DEEPEN UNDERSTANDING

Activity 3.3 Identifying Reasoning Verbs

What kinds of reasoning do you want your students to be able to do? Make a list of all reasoning verbs that come to mind.

Inductive and Deductive Reasoning

Induction and deduction both require inference, and to understand them, we need to be clear about what it means to infer. The *New Oxford American Dictionary* defines *infer* in this way: "deduce or conclude (information) from evidence and reasoning, rather than from explicit statements" (Jewell & Abate, 2001 p. 896). An inference, therefore, is a reasonable guess based on information, sometimes called, "reading between the lines."

When we reason *inductively*, we use particular facts or evidence to infer a general rule or principle. Sound inductive reasoning requires that we select relevant facts or evidence, interpret them accurately, and then draw careful conclusions based on them.

When we reason *deductively*, we begin with a general rule or principle and from that we infer a specific conclusion or solution. Sound deductive reasoning requires that we apply what the general rule tells us to a specific case and draw a plausible conclusion about that specific case. For example, consider the general rule, "All people get mad sometimes." We can therefore conclude, "Mom is a person; therefore, Mom gets mad sometimes."

Analytical Reasoning

When we reason analytically, we examine the components or structure of something. Analysis often requires that we investigate how the component parts relate to each other or how they come together to form a whole. We might ask students to analyze a controversial decision, wherein they identify the arguments for and against a particular action. We might ask them to conduct an experiment to analyze a compound to determine its component chemicals. Students engage in analysis when they determine the meaning of unknown words by breaking them into prefixes, suffixes, and root words. We undertake analysis to understand something more deeply or to provide an interpretation of it. For students to be successful at such tasks, they must be able to identify the parts of something and then have practice at describing relationships among those parts, or between the part and the whole.

DEEPEN UNDERSTANDING

Activity 3.4 Identifying Inductive and Deductive Reasoning

Which of these questions require an inductive inference and which call for a deductive inference?

- Given the evidence provided in the reading (an article about the stock market), what is the relationship between interest rates and stock values?
- Given what you know about the role geography plays in the growth of cities, describe the ideal location for a new city.
- If the chemical test yields this result, what element is it?
- Given what you know about the physical characteristics of insects, is this creature an insect?

(*Answers:* inductive, deductive, inductive, deductive)

Comparative Reasoning

Describing the similarities and differences between two or more items is at the heart of comparative reasoning. Notice that in this definition, comparative reasoning encompasses both *compare*—to find similarities, and *contrast*—to find differences. We begin with simple tasks such as asking students to say how two things are alike or different. But comparative reasoning in its more complex form requires that students select appropriate items to compare, and then select salient features to base their comparison on, before performing the actual comparison (Marzano, Pickering, & McTighe, 1993). The act of contrasting can be defined as identifying differences, or it can extend to the concept of *juxtaposition*, whereby we place two very different objects, emotions, thoughts, melodies, arguments, people, side by side to define each in sharp relief or to cause the differences between them to stand out distinctly. *Contrast*, used in this sense, is a device we manipulate for effect in areas such as writing, music, art, and drama. Venn diagrams and T-charts are two common graphic organizers used to help students understand the structure of comparative reasoning.

Classifying

Classification can be thought of as sorting things into categories based on certain characteristics. At its least complex application, classification consists of sorting objects into predetermined, clearly defined categories. To sort well at this basic level, students need practice at identifying and observing for the pertinent charactistics.

However, a more rigorous application of this pattern of reasoning requires students to select or create the categories. Playing the game "Twenty Questions" is an example of this aspect of classifying: the goal of each question is to find out what category the object fits into and to narrow the categories sequentially so as to deduce the correct answer. For example, a player might first ask, "Is it an animal?" to classify the object according to general type. Next, she might ask, "Is it bigger than a bread box?" to classify the object according to size. The third question might be, "Does it live around here?" to narrow the possibilities according to habitat, and so forth. The trick in Twenty Questions, as in all classification exercises, is to identify relevant categories that will provide the maximum information about the objects or concepts under consideration.

Another in-depth mental process we engage in during classification is refining categories as we sort to make them more precise, for the categories need to be as comprehensively defined as possible to allow for accurate sorting. We encounter new information or phenomena that don't quite fit the distinctions as they stand, so we revise the definition of our categories, or create new ones. For example, Richard is sorting a year's worth of photos to put them into albums. He starts by sorting them by season—winter pictures in this pile, spring pictures in this pile, and so on. Pretty soon he notices that he needs a more detailed ordering scheme if he is to create a chronological album, so he refines the categories to represent months. All is well until May, the month with three family birthdays, an anniversary, and Mother's Day—too many pictures. He decides to categorize May further by event. So it is that classification requires us to test our categories, notice when they don't quite fit, and carefully refine them to accommodate the new evidence.

