical information presented in the textbook curriculum. The first step entails identifying and defining the key knowledge forms (concepts and principles in particular) that are contained in an instructional unit (textbook unit or chapter, topical unit devised by the teacher, etc.). As you have seen, much of the information most textbooks contain is presented as a series of facts, rather than being organized into broader concepts and overlying principles. This is where the content area teacher's expertise is invaluable: shaping the factual content of the textbook into more meaningful knowledge forms. Some of the material present in the curriculum is more relevant than other material, as you can judge from the amount of emphasis it receives in the text and from your own understanding of the content area. The many pieces of information in an instructional unit will be more manageable for both the teacher and the student if they can be encompassed by a relatively small number (depending on the size of the instructional unit) of central concepts and principles. The task is to decide which information is critical for understanding the content. Which concepts and principles should the at-risk student be able to manipulate in order to demonstrate mastery of this part of the curriculum?

You may find a form like the one shown on the next two pages useful in this part of the curriculum analysis. As we have seen, often the textbook does not provide you with all the information you need to fill out a form like this. For example, some attributes of a concept might not be given, or examples and nonexamples may be missing altogether. As the content teacher you can use your own discretion in filling in the missing parts.

CONTENT PLANNING WORKSHEET

Date: _____
Teacher: _____
Class: _____
Textbook: _____
Other Curriculum Materials: _____

Approximate Schedule of Content to be Delivered

Week	Dates		Textbook Unit Chapters		Quiz Dates	Test Dates
	From:	To:				
1	From:	To:				
2	From:	To:				
3	From:	To:				
4	From:	To:				

KEY CONCEPTS

- | | |
|--|---|
| 1. _____
2. _____
3. _____
4. _____
5. _____ | 6. _____
7. _____
8. _____
9. _____
10. _____ |
|--|---|

IMPORTANT IDEAS

1. _____

2. _____

3. _____

CONCEPT DESCRIPTIONS

<i>Concept</i>	<i>Attributes</i>			<i>Examples /Non Examples</i>		
1		Page	¶		Page	¶
2						
3						
4						
5						

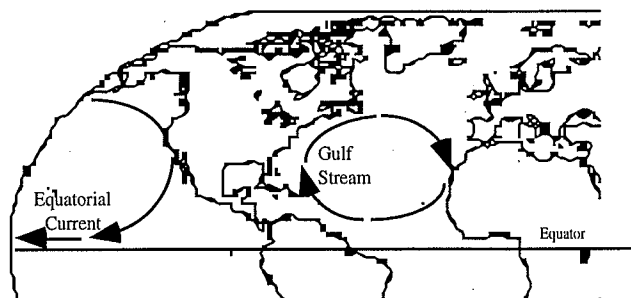
Notes:

Planning Instruction

In our model, the first step in designing instruction for students at-risk and/or with learning problems is to identify the key knowledge forms (concepts and principles) that would be presented. In this section we address how information should be framed. We have emphasized identifying the absolute minimum amount of information that could be used and still convey the gist of the material. However, another way to think of this step is to identify only concepts and principles from each unit that "hang together" or which can be framed according to some type of organizing scheme.

We'll begin by looking at a brief passage, from the beginning of a unit, on oceans.¹⁵ This passage was chosen for two reasons: (1) it illustrates very effectively three problems teachers immediately encounter when they attempt to impose some order on the information that is found in most content texts; and (2) it underscores the importance of the expertise content area teachers bring to the processes of planning and delivering instruction. Take a moment to read the passage and think about how you would organize the information it contains. Don't be alarmed if you get a little frustrated trying to sort it all out!

The **ocean** is a continuous body of salt water that covers a little over 70 percent of the earth's surface. Large as the ocean is, it is only part of the **hydrosphere** (HI druh sfih), or Earth's water portion. Water in lakes and rivers and ice frozen in glaciers are all part of the earth's water supply. Water moves from ocean to land and back to ocean in a continuous cycle. Like the circulation of air, the water cycle is powered by solar energy. **Evaporation** of water depends on the sun's radiant energy. **Transpiration** (trans puh RAY shun) of plants also depends on sunlight. Transpiration is the process in which water escapes from the leaves of plants. Water in the air condenses, then falls to Earth as precipitation. Eventually, most of this water returns to the ocean.



¹⁵N. C., Flemming, *The Undersea*. (New York: Macmillan Publishing, 1977).

Three Problems in Adapting Curriculum for Instruction

1. Concepts are not explicitly presented or defined, they are just labeled.

In this opening paragraph of the chapter, the concept ocean is presented (labeled) but never defined. Place yourself in the position of a student with learning disabilities: On almost any world map, the terms ocean, sea, bay, and gulf are used to describe "continuous body of salt water." So what is an ocean? If we use water movement (circulation) as one of the critical attributes (along with the other attributes such as salt water, large body of water, and boundary with continents), then we can distinguish an ocean from these other terms.

2. The text is full of extraneous information. Although the unit is on oceans, the opening paragraph quickly moves to evaporation and transpiration. In the excerpts below, you will find a considerable amount of information that simply needs to be left out. The important point is to focus the lesson as the expert in the content and the person most knowledgeable about your students. Ideally, in the process, you also can teach your students how to sort through information themselves to identify that which is relevant and that which is superfluous.

3. Critical information (attributes and exemplars) is not presented. This problem strengthens our belief that the content expert is the person who needs to be the instructor for students at-risk and with learning problems. Most curriculum texts must be supplemented with activities, with more information from other sources, with examples, and with interesting stories that make the content come to life. Obviously, this step must build a bridge between the curriculum and your goals.

In this section we describe a way to illustrate, by means of graphic organizers, the relationships among different pieces of information. We will address *how* the teacher can present this information during instruction in a later section. For now, though, consider the following uses of such visual depictions of content:

- ⇒ *Overhead transparency for organizing lectures.*
- ⇒ *Advance organizer, describing where the teacher (film, book, etc.) is moving.*
- ⇒ *Follow-along sheet for students to fill in as the teacher lectures.*
- ⇒ *Homework or in-class assignment for students to complete using source books.*
- ⇒ *Follow-along sheet for writing down notes before completing problem-solving essays.*
- ⇒ *Guide for students to use in participating in small group discussions.*
- ⇒ *Summary for use in reviewing and studying for tests.*

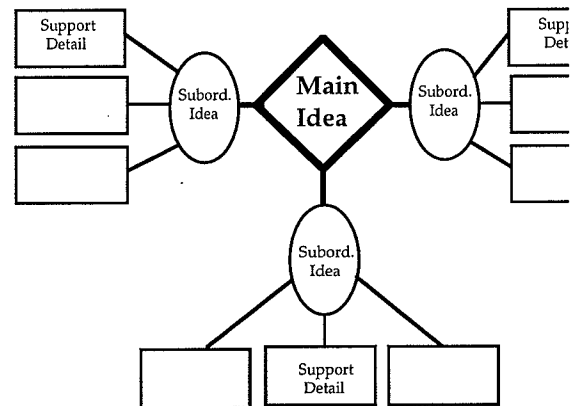
Samples of Different Graphic Organizers

Graphic organizers (GOs) are visual representations of linkages among key knowledge forms, and either reflect or generate underlying principles and important ideas. We have collected a wide variety of different GOs and present them as options you might consider. They vary in the manner in which concepts are defined and linked, as well as the way in which principles and important ideas are developed and refined. As a result, they create different contexts for learning and generating problem-solving arguments. The first examples of GOs have been described as maps and have been adapted from work by Grossen and Carnine.¹⁶

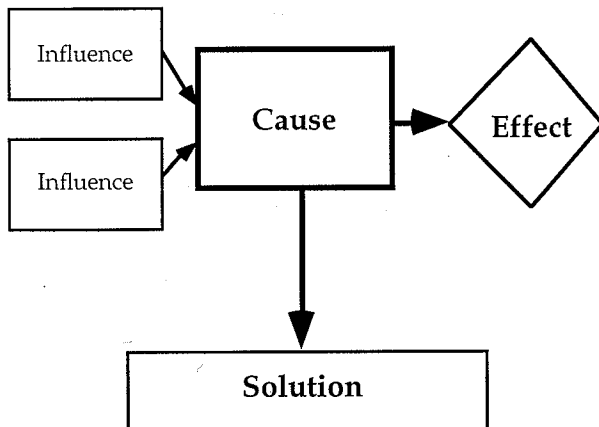
This type of GO is generic, working well with information that has no underlying cause-effect or time sequence. It works especially well for information that is (or can be) hierarchically organized.

R

Descriptive or Thematic Map



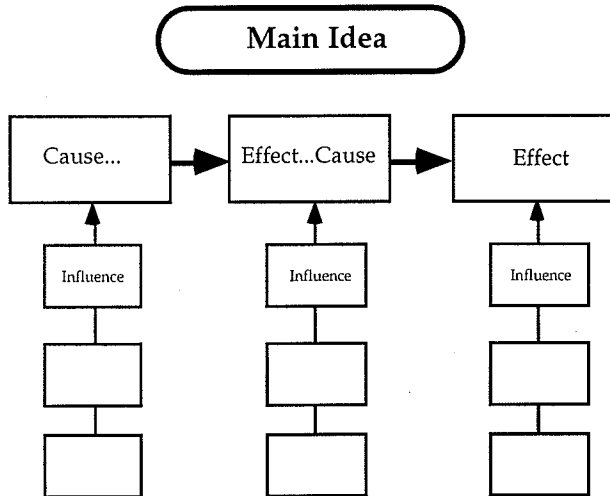
Problem and Solution Map



Q When information can be organized to reflect problems and solutions (often reflecting time or sequenced activities), then this type of GO map is very useful.

