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Beginning With What Students Know

The Role of Prior Knowledge in Learning

You've probably watched televised ice skating competitions and heard announcers wax rhapsodic about double axles or triple Lutzes. Perhaps the distinctions among these skating feats escaped you. Unless the announcer explained the movements or you figured them out for yourself, it is likely your confusion remained during and after the competition.

This experience is reenacted in our classrooms daily. Many students lack adequate prior knowledge to extract meaning from instruction. Yet we often make assumptions that they come to class possessing the skills and information to learn what we teach. Some research suggests that this assumption is erroneous and that learning is influenced as much by students' prior knowledge as by the new instruction they receive. Attention, then, needs to be paid to this fundamental aspect of the learning process.

Students, of any age, bring beliefs and life and academic experiences to the classroom that influence what and how they learn. At times, such prior knowledge facilitates learning by creating mental hooks that serve to anchor instructional concepts. Conversely, the acquisition of new content can be thwarted if it conflicts with students' preexisting misinformation. As a result, the role of prior knowledge in learning is paradoxical: it can lead to success and failure in the classroom. Consequently, teachers and students alike can benefit from taking time before instruction to identify what is known or, more accurately, believed to be known about a topic. Many strategies can tap students' prior knowledge. Later in this chapter, several are described.

WHAT ROLE DOES BACKGROUND KNOWLEDGE PLAY IN LEARNING?

Piaget (1968) disagreed with the *tabula rasa* notion of the child's mind. Instead, he proposed that young children gradually develop cognitive structures to make sense of the world. By the time they enter school, students have constructed informal theories about how things work, about themselves, and about others (Bransford, Brown, & Cocking, 2000; Carey & Gelman, 1991; Donovan & Bransford, 2005; Gardner, 1991). One example of a common childhood theory is the distinction between living and nonliving things. Some children perceive movement as a way to distinguish what is alive and what isn't. Since people move, they are alive, while plants are not, because they are stationary. In the classroom, children's conceptions about living and nonliving categories, or any other topic about to be taught, can be activated. When this is done, teaching shifts from transmitting knowledge to blank, absorbent minds to refining restructuring and building upon preexisting notions.

When preparing for instruction, most of us focus tremendous effort on the content we will teach. Often, less planning and instructional time is dedicated to accessing preexisting knowledge. This oversight can have significant implications. If preconceptions are not engaged, children may fail to correctly grasp new concepts or give up on a subject altogether. One simply needs to consider the prevalence of the notion that some people are good at math while many are not. Such ideas can prevent learning if not addressed. Further, if students' preexisting knowledge conflicts with the new content, the presented material information risks being distorted. For example, studies at all grade levels have shown students' chronic misunderstanding of basic physics concepts. When they attempt to explain the upward toss of a ball, they describe an initial upward force that is balanced at the top of its trajectory, and pulled by gravity back to the earth (Roschelle, 1997).

Physicists, by contrast, explain the ball toss in terms of a single force, that of gravity with positive, zero, and decreasing momentum. Research has shown that errors in solving math and science problems are not random (Roschelle, 1997). Instead, they emerge from students' underlying concepts or homespun theories. Furthermore, when students are asked to produce rote memory answers to questions, they may appear to know more than they do. If asked to apply the concepts to new problems or to give analogies, they may give responses that consist of unconventional and unacceptable explanations. To counteract the potential negative influence of prior knowledge, teachers and students can dedicate time and effort to making thinking visible and malleable.

WHAT DO RESEARCH STUDIES SHOW ABOUT PRIOR KNOWLEDGE?

Background knowledge is the raw material that conditions learning. It acts as mental hooks for the lodging of new information and is the basic building block of content and skill knowledge. In the literature, the term prior knowledge is often used interchangeably with background knowledge. Here, the terms are used synonymously since they mean essentially the same thing. It is interesting to consider how researchers define the concept. Some simply define prior knowledge as what a person already knows about the content (Marzano, 2004; Stevens, 1980) while others have more complex definitions. For example, Biemans and Simons (1996) conceive of prior knowledge as "all knowledge learners have when entering a learning environment that is potentially relevant for acquiring new knowledge (p. 6). Dochy and Alexander (1995) go further by claiming that prior knowledge is the whole of a person's knowledge, including explicit and tacit knowledge, metacognitive and conceptual knowledge.