We classify to count and compare (as in creating a bar graph to show relationships among things), to clarify (as in determining whether a sowbug is an insect), to differientiate (as in determining whether a statement is a main idea or a supporting detail), to draw conclusions (all people get mad sometimes; my mother is a person; my mother gets mad sometimes), to make decisions (as in categorizing household expenses to determine how to save money), or to organize information or concepts (as in outlining a paper to make sure information is in the right place). In its grandest application, classification is about the organizational schemes we impose on the world around us to understand it better. How we identify those categories controls how we view the world.

Evaluative Reasoning

Evaluative reasoning involves expressing and defending an opinion, a point of view, a judgment, or a decision. It can be thought of as having three facets: an assertion, criteria the assertion is based on, and evidence that supports the assertion. When engaging in evaluative thinking, students generally are able to begin with an assertion, but are often unable to articulate the other two components, criteria and evidence; in many cases, students express an opinion and then support it with further opinions.

We cannot call this *evaluative* thinking until students are able to identify criteria for making their assertion and are able to provide credible evidence that matches the criteria. For example, let's say we ask students to take a position on whether a literary character should or shouldn't have done something. Either position is defensible, but to demonstrate evaluative thinking, students will have to select and defend evaluative criteria. (How do we judge an action? On what basis? Such criteria might include one or more of the following: the action's effect on others, a moral or ethical stance towards the action, its effect on the character, the potential for long-term benefit vs. short-term gain, and so on.) Then, to defend their judgment, students will have to produce credible evidence and show how it fulfills their criteria. Similarly, when we ask students to evaluate the quality of their own work, they will need to use criteria describing levels of quality and then match their observations about their work to the criteria. In mathematics problem solving, students choose a strategy by evaluating the options, and they also must evaluate how well the strategy they selected is working along the way. In science, students evaluate the validity of their conclusions based on what they know about experimental design. In social studies, we ask students to evaluate the quality of the arguments a politician makes against a set of criteria.

Synthesis

Synthesis is the process of combining discrete elements to create something new. Cookies are an example of synthesis; when we combine the ingredients—eggs, milk, flour, sugar, salt, and vanilla—we get something new, cookie dough, which some people bake before eating. The process of synthesizing involves identifying the relevant ingredients to combine and then assembling them in such a way so as to create a new whole. Writing a report is an act of synthesis; we want our students to create something new (in their own words) from separate ingredients through a specific process. To do that they must locate and understand various bits of relevant information, sort through them, think about how they fit together, and assemble and present them in a way that does not copy any of the original sources.

Assembling differs according to the context. The color green can be synthesized by mixing blue and yellow pigment with a little water. To make the nylon used in women's stockings the ingredients, 1,6-hexanediamine and adipic acid, are mixed and then heated using steam under pressure. The act of interpreting data to draw a conclusion requires that we take discrete bits of information, look for patterns, and create new information—the conclusion. To write a story, we try out various combinations of setting, characters, problem, and resolution until we are satisfied with the mix.

The accompanying CD includes resources for teaching various patterns of reasoning in the file entitled "Graphic Organizers."

Concluding Thoughts About Patterns of Reasoning

These categories of reasoning will help you think through the learning targets you hold for students and to identify which ones call for which type of reasoning. A plethora of classification systems for reasoning exists, each a synthesis of its author's thought. We have chosen these six patterns (inductive and deductive inference, analysis, comparison, classification, evaluation, and synthesis) to represent those most commonly found among various taxonomies and systems. We also wanted to define reasoning targets in terms of patterns commonly represented in standards documents, and in terms you and your students could relate to. You may find other patterns or definitions that fit your needs more closely. Before you adopt them, be sure they are based on the best current understanding of reasoning in your subject area, and be sure you can explain them clearly in student-friendly terms. Table 3.3 shows examples of language arts and science reasoning targets representing each of these six patterns.

TRY THIS

Activity 3.5 Identifying Reasoning Targets

Identify five to seven statements in your local curriculum document (or whatever document you use to guide teaching) that represent reasoning learning targets. Categorize them according to the pattern of reasoning called for. Refer to Tables 3.1 and 3.2 for examples.

Reasoning Target Types

Inductive/Deductive	Analytical
Comparative	Classifying
Evaluative	Synthesis