¹⁶B. Grossen, & D. Carnine, "Translating research on text structure into classroom practice," *Teaching Exceptional Children*, 24(4) (1992): 48-53.

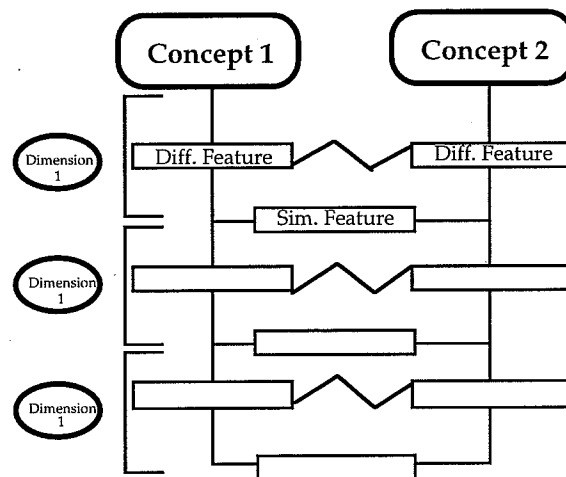
Sequential Episodic Map



Q This type of GO is similar to the one above in depicting a cause-effect; however, less emphasis is placed on solutions and more emphasis is given to a sequential chain of causes which turn into effects and further causes.

R This type of map is well suited for organizing concepts by attributes and then comparing them in terms of both similarities and differences

Comparative and Contrastive Map



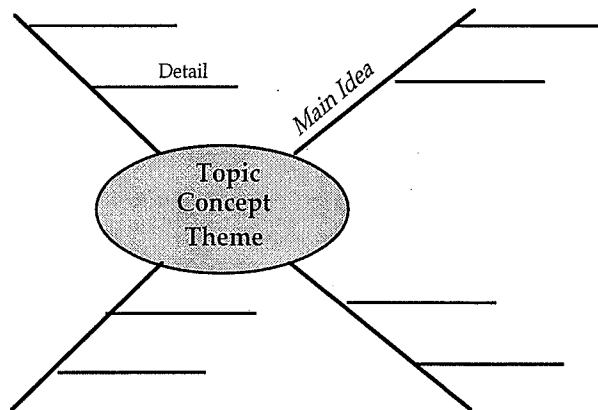
The next set of GOs comes from Tinzman, Jones, and Pierce. As they write, "for decades, students have been taught linear outlining as the general principal representation and organization of information in a chapter. This made sense because it was assumed that reading, writing, and perhaps even thinking, proceeded in a sequential, linear fashion. Because this assumption is being challenged, graphic organizers are examined as valuable, nonlinear ways of representing information in matrices, cycles, and sequences. Such graphic organizers better reflect the structure

of information, making the relationships among the ideas and concepts clearer, thus making information more meaningful and memorable."¹⁷

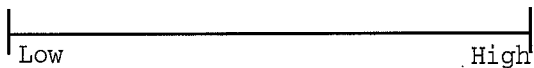
¹⁷M. Tinzmann, B. F. Jones, & J. Pierce, "Changing Societal Needs: Changing How We Think About Curriculum and Instruction. In C. Collins & J. N. Mangieri (Eds.). *Teaching thinking: An Agenda for the 21st Century*. (Hillsdale, NJ: Lawrence Erlbaum Associates, 1992).

Spider Map

This GO is best used to relate a main idea or central theme when no particular hierarchy of information is reflected. **R**



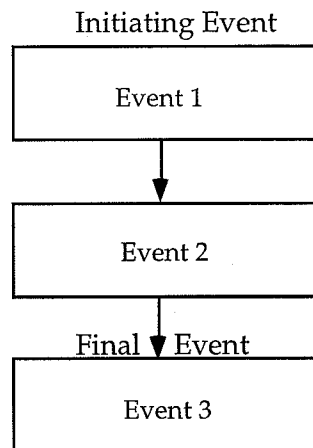
Continuum Scale



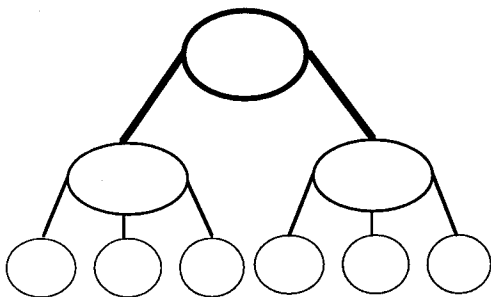
Q When information can be framed within a continuum of less to more, low to high, few to many, this kind of GO is effective.

This GO is simply a variation of the previous one; it is best applied to show linear steps, stages, or progressive development. **R**

Series of Events Chain

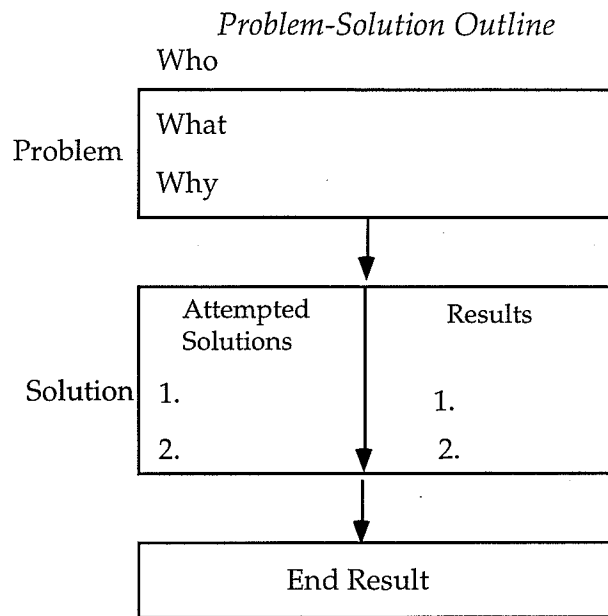


Network Tree



Q When information is very hierarchical, reflecting superordinate and subordinate (as well as branching) ideas or elements, then this GO is most useful.

In this type of GO, antecedent events can be organized to describe a problem and then several options offered and compared for solutions.

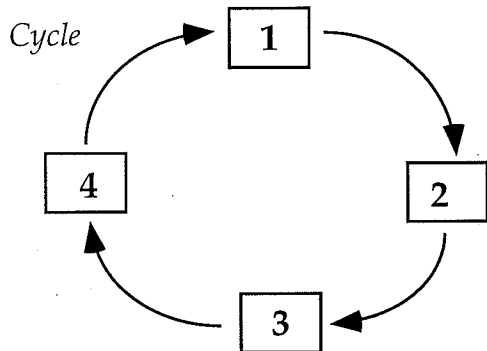
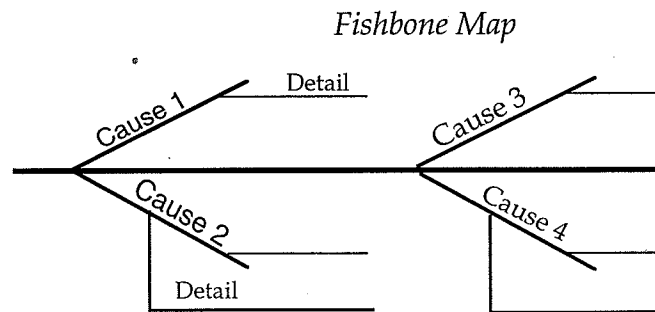


Compare-Contrast Matrix

Attribute 1		
Attribute 2		
Attribute 3		

Q As in the map presented earlier, concepts can be compared in a systematic way, attribute by attribute.

This GO format is a good choice when casual interactions are complex and non-redundant.

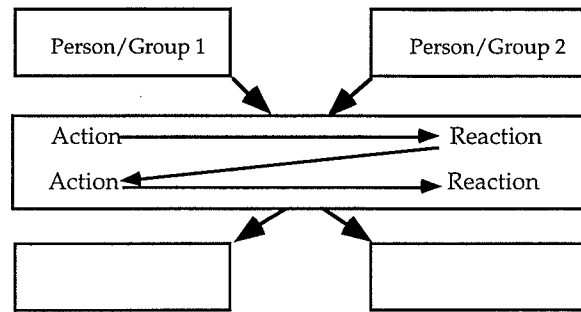


Q A GO like this can be used when information can be organized into a circular or cyclical pattern that has no absolute beginning and ending.

Human Interaction Outline

In the social sciences and humanities, events and interactions can best be depicted in a chain of action and reaction.