Another helpful perspective of background knowledge is evident in Australia's Productive Pedagogies efforts. The State of Queensland's Department of Education (2002) refers to "high connection" and "low connection" learning.

High connection learning gives students the opportunity to link their prior knowledge to the topics, skills, and competencies addressed in the classroom. By contrast, low connection learning introduces new information without any direct or explicit exploration of students' background knowledge. Queensland educators are encouraged to teach productively by tapping student background knowledge.

The Australian example is noteworthy. Substantial research has validated the important role prior knowledge plays in students' academic success (Educational Research Service, 2006; Marzano, Gaddy & Dean, 2000; Smith, Lee, & Newmann, 2001). In fact, research has identified "red flag" approaches to teaching that undermine student motivation and learning. These include foregoing connecting new material to students' prior knowledge (Dolezal, Welsh, Pressley, & Vincent, 2003). Such connections are important because students confront new information every day. They must integrate the new material into their existing knowledge, construct new understandings, and revise current beliefs or theories as needed. Students who lack adequate prior knowledge or are not able to activate what they know often struggle to progress in a subject area or school itself.

As educators, we are fortunate to have meta-analyses and other research available on effective strategies. Before considering the findings from these studies, it should be clarified that there are two primary classroom approaches to working with prior knowledge. The first includes tapping or activating preexisting knowledge. The second approach is that of building or developing new background knowledge. The strategies included in this chapter address both.

Much of the research on background knowledge has focused on basic skills acquisition (Donovan & Bransford, 2005; Marzano, 2004; Strangman & Hall, 2004). For example, we know that reading comprehension (in many subject areas, not just language arts!) increases when background knowledge about a text's content is engaged (Bolin, 2005; Christen & Murphy, 1991; Graves &

Cook, 1980; Hayes & Tierney, 1982; Ogle, 1986; Stevens, 1982; Strangman & Hall, 2004). Successful techniques for tapping prior knowledge need not be difficult. Several meta-analyses (Marzano, 1998; Pressley, 1992; Strangman & Hall, 2004) reveal that simply asking students what they know about a topic before reading or instruction can raise achievement. Likewise in math and science, research has demonstrated that asking students questions about key concepts and/or clarifying them before teaching the content increases achievement (Fuson, Kalchman, & Bransford, 2005; King, 1992; Minstre1l, 1989).

Many studies suggest that mathematics instruction should build on students' existing knowledge along with teaching computational algorithms (Ball, 1993; Bolin, 2005; Bransford, Brown, and Cocking, 2000; Carpenter & Fennema, 1992; Carpenter, Fennema, & Franke, 1996; Donovan & Bransford, 2005; Educational Research Service, 2007; Lambert, 1986). This is because students often possess relevant information that can assist them in mastering new content. A case in point is that many children have informal methods for working with math in their everyday lives. Such knowledge can be engaged when the formal symbol systems are taught. Younger students might explain how they know the number of classmates stepping on and off a school bus. Older youth can be asked about financial approaches to buying a car. For those struggling with math using student think out louds and explicit instruction have been shown to enhance background knowledge (Education Research Service, 2007; Gersten & Clark, 2007). It is also important that teachers teach and ask their students to use the language of mathematics and the actual vocabulary encountered in the classroom and text.

Vocabulary plays a fundamental role in any student's knowledge base. In fact, some research suggests that teaching vocabulary is synonymous with building background knowledge (Marzano, 2004). Understanding key words is critical before learners can progress academically. For example, the average number of new words expected to be learned by a middle schooler is around 600 annually while for a high schooler it is 800 (Bolin, 2005; Marzano, 2004). It is easy to see how students can fall behind if they do not learn vocabulary.