R



In summary, GOs can be used to give structure to the numerous pieces of information contained in the curriculum. As you can see, graphic organizers have great potential for being used in a number of ways within the lesson. They can provide a framework for focusing on the intellectual operations which can be part of the interactive delivery (and translation) of this information and the assessment of learning (how students use this information in addition to the more traditional focus on what information students have mastered). As the content expert, it is your role to provide both the structure and the content of graphic organizers. Typically, the curriculum text can be used as the primary reference; often, this text is inadequate.

To illustrate the ways in which GOs can be used to clarify and augment information found in the text, we selected a passage about the ocean from an Earth Science textbook.¹⁸ You should notice, however, that the text and graphic organizer do not match perfectly. Rather, in constructing the graphic organizers, information has been deleted and added to reflect the teacher's emphasis. Generally, the guiding rule for making changes in the information is to simplify the information and to emphasize important relationships by reducing the number of words and visually structuring the main ideas.

As you follow the examples of GOs in this section, focus on the "primary thinking process" each one represents. How are concepts selected and organized to fit together and reflect structure? The goal in using GOs is to communicate not only content but also structure. Also, as you read the content in the left column and compare it to the GO in the right column, you may come up with different GOs that highlight the information in a different way. There is no single "right" way to construct a GO to illustrate a given chunk of information: you, as the content expert can and must decide what's important.

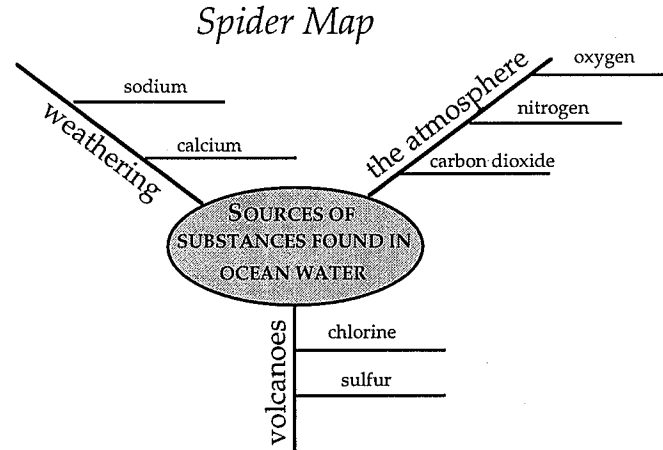
¹⁸M. S. Bishop, B. Sutherland, & P. G. Lewis, *Focus on Earth Science.*, Chapter 10: Oceanography (185-195). (Columbus, OH: Charles Merrill, 1981).

The Ocean: A Unit for Applying Graphic Organizers

Text Excerpts

Ocean water has a number of different elements in solution. Some substances are carried to the ocean by rivers that flow over weathered rocks. Many elements are in solution in the water vapor given off by volcanoes. Chlorine gas is one material that is added by volcanic action. Sodium is a product of weathering and probably is carried to the ocean by surface waters. Sodium and chlorine combine to form halite or common salt. Other substances dissolved in sea water include calcium chloride, magnesium chloride, and sodium and potassium compounds. Ocean waters have traces of many other substances as well as gases from the atmosphere. Oxygen, carbon dioxide, and nitrogen are dissolved in sea water and available for marine life processes. Ocean waters are low in both silica and calcium because marine life uses these substances in their life processes.

Graphic Organizers

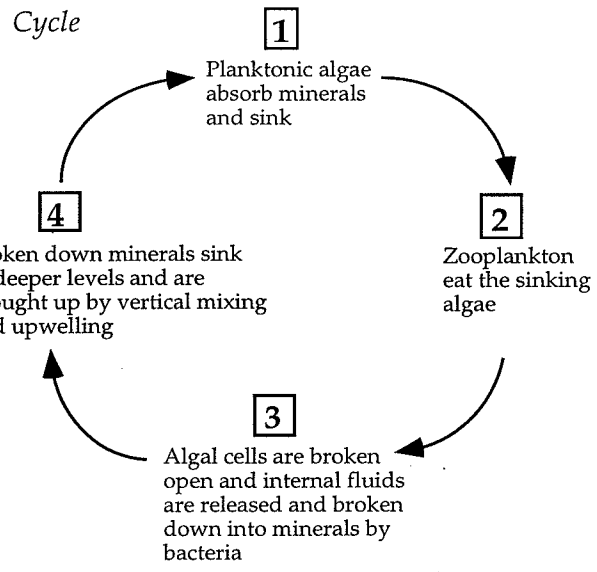


Living things abound in the ocean. Marine animals are classified by their habits and by the part of ocean water which they use. **Plankton** (PLANG tun) are plants and animals that float at or near the ocean surface. Plankton, for the most part, are microscopic (too small to be seen with the unaided eye). Diatoms are tiny one-celled plants, a type of algae. Each cell has a crystal-like covering of silica. Diatoms are the main source of food for many sea animals, including whales. Diatoms multiply rapidly when storms mix the ocean waters and bring up large quantities of nutrients from the deep currents. Then diatoms may cover the ocean surface and form a great blanket of food. Marine animals move in quickly and the food is soon used up. **Nekton** (NEK tun) include all swimming forms from tiny herring to huge whales. Nekton can move from one depth and place to another. Some nekton prefer cold water, others like warm regions. Some of them roam the entire ocean. Most flesh-eating nekton prefer cold water, others live just below the surface where food is plentiful. Many nekton come to the surface only at night to feed on plankton. **Benthos** (BEN thahs) are bottom dwellers. They live in shallow water where sunlight reaches the seafloor. Such areas are near the margins of islands and continents. Benthos include coral, snails, starfish, clams, and other animals that live on the seafloor. Some animals are attached to the seafloor. Others can move about but live on the bottom. Algae, the dominant sea plant, lives attached to the bottom.

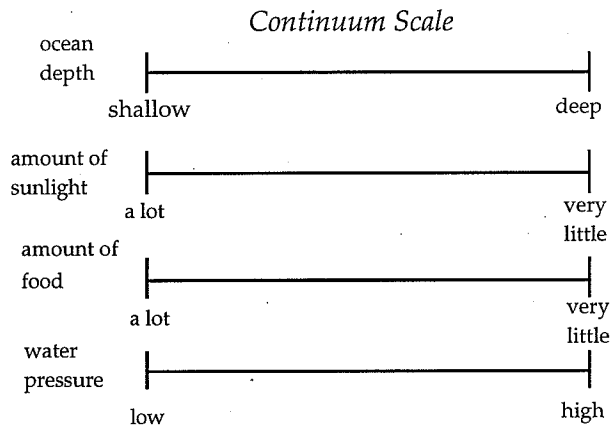
Compare-Contrast Matrix

	PLANKTON	NEKTON
Movement	floaters	swimmers
Habitat	surface waters	all depths
Food Source	photosynthesis	plankton

Both oxygen for animals and carbon dioxide for plants are dissolved in sea water. Some animals get food simply by circulating sea water through their bodies and filtering out nutrients. Buoyancy (BOY un see), or upward lift, of water makes movement in ocean water very easy. Little protection is needed against either heat or cold because the temperature range of sea water is so small. Despite all the advantages of the sea, however, many marine animals do not live long. There is a constant danger of being eaten by other sea creatures. Plants are the base of the food chain in the ocean as they are on land. Plants use sunlight, carbon dioxide, and water to form sugars and starches by the process called photosynthesis. Plant-eating animals use the food energy directly. Flesh-eating animals use the food from plants indirectly.



Ocean plants can live only as deep as sunlight reaches. Most plants belong to the floating plankton. Near shore, some seaweeds live attached to the bottom. Food becomes scarce as water depth increases. Scientists have found life even at the bottom of the Marianas Trench which is nearly 11 kilometers deep. Organisms exist despite the fact that water pressures are very great and no light reaches this depth.



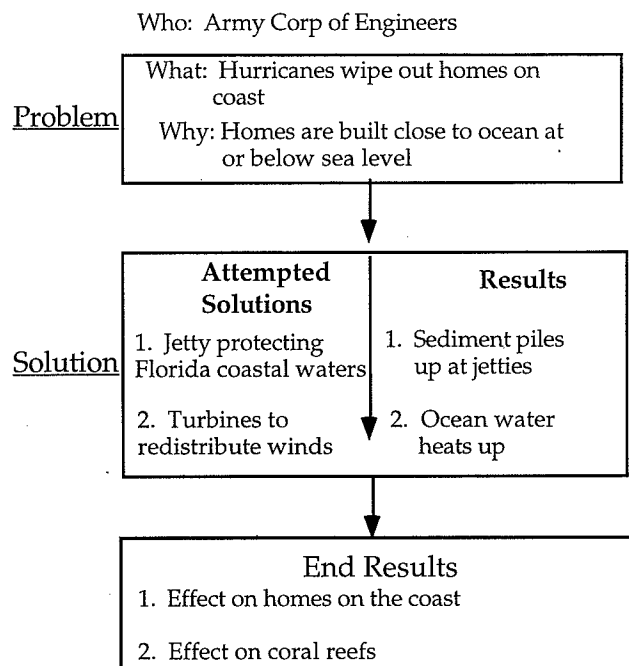
The **shoreline** is the boundary where land and sea meet. Shorelines mark the average position of sea level. During historical times, sea level has been fairly constant. We use it as a reference from which to measure elevation. **The shore zone** includes the area lying between high and low tides. The boundaries of shore zone change often, sometimes from hour to hour depending on wind and tide. Near the shore, materials are in constant motion. Sediments are moved back and forth by incoming and outgoing waters. The **coast** is a strip of land lying between the shoreline and the first big change in the land surface. The width of the coast may vary from several meters to several kilometers, depending on the topography or relief of the land. The coast belongs to the continent, but it is linked to the sea by contact with ocean waves and currents. The **continental shelf** is a relatively flat part of the continent which is covered by sea water. The shelf lies between the coast and the continental slope. Water from the ocean basin covers the shelf. The width of the shelf depends on changes in sea level. The shelf is usually narrow where mountains are close to shore. In areas like the Atlantic and Gulf coastal zones, the shelf is wide and gently sloping. The **continental slope** is the steeply sloping surface between the outer edge of the continental shelf and the ocean basin proper. If you think of the ocean basin as a pan, the continental slope becomes the side of the pan.