Unfortunately, many students do begin behind. Studies of diverse first-grade students reveal that many possess half the vocabulary knowledge as their peers (Graves & Slater, 1987; Marzano, 2003; Nagy & Herman, 1984). Fortunately, all teachers at all grade levels, in all subject areas, can teach the essential words for their disciplines. A benefit of the standards movement is that it has targeted specific words in subject areas which can be the ones taught. Further, it is important that students use and apply the words themselves. Teachers may be interested in the work of Marzano (2004, 2005) and his colleagues at Mid-Continent Research for Education and Learning (MCREL). They identified nearly 8,000 words for common subject areas and suggest that teachers and schools teach 30 key terms per subject area annually. Additionally, the Tennessee State Department of Education (2006) has launched a statewide effort and has posted K–12 vocabulary for core subject areas on its Web site.

The recent emphasis on developing background knowledge by teaching key vocabulary echoes research findings from the cognitive sciences. In addition to the acquisition of facts, learners of all ages need to be taught key organizing ideas or generalizations of the topic or discipline at hand (Bransford et al., 2000; Diamond & Hopson, 1998). Big concepts or categories provide the glue for factual understanding, accommodate in-depth learning, and allow students to transfer and apply what they know. If a conceptual framework is lacking, students will be left to rely on their own preconceptions about how the world works.

Many researchers maintain that a significant purpose of education is to correct students' erroneous notions (Bransford, Brown, & Cocking, 2000; Donovan & Bransford, 2005; Gardner, 1991; Strangman & Hall, 2004). Attempts to make sense of the world, self, and others begin in early childhood and such homespun theories are not often correct. Subsequently, they can have consequences in K–12 education. Strangman and Hall (2004) report several studies that show that when students do harbor misperceptions, prior knowledge activation can actually impede new learning. Preexisting ideas can distort or interfere with the new content. If this occurs without intervention, students can fare poorly on tests and disregard information that conflicts with theirs. When teachers encounter misperceptions they should find, or help the student to discover, thoughtful ways to correct such ideas. Of course, establishing the conditions that enable student thinking to be revealed is no small task in and of itself. A positive, inquiry-based classroom environment is a prerequisite for students to share what they think they know. At the same time, creating a level playing field of knowledge for all students matters. Even a shallow amount of correct prior knowledge does much to improve learning in the short run and allows for greater depth at a future time (Marzano, 2004).

It would be a mistake to think that prior knowledge's only influence on learning is negative. This is not the case. Learning ultimately begins with the known and proceeds to the unknown. Connecting everyday experiences with classroom topics and intentionally engaging preexisting knowledge with new classroom content can promote meaningful and lasting learning.

A large number of studies on the topic of prior knowledge has focused on improving reading comprehension. This lens into prior knowledge emerged because of the need for students to be able to read to learn in all subject areas. Several approaches have been identified as capable of improving students' comprehension of informational texts.

Direct instruction strategies have shown much promise with diverse elementary, junior and high school students (Graves, Cooke, & Laberge, 1983; Stevens, 1982; Strangman & Hall, 2004). Examples of such techniques include vocabulary instruction as mentioned above, introducing difficult concepts contained in a text before reading, and providing plot and character synopses before reading narrative text.

Of course, there are many alternatives to direct instruction as well (Education Research Service, 2006). Such strategies include individual reflection and recording, interactive discussions, peer question and answer sessions, and, importantly, connecting concepts in a text with one's prior knowledge. Students can also compare and contrast new and existing knowledge. Patchen (2005) also talks about diversifying classroom groups to encourage participation among all students and to pose questions to everyone that are answerable. For example, teachers can ask students' for their opinions of classroom readings to avoid right or wrong response constraints.

For culturally diverse students, previewing can be especially vital in achieving academic success. Sandefur, Watson, & Johnston (2007) explain that some students need explicit frames of reference. The authors recommend "frontloading" the development of prior knowledge through visual media or simply talking about the issue.

It goes without saying that background knowledge is contextual and culturally construed. A challenge for teachers is to insure that all students reach the same high standards while communicating respect for their students' uniqueness. Building a common knowledge base among all students is challenging, and yet, as researchers have shown, good teaching remains good teaching in most environments (Ellison, Boykin, Towns, & Stokes, 2000; Williams, 2006). For example, Williams (2006) explains whether culturally relevant teaching differs from good teaching: "Culturally relevant teaching includes all that is considered good teaching but also takes the learner's cultural background into consideration, building on the student's experiences and affirming his or her cultural identity" (p. 12).