Shells and diatom coverings cover about half the ocean floor. **Coral reefs** are calcite deposits built in shallow water on the edge of the continental shelf. The reef structure is started by coral organisms that live in colonies. The corals build structures that look something like tiny apartments. Once the reef structure begins, many other forms of life join the colony and add to the reef growth. Conditions favorable to the growth of coral reefs are found in the South Pacific Ocean and in the Caribbean Sea. Water temperature must be between 20 and 26° C. The water needs to circulate freely in order to bring food to the stationary animals. The water also must be shallow enough so that sunlight reaches the reef. If the reef is growing close to shore with little water separating the two, we call it a **fringing reef**. Reefs are common around volcanic islands in the South Pacific. Many of the volcanic islands slowly sink below sea level. The coral reef, however, continues to grow upward toward the sunlight. Sometimes the volcano sinks completely out of sight beneath the water. Then only the circular reef can be seen. This kind of coral island is known as an **atoll** (A tawl). The ring of coral surrounds quiet water or a **lagoon**. At some depth below the lagoon, the former volcanic island is submerged.

Compare-Contrast Matrix

	SHELF	SLOPE
Temp. and light	Higher temp. More light	
Density of plankton	More	
Density of Nekton		More

Problem-Solution Outline



☛ Construct a graphic organizer to accompany the world geography passage on page 23. Focus on the most important knowledge forms that we identified earlier.

Interactive Teaching

We now turn our attention to teaching the content. The previous two steps can be used as a guide to: (a) identify the critical knowledge forms and intellectual operations and (b) develop graphic organizers that link these knowledge forms to one another and set the stage for using the information to solve problems. The very active nature of teaching demands that instruction be analyzed separately from the information that will be taught. Many factors have great potential for derailing a lesson, including the skills and background knowledge of the students, the activities used during the lesson, unplanned questions (and responses), etc. Two problems in particular often arise.

1. If content delivery never moves beyond simply *transferring* information, students may not be exposed to the modeling and use of complex intellectual operations. This problem can arise when the teacher merely uses different words to describe the same information that appears in the curriculum. The emphasis in this approach is on "what" rather than "how." For example, in a unit on insects, the teacher might focus solely on the different body parts instead of the functions of those parts.

2. At the other extreme, content may be too rich in different intellectual operations. It is possible for teachers to become so caught up in the quest for authentic tasks and problem-solving that they lose sight of what is important for their students to learn. Instruction takes on a menu approach with no consistency in modeling complex thinking. If adequate time is not devoted to modeling the steps in the various intellectual operations, students are not likely to use and transform information on their own. Because both content and intellectual process need to be included, the examples become harried and unclear.

We encourage an emphasis on *using* information. This involves selective translation of simple knowledge forms (facts and concepts) into more complex ones (concepts and principles). Teachers and students can then use this translated information to engage in complex intellectual operations like evaluation, prediction, and application, instead of being limited to summarizing facts. If students are to arrive at this level, teachers need to have provided many opportunities for individual students to see and hear socially constructed (and well explicated) contexts for using information. Selectivity is the key: not all information can or should be modeled in complex operations. Sometimes, students really do need to memorize key facts and

concepts that form the basis for later learning. The expertise of the content teacher is required to make judgments about how to teach what content.

Following are sets of dialogues that illustrate some options that teachers can consider as they attempt to integrate critical thinking skills into their instruction: These teacher-student interactions could be based on GOs but go well beyond them. We approach such interactive instruction with the assumption that questions and answers between teachers and students represent the "teachable moment." This dialogue is where the intellectual operations are modeled and ranges of examples are presented. Students are likely to follow the lead of teachers: If critical reasoning is not displayed by the teacher, it is unlikely to be displayed by the student. Even more importantly, these dialogues allow teachers to check for understanding. By responding to questions and problems posed by teachers, students need to structure information and use it. This production response provides a golden opportunity for "authentic" assessments. Later, in the last section, we extend this logic to the formal evaluation of learning using essays and permanent products (projects, reports, lab write-ups, etc.). However, as a formative evaluation system, the primary datum is likely to arise from teacher-student interactions.

We have structured this section in the following manner to focus your attention on the choices that can be made. All of these choices deal with how information is used to solve problems. In dialogue we extend the discussion into a direction, labeling each teacher question-response and student question-response. In reading these interactions, focus on not only the teacher as the sole source of information, but also the student's response as a public event that may be a source of (incidental) learning for other students in the class. All of the dialogue is based on the textbook passage taken from the unit on oceans.

Background—Mr. Smith has just finished summarizing the life cycle of organisms in the ocean . . .

Intellectual Operation	Teacher Dialogue	Student Dialogue	Intellectual Operation
<i>Summarization</i>	<p>OK. To summarize, the plankton kinda sink as they lose nutrients, they lose their buoyancy, and begin to sink. Some of them actually sink low enough that they end up moving out of the euphotic zone. Does anybody remember what the euphotic zone is?</p>	<p>Yeah. It's the depth zone where photosynthesis can happen. But I don't remember what happens below this level. Isn't it about 100 meters down from the surface?</p>	<i>Reiteration</i>
	<p>That's right. But what's really important is that these plankton begin to sink and die, at least those that aren't eaten by other nekton and benthos, which we'll talk about later. So who knows what happens to these dead and dying plankton? Do they just sink to the bottom and sit, eventually forming the ooze we talked about earlier?</p>		
	<p>Excellent. You're right. So when are the storms most present?</p>		
<i>Summarization</i>	<p>And so, the algae get these nutrients back up; but also some of these algae are forced down below this zone (where there's no light) and they die. Let me summarize the problem and the cycle.</p>	<p>Well, it depends on the season and time of year. And doesn't the euphotic zone get this layer of dying and dead plankton that kind of floats at the bottom of it? Well, the problem is how does this stuff...you know it's rich in nutrients...how does it get back up to the top where the living algae are hanging around? Didn't storms and the wind stir up the water and move the nutrients back up?</p> <p>Spring and fall.</p>	<i>Application</i>

Intellectual Operation	Teacher	Student	Intellectual Operation
	Dialogue	Dialogue	
<i>Summarization</i>	<p><u>Problem:</u> Light is at the top (which is needed for photosynthesis) but most of the nutrients are at the bottom. In the fall and spring, vertical mixing occurs (caused by storms, wind, and changes in temperature).</p>	<p>And vertical mixing is different than upwelling?</p>	<p><i>Reiteration or Summarizati</i></p>
	<p>Yes. Let's hold on that, Jim.</p> <p><u>Cycle:</u> In the fall, changes in temperature and wind feed the nutrients to the algae in the top layer. By the middle of winter, the mixing is too much and a lot of the plankton get mixed well below the euphotic zone causing them to die, so the "growing season" starts to slow down. Also, the days grow shorter, and with less light, photosynthesis slows down. But then in the spring, with the rich nutrients in the euphotic zone, and the increases in temperature (and fewer storms), the plankton bloom. But by summer, the long days bring lots of light, the euphotic zone grows deeper and the plankton really take off. The problem is that with warm water, it sits on the cooler and nutrient-rich water so the circulation is more horizontal than vertical. Plus the storms kinda decrease. Besides, with so much growth, the plankton actually starve and begin to die. Then the whole process repeats itself over and over again.</p>	<p>I suppose by fall the winds pick up and the temperatures drop. The plankton growth begins to increase. Is this process the same everywhere in the ocean? In the open ocean, on the continental shelf and slope?</p>	<p><i>Summarizati</i></p>
	<p>Can anyone summarize this process?</p> <p>Pretty much so. OK. Now put on your thinking caps.</p>		

Options for Intellectual Operations

In the above dialogue, both the teacher and the students presented several different intellectual operations. It is possible to rearrange these operations and redirect the purpose of the lesson. Notice that the lesson moves in and out of reiteration and summarization. Quite likely, all instruction needs to include students previewing and reviewing the content. Then, with familiarity with the basic concepts, students can be launched into more complex intellectual operations like prediction, evaluation, and application. You can think of a lesson as having a shape, or topography, in which the student-teacher interactions vary in terms of the complexity of the information presented and the manner in which it is used. Although it may differ across teachers, this shape may help structure the content and develop the higher order intellectual operations.

☛ Can you think of other ways the information in the above dialogue could have been presented? What intellectual operations are possible with this content? Here are four possibilities.

Prediction

What would happen if a big power plant came into an area (like Monterey or Coos Bay) and built a huge power generating plant (using coal or nuclear power)? To keep the turbines from overheating, water was passed through the main generators and then released out into the bay. Let's say that the water was warmed a full 15 degrees several miles out into the bay. How would this affect the life cycle of algae? Describe this cycle.

Illustration

Can anyone give me an example of another cycle on land that repeats itself? You know, what other phenomenon has a continual sequence of events that are triggered and then lead to other events that end up with the initiating one?

Evaluation

Do you think the effect on fishing productivity is greater from upwelling or vertical mixing? Explain how or why. Describe the effects on both the number of plankton and nekton.

Application

The fishing industry has had a terrible year. The big commercial fleets are bringing in fewer and fewer tuna, haddock, cod, and perch. A lot of local folk keep talking about El Nino, the great warming currents along the West Coast. How would this phenomenon explain the problems with fishing?

Checking Student Perceptions

Traditionally, schools have judged success in content classes in terms of student outcomes. Teachers typically look at student performance and ask, "Did the students learn the information I think they should have learned?" However, in evaluating student outcomes, teachers also are evaluating the effects of their own instruction. For example, you also could look at your own instruction and ask, "Did I teach the information I think students should learn?" Addressing this question becomes increasingly important as we expect students to use content information in more complex intellectual operations. As we noted in the beginning of this training module, our research suggests that if we want students to perform complex operations such as prediction, evaluation, and application, they must be exposed to effective models and have opportunities to practice them in class.

As we have seen, textbooks simply don't provide the raw material that is needed for complex intellectual operations. Problem-solving and critical thinking require concepts and principles rather than facts. However, another problem with textbooks is that they present lots of information that not only may be irrelevant to the purposes of your lessons, but actually may interfere with students learning the information you view as most important.

We have found that the problem of "seductive details"¹⁹ also shows up in interactive instruction. Sometimes students remember the wrong things. Information you consider a minor but enriching detail may be remembered by students as the most salient information from a lesson, and they may miss the most important points altogether. Here is an example from our research that illustrates this point.

We examined textbook lessons and supplemental curriculum materials, and observed all the lessons in two middle school world geography classes for a week. The lessons focused on the physical and cultural geography of North Africa, and particularly Egypt and the Nile basin. Most of the instruction in the class was aligned very closely with the textbook. Students frequently took turns reading aloud from the book during class. However, the teacher occasionally interjected details from his own experiences to supplement the textbook. The following is a verbatim transcript from an instructional episode on the second day of our observations:

¹⁹R. Garner, M. G. Gillingham, & C. S. White, "Effects of 'Seductive Details' on Macroprocessing and Microprocessing in Adults and Children," *Cognition and Instruction*, 6(1989): 41-57.

Student: I know somebody who went to the Nile River last year and they got some of the water. It's really brown.

Teacher: Yes but you never stick your hand in the Nile River, ever.

Student: Why, piranhas?

Teacher: No there's something else. Actually if you put your hand in the water, you'll catch a disease. It's called schistosomiasis. It's a little bitty microscopic snail that crawls into the pores of your skin and starts living off of you. You don't go swimming in the Nile River. I've asked doctors this. I've said 'What if you just put your hand in for a moment?' They said don't do it because you can get the disease, just like that (snaps fingers).

Student: Is it a permanent disease?

Teacher: If it's treated it can be temporary. If not, then sure, it's a parasite that will live off your bloodstream.

The entire "snail" discussion consumed less than 30 seconds of five 40-minute class periods and represented the only time students were exposed to information about a parasitic snail in either the curriculum or teacher conversation. At the end of the week, we asked students to write an essay that summarized the most important information they had learned about North Africa. On their essays, 12 out of 26 students made some reference to snails or parasites. Furthermore, the students who did attend to schistosomiasis content tended to devote a considerable amount of writing to it and often showed evidence that they had developed serious misconceptions. Here is an example of student writing that typified this phenomenon:

All the people in the Middle East are poor and if you put you hand in some water holes you will get a disease. From a little slug that get in your pores and gives you a disease you can get it just by putting your hand in the water. And their is no place for the people in Egypt to go to get medicine because they have no modern medical Facility and most of the people die Form the disease they get From the microscopic snail. It is a really bad place to live and they have nothing but mud houses and they dress scummy.

As this episode illustrates, it is important to check students' perceptions on a regular basis to see if the information they think is important in a lesson is the same as the information you think is important. This issue seems to be particularly important for low achieving and at-risk students. We have found that special education and Chapter 1 students whose perceptions of the importance of various concepts presented in a lesson are similar to their teachers' tend to perform better on end-of-the-unit tests than those students whose perceptions are less well aligned with those of their teacher.

To check student perceptions, we simply ask them to list the words they think are most important from recent lessons. We also ask students to list the ideas they think are important and to either draw a sketch or write a paragraph that tells how various ideas and concepts are related to one another. The entire process generally takes no more than ten minutes away from instruction. An example of a perception probe is included in the appendix, along with a set of suggested administration procedures. The probe has three sections: "Most Important Words," "Most Important Ideas," and "Putting It All Together."

We advocate use of somewhat standardized administration procedures so comparisons across administrations of the probe can be made, but the procedure should not be viewed as a form of a test. It is important to remember that this is a check on what students think is important in instruction, not what they have learned. Therefore, it wouldn't make sense to score students, perception probes in terms of correctness. However, perception probes can provide a view of instruction that teachers rarely obtain because data obtained from perception probes can be used for a number of instructional decisions. For example, the overall perception of the class can be obtained by listing "Important Words" in order of how frequently students wrote them down. The extent to which the terms most frequently identified by students match the teacher's perceptions of the most important information in a lesson may be one gauge of the effectiveness of instruction. Alternatively, students' lists can be compared to see the extent to which students differ from one another in the range and number of concepts identified. To obtain an estimate of the extent to which students have misconceptions about the material you have taught, you can simply read the ideas students list or review their paragraphs. Finally, if you use graphic organizers in your instruction, you can look at students' sketches to estimate the effectiveness of the graphic organizers in communicating complex relationships.

☞ What do you think are the instructional implications of the following findings from a perception probe?

1. With the exception of one or two words, students had few words in common on their lists.
2. Almost all students listed the same three words. Few students listed more than 5 words.

Developing Assessment Tasks

The goal of instruction in content area classes is for students to learn information and skills that comprise content knowledge. We assume that students will come into content classes in the fall without this knowledge and leave in the spring having learned some body of information pertaining to the content area. Unfortunately, teachers have had few tools available for testing this assumption. Published, norm-referenced achievement tests are not matched to curriculum materials and rarely contain more than a dozen items pertaining specifically to social studies or science content at any grade level. Testing materials that accompany most curriculum series tend to be disjointed and rely on selection responses that provide little information about student thinking. For the most part, teachers rely on their own judgments and observations of student performance. These judgments often are very accurate, but unfortunately may not be viewed as "real data" by administrators or parents. On the other hand, teachers may have only a vague notion of the direct effects their instruction has on student learning because they have few tools for evaluating instruction on an ongoing basis.

While you can learn a lot about the effectiveness of your instruction by probing student perceptions, the "bottom line" is that students need to acquire, retain, and then use content information in complex intellectual operations. Eventually, you need to ask directly, "Did the students learn what I wanted them to learn?" In other words, you need to give a test. As we have been discussing in this training module, content area classes involve more than just collections of facts and simple concepts. One of the goals of instruction is for students to use multidimensional concepts and principles in complex operations. Therefore, the testing procedures used should reflect the complexity of the thinking students are expected to do.

Not surprisingly, given that curriculum materials contain mostly facts, the tests included with most textbooks also tend to focus on facts. The result is that items on end-of-chapter and unit tests often resemble the questions one might find in a trivia game and may provide little information about the extent to which students use information.

In designing measures that tap student thinking there are two issues to consider. First, the task must focus on more complicated knowledge forms, i.e., concepts and principles. As you have seen, there is only so much thinking a person can do with facts. For example, how could a student illustrate or evaluate the fact, "The capital of Indiana is Indianapolis"? It would make no sense to ask a student to "Give an

example of the capital of Indiana" or "Choose the best capital of Indiana from among South Bend, Muncie and Indianapolis."

Second, even if the task focuses on concepts or principles, it must prompt students to use the information in complex intellectual operations. For example, compare these two test items:

1. Matter can neither be created nor destroyed is an example of which law?

2. At the beginning of a chemical reaction, all the substances have a mass of 2 kilograms. What will the mass of all the substances be at the end of the reaction? _____

How do you know? _____

The first item simply asks students to recognize the wording of the law of conservation of matter but provides no information about whether or not students can use it to solve a problem. The second item also tests this law but asks students to use it to make a prediction. Finally, by asking students to defend their answer, the item makes it possible to observe student thinking directly. By the way, published curriculum materials aren't all bad. Item number 2 was taken from an end-of-the-unit test in a sixth grade science textbook.

As you can see, test procedures that require students to produce a response provide much more information about student thinking than items that simply require them to select an answer. However, this does not mean all production items automatically measure thinking. Often fill-in-the-blank items are really multiple choice items in disguise. Here is an example:

Tell which three oceans border the continent of Asia.