Teachers can strike a balance between commonality and diversity in their classrooms. All students can be helped to acquire the same skills necessary for contemporary society, and at the same time, respect for their diversity can be affirmed. What are strategies that teachers can use to engage students' cultural knowledge? Such techniques consist of asking open-ended questions so that students are not limited to right or wrong responses or approaches (DomNwachukwu, 2005; State of Queensland, 2002).

As the brief literature review reveals, background knowledge plays a significant role in student achievement. There are myriad such strategies for teachers to employ in their classrooms. Building on direct techniques consists of immersing students in hands-on experiences such as science labs, mentoring, or field trips. Building approaches also include teaching key academic vocabulary, previewing what is ahead, and explaining difficult concepts before they are taught in depth. Activating or tapping prior knowledge strategies includes reading, writing, discussing, thinking out loud, and visual cues or organizers.

Engaging students' preexisting knowledge or misperceptions offers teachers one way to informally diagnose their students' baseline. This can then serve as the critical first step in the learning cycle of the classroom. By meeting students where they are, teachers can make informed, strategic decisions about the content to be taught.

In the pages ahead, there are 17 research- and teacher-tested strategies for activating and building student background knowledge as well as resources for finding more.

#1: THE KNOWN AND THE UNKNOWN

A simple strategy for tapping student prior knowledge is the use of Known and Unknown charts. At the beginning of a lesson or unit, introduce the new topic or concept to the class. Using butcher paper or the blackboard, draw a chart with two columns. The first column should be labeled The Known and the second The Unknown (see Figure 1.1). To elicit student prior knowledge, ask students open-ended questions about the concept, such as: What makes stories interesting to read? What makes plants grow? Student responses should be logged as appropriate in either column. Students can also be asked what they are curious about and those responses placed on the chart as well. If content is not suggested by the class, inform students of the additional topics that they'll cover. Ask them where to place those concepts on the chart as well. This will give students a quick preview of what is ahead in their studies. During this activity, teachers should be on the lookout for any student misperceptions. If misinformation is volunteered, reframe the student statement as a question and write it in the second column. Doing this will avoid reinforcing erroneous notions.

This strategy can help teachers fine-tune the content of their instruction. When teachers assess what students know, they can strategically allot time to the areas of greatest need.

Figure 1.1 The Known and the Unknown

The Known	The Unknown

Known and Unknown charts can also be completed individually by students as long as the charts are reviewed and any misperceptions are pointed out. The charts can also be saved or posted and referred to as the class progresses through the unit. Some teachers have students check off items as they are learned. Others put the charts away the day they are created and bring them out at the end of a unit for students to compare and contrast their prior knowledge with current content knowledge.

#2: THINGS I KNOW, THINK I KNOW, WANT TO KNOW

Make a chart and divide it into three sections titled, What I Know, What I Think I Know, and What I Want or Need to Know (KTN) (see Figure 1.2). After informing students of what they are about to study, ask them to brainstorm what they think they know and want to know about the topic. Ask contributors to identify the appropriate column for their suggestions. List the suggestions, while once again as in Strategy #1 noting any that reflect misinformation. Put the misinformation into the column titled What I Think I Know.

Figure 1.2 KTN Chart

What I Know	**What I Think I Know**	**What I Want or Need to Know**

A good sequence for the KTN is to first develop a whole-class KWL chart, then small group charts, and then individual charts. This scaffolds students' skills at learning how to tap their own background knowledge. Check the charts for any misinformation and tell students that they'll learn content that clarifies any areas of confusion.

#3: WHAT I KNOW, WANT TO KNOW, AND LEARNED

Three-column charts can be drawn that are similar to KTN, as shown below in Figure 1.3. A teacher or student serving as the recorder can log what classmates say they already know about an upcoming lesson, what they want to know, and what they learned (KWL) after instruction. Although this method is similar to the one above, it differs in that it records the entire process of learning from prior knowledge to completed studies. Just like the KTN, this chart can be scaffolded from whole group to small group to individual.