_____ / _____ / _____

Obviously, there are a limited number of oceans from which to choose. The item could easily have been formatted as follows:

Circle the three oceans that border the continent of Asia.

- (a) Indian
- (b) Atlantic
- (c) Arctic
- (d) Pacific
- (e) Antarctic

The goal is to use items that elicit enough behavior to provide students an opportunity to demonstrate use of information. The disadvantage of production tasks is that they can be difficult and time-consuming to score. Furthermore, the more behavior an item prompts, the more subjective the scoring procedures often become. This is largely because the responses may represent partial understanding or mastery of material. As an example, compare these three responses to the prediction item about the law of conservation of matter presented above:

Student 1 It will have 2 kilograms because matter isn't created or destroyed in a chemical reaction.

Student 2 You don't use up any matter in a reaction.

Student 3 Because of the law of conservation of matter.


All three of these items are correct to varying degrees. If you award partial credit, what criteria should you use? Student 1 has succinctly summarized the law and the answer would clearly be judged acceptable. Student 2 has partially summarized the law but may believe that matter could be created in a reaction, a common misconception. Finally, Student 3 is correct in citing the law, but the answer doesn't allow us to know how well they understand it.

One strategy for scoring production items is to develop a set of anchors for assessing the extent to which the response fits what would be considered to be correct and complete. Here is an example of a three-point scale for scoring the law of conservation of matter item:

Points	Characteristics of Answer	Examples of Acceptable Answers
3	<ul style="list-style-type: none"> answer is an accurate summary or reiteration of the law of conservation of matter: Matter is neither created nor destroyed in a chemical reaction 	<ul style="list-style-type: none"> Matter is neither created nor destroyed in a chemical reaction
2	<ul style="list-style-type: none"> answer includes references to matter and chemical reactions but fails to include the information that (a) the matter is not created OR (b) matter is not destroyed answer refers to law of conservation of matter but does not summarize this law 	<ul style="list-style-type: none"> You don't lose matter in a chemical reaction You don't make matter in a chemical reaction Because of the law of conservation of matter
1	<ul style="list-style-type: none"> answer includes some elements of the law of conservation of matter, but these are not linked to a reasonable explanation or conclusion is incorrect. answer is a restatement of the question answer is vague or too general 	<ul style="list-style-type: none"> after you're done you have the same amount of matter you can't take any away
0	<ul style="list-style-type: none"> no response is given answer is incomprehensible or completely unrelated to question 	

Here is another item from the same test that was scored using an analytic scale.

Pretend you are telling your parents what you've learned about the periodic table. Tell them what it is and the ways it is organized. Tell how the elements are classified.

 What intellectual operation does the above item prompt?

The item was scored using three sets of anchors corresponding to the three parts of the question. Each set of anchors is given below.

Tell what it is:

Points	Characteristics of Answer	Examples of Acceptable Answers
3	<ul style="list-style-type: none"> Answer is accurate summarization that the table is used by scientists to classify elements. The table has symbols that stand for the elements. 	<ul style="list-style-type: none"> It's a table that scientists use when they want to classify elements. Each element is shown by a symbol
2	<ul style="list-style-type: none"> Answer refers to elements but fails to include information that the table is used to classify them. Answer is correct but incomplete 	<ul style="list-style-type: none"> The periodic table is all the elements It's a table scientists use to look up elements It's a table of elements that shows the symbols for each one
1	<ul style="list-style-type: none"> No reference is made to classification OR elements OR symbols Answer is vague or too general Answer is a restatement of the question. 	<ul style="list-style-type: none"> It's a table of atoms that scientist use we learned about The table is all the matter It's a table of symbols
0	<ul style="list-style-type: none"> no response is given answer is incomprehensible or completely unrelated to question 	

Tell how it's organized:

Points	Characteristics of Answer	Examples of Acceptable Answers
3	<ul style="list-style-type: none"> Answer includes all dimensions of the organization system: It is organized according to atomic number, atomic mass, metals, non-metals, families, and periods 	<ul style="list-style-type: none"> It is organized according to atomic number, atomic mass, metals, non-metals, families, and periods
2	<ul style="list-style-type: none"> Answer includes more than one but not all of the dimensions in the organization system 	<ul style="list-style-type: none"> It is organized according to atomic number, non-metals, and families
1	<ul style="list-style-type: none"> Answer includes only one dimension in organization Answer is vague or too general Answer is a restatement of the question. 	<ul style="list-style-type: none"> It is organized by families It has different things about the elements that tell you about them
0	<ul style="list-style-type: none"> no response is given answer is incomprehensible or completely unrelated to question 	

Tell how elements are classified:

Points	Characteristics of Answer	Examples of Acceptable Answers
3	<ul style="list-style-type: none"> • Answer is an accurate summarization of: Elements are classified as solids, liquids, and gasses. 	<ul style="list-style-type: none"> • Elements are classified as solids, liquids, and gasses.
2	<ul style="list-style-type: none"> • Answer is accurate but incomplete 	<ul style="list-style-type: none"> • Elements can be solids and gasses
1	<ul style="list-style-type: none"> • Answer includes only indirect reference to a classification scheme • Answer is vague or too general • Answer is a restatement of the question. 	<ul style="list-style-type: none"> • Some of the elements on the table are solids, and some are gasses • There are different ways to classify the elements, depending on what they are
0	<ul style="list-style-type: none"> • no response is given • answer is incomprehensible or completely unrelated to question 	

Anchors such as these permit fairly quick scoring of production items according to some predetermined criteria, and as you can see they can be used with tasks that vary in the degree of complexity of thinking prompted. However, there are two problems with making up separate anchors for each item on a test. First, as you can imagine, it takes a long time to come up with anchors that represent a continuum of performance. Second, it is difficult to make judgments about student thinking on the basis of multiple tests because the context changes each time. For example, can we say that a student can effectively make predictions on the basis of the law of conservation item only? What about predicting in the context of ecology or alternative energy? Is it the context or the intellectual operation that we are measuring?

One approach to solving this problem is to use a set of guidelines that could be applied in multiple contexts. Here is an example of an essay task that asks students to make a decision and then support it with a reasoned argument. As you now know, it is an evaluation item.

Name _____ Date _____

Welcome to Mondo Bondo

Mondo Bondo is a small planet in a galaxy not far from here. It is covered with large trees, the sun shines most of the time and a steady wind blows all year long. People on Mondo Bondo cook and heat their homes with wood from the trees and use animals to do farm work. Gathering firewood and taking care of the animals is hard work so they have very little time to relax and enjoy the beauty of their planet. Recently, scientists have discovered large deposits of fossil fuels on Mondo Bondo. There are oil reservoirs, coal seams, and natural gas deposits.

Some of the people on Mondo Bondo would like to use these fossil fuels to heat their homes, and cook their food. They also want to build refineries to make fuels to power tractors, cars, and trains. These people want to make life easier so they will have time for the finer things, like art and music.

Other people on Mondo Bondo do not want to use the fossil fuels. They like their life the way it is now, even though it is hard. These people are afraid of what will happen to their planet if people start burning coal, oil and natural gas. This disagreement between the people who want to use the fossil fuels and the people who don't want to use them has caused many arguments and the good people of Mondo Bondo don't know what to do.

Pretend you are an ambassador from Earth who has been asked to help the people of Mondo Bondo with their problem. Write a letter to give them some advice that will help them decide what to do. Tell them about the benefits and the problems they can expect if they decide to use the fossil fuels. Also, tell about some solutions to these problems. Finally, give them some ideas about other energy alternatives they could explore. Use the back of this page if you need more room.

Dear People of Mondo Bondo . . .

Here are two sets of anchors that could be used to score student essays generated with this prompt. The first set of anchors is specific to the Mondo Bondo prompt.

ANCHORS FOR SCORING MONDO BONDO ESSAY

Score	<i>Characteristics</i>
5	<p>(a) The answer provides a summary of benefits associated with use of fossil fuels that extend those presented in the answer starter (efficient, can be used to power many machines, industrial development, etc.).</p> <p style="text-align: center;"><i>AND</i></p> <p>(b) The answer summarizes problems that can be expected (environmental damage from pollution, mining, and drilling; non-renewable supplies; etc.)</p> <p style="text-align: center;"><i>AND</i></p> <p>(c) The answer summarizes energy alternatives available to the inhabitants of Mondo Bondo (solar, wind, wood, animals, etc.) and presents or makes some attempt to present pros and cons associated with these.</p>
4	<p>The answer addresses all three aspects of the question: benefits, problems, and solutions, however, it may contain one or two inaccuracies. The author demonstrates that they understand generally the issue but may not be firm on some aspect of the problem. For example the author may present only one energy alternative or may focus on only one problem associated with fossil fuels.</p>
3	<p>(a) The answer is correct but incomplete. For example, it may present problems associated with fossil fuels beyond those stated in the scenario but no solutions or it may not address energy alternatives.</p> <p style="text-align: center;"><i>OR</i></p> <p>(b) The answer presents only one side of an argument. For example, it may accurately tell problems associated with fossil fuels but not address any benefits. Or it may argue for development of the fossil fuels without presenting problems and energy alternatives.</p> <p style="text-align: center;"><i>OR</i></p> <p>(c) The answer attempts to address the scenario but contains many inaccuracies or misconceptions about benefits, and problems associated with fossil fuels and energy alternatives.</p>
2	<p>(a) The answer simply restates the advantages and disadvantages associated with use of fossil fuels, provided in the answer starter. (Wood is labor intensive, fossil fuels are labor saving.) The answer addresses the problem but no attempt is made to go beyond the information presented. The answer presents minimal evidence of the student's understanding of problems associated with fossil fuels and some solutions for these problems.</p> <p style="text-align: center;"><i>BUT</i></p> <p>(b) The answer contains at least two key vocabulary words (except fossil fuels or energy)</p>
1	<p>(a) The answer attempts to address the issues presented in the scenario, but the writer is completely off target with respect to the issues presented. No mention is made of problems or solutions associated with fossil fuels. The answer presents no indication the student understands the issues associated with fossil fuels.</p> <p style="text-align: center;"><i>BUT</i></p> <p>(b) The answer contains at least one key vocabulary word (except fossil fuels or energy)</p>
	<p>(a) No response</p> <p style="text-align: center;"><i>OR</i></p> <p>(b) Response is irrelevant to scenario or incomprehensible. Contains no vocabulary words beyond those used in the answer starter.</p>

The next set of anchors is generic. These anchors can be used with any evaluation task. Evaluation requires use of appropriate criteria to make a decision when presented with a situation. Complete answers involve three parts: (a) communication of a clear choice or decision, (b) presentation of a rationale or criteria to support the choice, and (c) correct and logical reasoning.

ANCHORS FOR SCORING EVALUATION RESPONSES

Score	Characteristics
5	<ul style="list-style-type: none"> •The essay presents a clear and unequivocal choice (or choices) from among the options provided in the prompt. <li style="text-align: center;">AND •Specific reasons or rationale are presented in support of the choice(s). <li style="text-align: center;">AND •The rationale presented has a correct and logical basis within the context of the prompt or instruction presented.
4	<p><i>Two of the three features required for a 5-point answer are present:</i></p> <ul style="list-style-type: none"> •The essay presents a clear and unequivocal choice (or choices) from among the options provided in the prompt AND specific reasons or rationale are presented in support of the choice(s) BUT the essay contains factual errors or faulty logic in the context of the prompt of instruction. <li style="text-align: center;">OR •Specific reasons or rationales are presented in support of the choice(s) AND any rationales presented have a correct and logical basis BUT the choice (or choices) made from among the options provided in the prompt is vague or ambiguous. <li style="text-align: center;">OR •The essay presents a clear and unequivocal choice (or choices) from among the options provided in the prompt AND any arguments have a correct and logical basis in the context of the prompt of instruction BUT no specific reasons or rationale are presented in support of the choice(s).
3	<ul style="list-style-type: none"> •A choice (or choices) is made from among the options provided in the prompt but it is vague or ambiguous. The essay does not communicate a clear decision. <li style="text-align: center;">AND •Reasons or rationale are presented in support of the choice(s) but these are not directly pertinent in the context of the prompt or instruction AND/OR rationales are not stated clearly in a manner that supports a choice. <li style="text-align: center;">AND •Arguments or rationales presented contain up to two errors of information or logic.
2	<p><i>Two of the three features required for a 5-point answer are absent:</i></p> <ul style="list-style-type: none"> •The essay presents a clear and unequivocal choice (or choices) from among the options provided in the prompt BUT no specific reasons or rationale are presented in support of the choice(s) AND the essay contains factual errors or faulty logic in the context of the prompt of instruction. <li style="text-align: center;">OR •Specific reasons or rationales are presented in support of the choice(s) BUT the essay contains factual errors or faulty logic in the context of the prompt of instruction AND the choice (or choices) made from among the options is vague or ambiguous. <li style="text-align: center;">OR •The essay presents a clear and unequivocal choice (or choices) from among the options provided in the prompt BUT the essay contains factual errors or faulty logic in the context of the prompt of instruction AND no specific reasons or rationale are presented in support of the choice(s).
1	<ul style="list-style-type: none"> •No clear choice (or choices) is presented from among the options provided in the prompt. <li style="text-align: center;">AND •The essay shows little evidence of reasoning or use of criteria in decision-making. <li style="text-align: center;">AND •The essay contains factual errors or faulty logic in the context of the prompt of instruction.

The value of the last set of anchors is that they can be used to assess students' ability to use the complex intellectual operation "evaluation" in a wide range of contexts. For example, the anchors could be applied to test items, essays, research projects, or lab activities. Furthermore, once you are familiar with the anchors, scoring can become quite efficient and quick, addressing one of the problems we noted with production responses. Finally, the anchors could be used to communicate directly to students the expectations you may have for their performance in using information presented in content classes.

➡ Here are three essays written by students in response to the Mondo Bondo prompt on page 58. Use the two sets of anchors to score the essays. Which anchors do you think work best?

I would like to give you some advice to solve your problems. If you have no time to enjoy your planet use some of the fossil fuels but don't use too much because they are Non-renewable. Use crude oil to make plastic, metal, etc because you can reuse them over and over and over again. Use coal and natural gas to heat your home. but don't use too much. Use trees, sun, wind, water, and animals

If you are thinking of using The Fossil Fuels your crazy, They do nothing but pollute. Well I'm sure They help with electricity and to heat homes, But think of it this way when you burn coal sulfur oxides get in the air nitrogen to and when they mix with storm clouds it comes down as acid rain.

If I were you I'd think about solar energy and stay with sun, wood, and animals, to do some work. I mean I know that if you don't use Fossil Fuels you will probably have no time to enjoy the world But if you use the Fossil Fuels soon you won't have a world

I understand you don't have much time to enjoy your planet, and some of you want to use fossil fuels to make life easier. Well, we use fossil fuels here on earth, and they're great, but there are bad problems. now if I were you I would use some fossil fuels to heat homes. I would still use wood & animals as you are, because if you rely on fossil fuels you are going to destroy your planet, and there wouldn't be anything to enjoy on your planet. so use some fossil fuels for something like windmills that can create energy, or plastics that last awhile. Enjoy your planet as it is, not when it's polluted or destroyed. so keep in mind those problems like ruining the ozone and polluting and it being Non-renewable. so use those fossil fuels wisely.

Appendix

Directions for Completing Content Planning Worksheet

Complete this planning worksheet for each 2- to 3-week segment of content you plan to teach. This segment probably would correspond to a chapter in the textbook you normally use in the class specified, but it could correspond to an entire unit in the textbook, or a few chapters taught together as a short unit, or selected parts of a chapter. However, please refer to a complete segment rather than a specific lesson or set of lessons. For example, if you generally give a test about every two or three weeks (or three or four times a quarter), think of all the material you teach between each test.

Please provide three types of information:

- Key Concepts
- Important Ideas
- Graphic organizer

SPECIFIC DIRECTIONS

CONCEPTS

Please use this definition of concept:

- *Concepts are specific words or short phrases that refer to classes of objects or events that share some common defining attributes.*
- *Concepts involve three parts: a label, key attributes, and a range of examples.*

1. Please identify the key concepts that you consider *critical* for understanding the content you plan to teach during the three-week interval indicated. Learning these concepts would, in your opinion, mark the difference between mastery and nonmastery of the material you will cover.

List as many concepts as you feel are important, **up to ten**. Concepts you might target could include terms such as "molecule," "fossil fuel," "holy war," or "vassal." However, *specific examples* of concepts would not be applicable. For example, the concept "epoch" might be exemplified by "ancient Greece," "ancient Rome," or "the middle ages." These examples would not qualify as concepts according to the definition used here.

2. List one or two key defining attributes for each concept. These attributes would enable discrimination between what is and is not an example of the concept.

3. Provide 2 or 3 examples of each concept AND when possible or applicable also include non-examples that further aid in discrimination of the critical features of the concept.

IMPORTANT IDEAS

Please list **up to three** ideas that you believe are critical to mastery of the content you will teach. Ideas are more general than specific concepts in that they represent unifying themes or topics. Please focus on ideas contained within the context of a single unit rather than global themes or topics that cut across the entire course. For example, in a unit on fossil fuels, you might want students to understand the idea that "Use of fossil fuels results in environmental damage in the form of increased greenhouse gasses and acid precipitation." This idea would be more context-specific than the global theme, "Humans interact with their environment in a variety of ways, with both positive and negative effects," which could apply to a wide range of applications across a science curriculum.

Please frame the important ideas you want students to learn as complete sentences, rather than a few words or phrases.

GRAPHIC ORGANIZER

Sketch a graphic organizer of the content you will teach that shows the key relationships among concepts and ideas.