Additional columns are sometimes added to turn the KWL chart into a learning log. For example, a fourth column might be labeled "What Else I Want to Learn," then a fifth could be labeled "How I Used the Information." It is advisable that students chart the new vocabulary they acquired to reinforce their background knowledge for future studies.

Figure 1.3 KWL

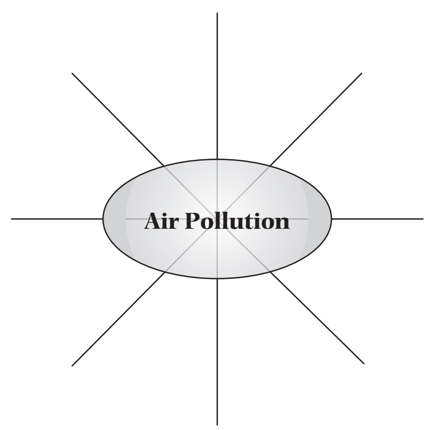
What I Know	What I Want to Know	What I Learned

#4: GETTING ORGANIZED GRAPHICALLY

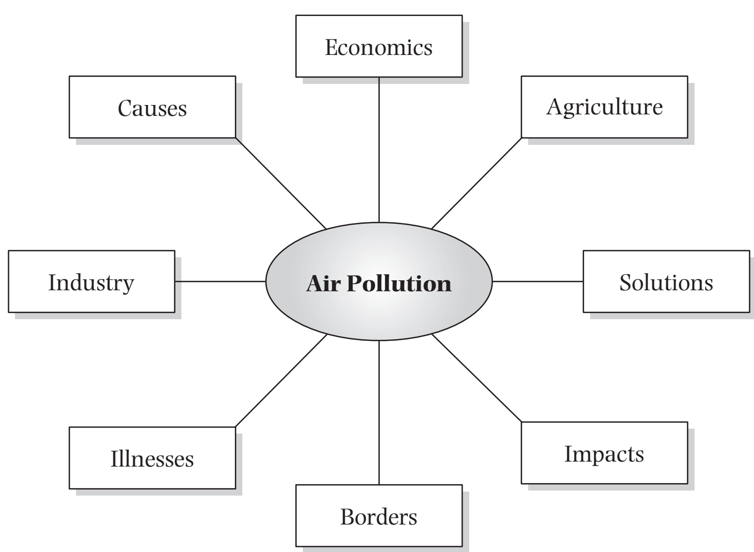
Students' prior knowledge can be tapped with simple graphic organizers. Graphic organizers are diagrams that visually display information. Depending on their structure, they can show relationships among data, such as hierarchies or subcategories, to use for many purposes as they assist students in visually organizing information and isolating important details. For the first example in Figure 1.4, students were asked to write a given topic in the center of a piece of paper (Step A). Next, for Step B, they brainstormed topics they knew were related to the topic in Step A. As they progressed through the unit, they added concepts to their organizers as shown in Step C.