Content Planning Worksheet

Date: _____
Teacher: _____
Class: _____
Textbook: _____
Other Curriculum Materials: _____

Approximate Schedule of Content to be Delivered

Week	Dates		Textbook		Quiz Dates	Test Dates
	From:	To:	Unit	Chapters		
1	From:	To:				
2	From:	To:				
3	From:	To:				
4	From:	To:				

KEY CONCEPTS

- | | |
|--|---|
| 1. _____
2. _____
3. _____
4. _____
5. _____ | 6. _____
7. _____
8. _____
9. _____
10. _____ |
|--|---|

IMPORTANT IDEAS

1. _____

2. _____

3. _____

CONCEPT DESCRIPTIONS

<i>Concept</i>	<i>Attributes</i>			<i>Examples /Non Examples</i>		
1		Page	¶		Page	¶
2						
3						
4						
5						

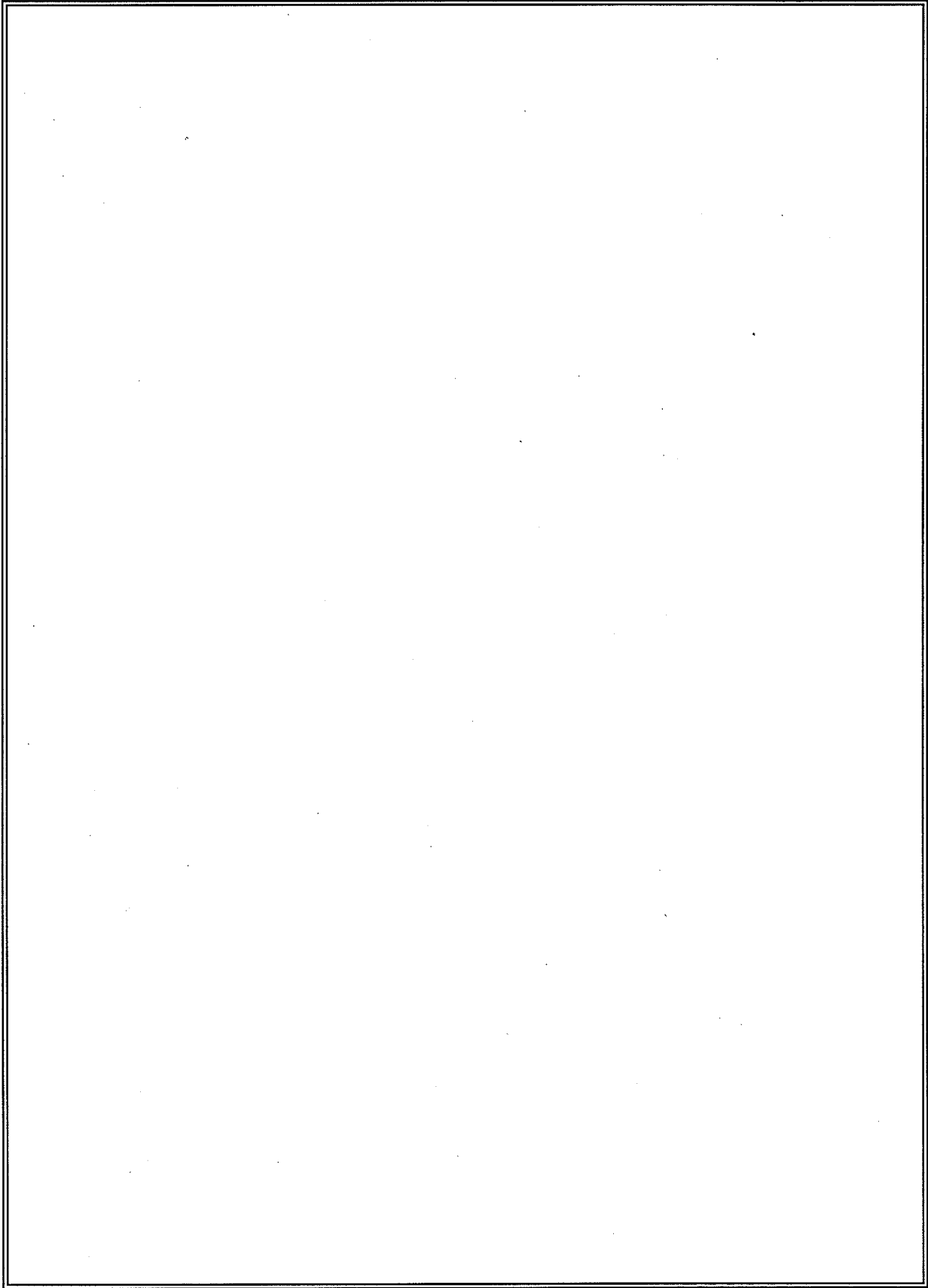
Notes:

CONCEPT DESCRIPTIONS

<i>Concept</i>	<i>Attributes</i>			<i>Examples /Non Examples</i>		
6		Page	¶		Page	¶
7						
8						
9						
10						

Notes:

GRAPHIC ORGANIZER



Directions for Administering Perception Probes

The probes should be administered during the last 5-10 minutes of class, or after most of the new information in a day's lesson has been presented. Administration procedures are standardized for both the time allowed for each section of the probe and the directions provided to students. The purpose of the probes is to get a quick "snapshot" of students' understanding of the material presented in a particular lesson and the relationship of this material to previous lessons.

Before administering the probe, decide on a word or short phrase that summarizes the topic of the lesson you have just presented. You will need to insert this *Summary Phrase* into the directions below. (Examples: "Geography of the Middle East," "Ancient Cultures of Greece," "Diet and Nutrition," "Matter")

General Directions for Teachers

1. Erase from blackboards and white boards any material associated with *today's* lesson. (Permanent displays, or information that relates to multiple lessons or a whole chapter, do *not* need to be erased or covered.)
2. Instruct students to close their notebooks and textbooks, and to put away any worksheets associated with today's lesson.
3. Distribute probe sheets, and instruct students to leave the sheets face down until instructed to turn them over.
4. Read or paraphrase the following directions aloud. (All directions to be read aloud are printed in bold.)

For the last [few days/week/few weeks] we have been discussing (Insert the *Summary Phrase* here). This is a check to see if you've been learning the most important things we've been talking about. Listen carefully while I tell you what you need to do.

You must use a blue or black pen or a pencil to complete this worksheet. Turn over the worksheet and write your name and today's date in the spaces provided. Please write your first and last name. Do not write anything in the space marked "ID."

Follow along with me while I read the directions.

Pretend you are telling a friend what you have been learning in class. You would want to tell them about the most important words and ideas. You also would want to tell them why these words and ideas are important.

Find where it says "Important Words."

When I say "Begin" list the words related to [Insert the *Summary Phrase* here] that you think are most important. You may list new words you learned for the first time today or you may list words we have talked about in other classes in the last [*few days/week/few weeks*]. List all the important words you can remember.

Do your best thinking and don't worry if you can't remember how to spell a word.

At the end of three minutes, I'll tell you to stop working. Keep working until I tell you to stop. If you fill in all of the blanks provided, put your pencil down and stop writing. **DO NOT GO ON TO THE NEXT SECTION UNTIL I TELL YOU TO DO SO.** Are there any questions?

Begin.

Allow 3 minutes for this section.
At the end of 3 minutes, say:

Stop working. Don't write any more words.

Now look at the section that says *IMPORTANT IDEAS*. Ideas are the thoughts you have about the things we've been talking about in class.

When I say **begin**, write three important ideas related to [Insert the *Summary Phrase* here] that we have discussed in class. You may write a phrase or a complete sentence, but be sure to provide your friend with enough information for them to know what you mean.

At the end of three minutes, I'll tell you to stop working. Keep working until I tell you to stop. If you fill in all of the blanks, put your pencil down and stop writing. **DO NOT GO ON TO THE NEXT SECTION UNTIL I TELL YOU TO DO SO.**

Are there any questions?

Do your best thinking and don't worry if you can't remember how to spell a word.

Begin.

Allow 3 minutes for this section.

At the end of 3 minutes, say:

Stop working.

Now look at the section that says *PUTTING IT ALL TOGETHER*.

When I say **begin**, tell how the words and ideas you listed above are related to one another. You may write a short paragraph or you may draw a sketch that shows how these ideas and words are connected. Use as many words and ideas from your lists as you like. If you need more room, use the back of this page.

You will have two minutes to work on this section. Keep working until I tell you to stop. Are there any questions?

Begin.

Allow 2 minutes for this section.

At the end of 2 minutes, say:

Stop working and put your pencils down.

Perception Probe

Pretend you are telling a friend what you learned in class today. You would want to tell your friend about the most important words and ideas discussed. You also would want to tell your friend why these words and ideas are important to remember.

IMPORTANT WORDS

List the words you think are most important to help your friend understand the material discussed in class today. You may list new words you learned for the first time in this chapter or unit or you may list words we have talked about in previous classes. List as many important words as you can remember.

1. _____	5. _____	9. _____
2. _____	6. _____	10. _____
3. _____	7. _____	11. _____
4. _____	8. _____	12. _____

IMPORTANT IDEAS

Tell three important ideas that were discussed today. You may write a phrase or a complete sentence, but be sure to provide your friend with enough information for them to know what you mean.

1. _____

2. _____

3. _____

PUTTING IT ALL TOGETHER

Tell how the words and ideas you listed above are related to one another. You may write a short paragraph or you may draw a sketch that shows how these ideas and words are connected. Use as many words and ideas from your lists as you like. If you need more room, use the back of this page.