Figure 1.4 Graphic Organizer

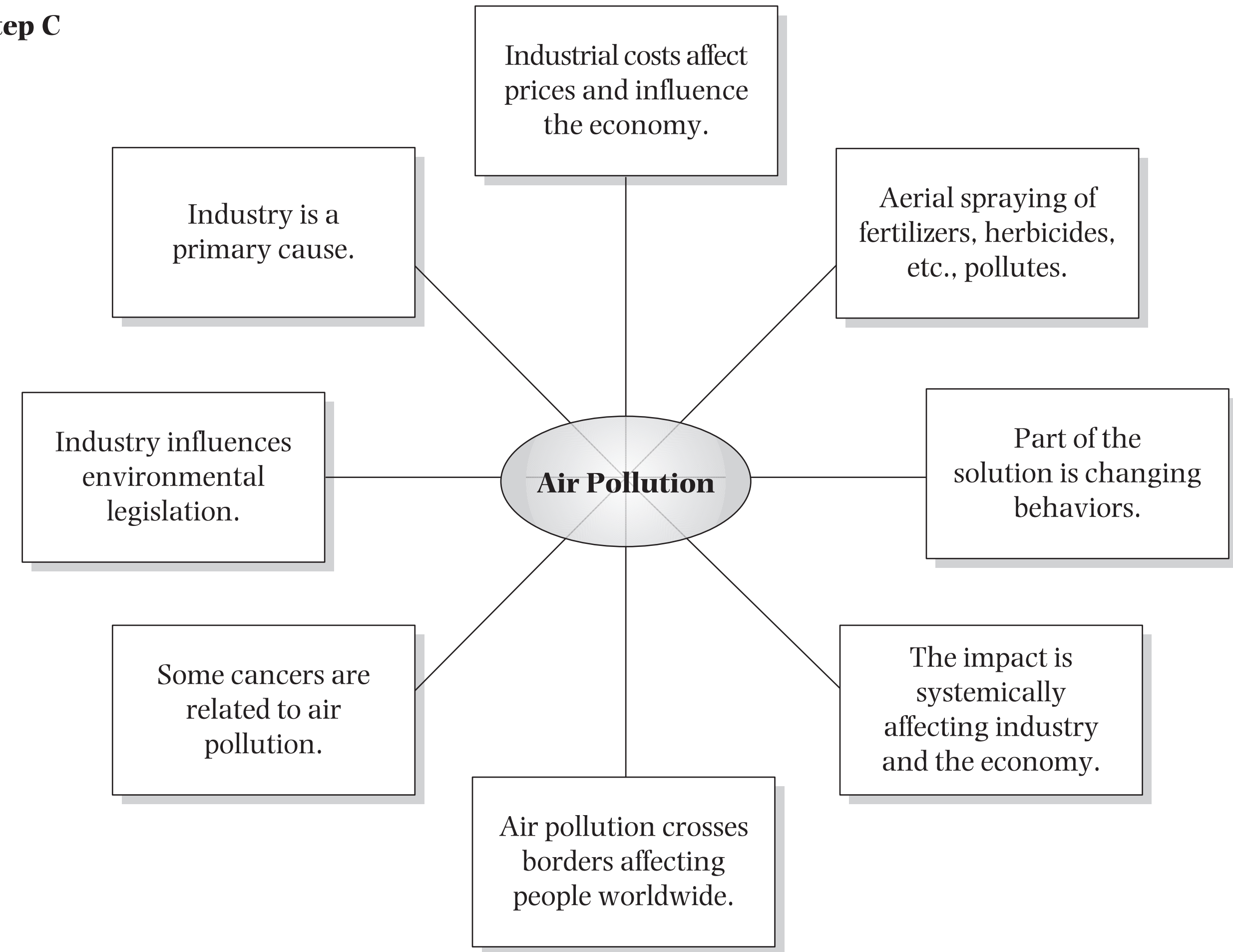
Step A



Step B



Step C

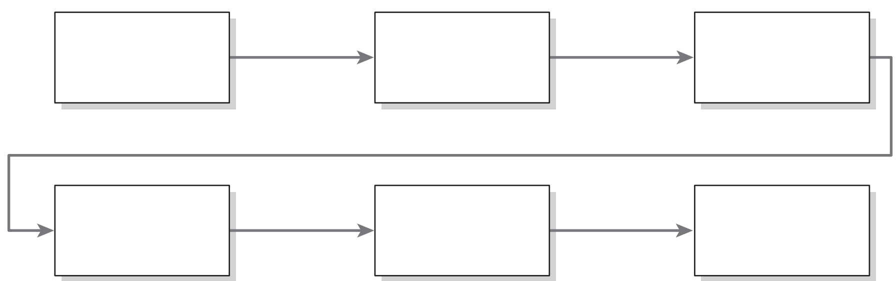

Industrial costs affect prices and influence the economy.
Industry is a primary cause.
Aerial spraying of fertilizers, herbicides, etc., pollutes.
Industry influences environmental legislation.
Air Pollution
Part of the solution is changing behaviors.
Some cancers are related to air pollution.
The impact is systemically affecting industry and the economy.
Air pollution crosses borders affecting people worldwide.

#5: VISUAL SEQUENCING

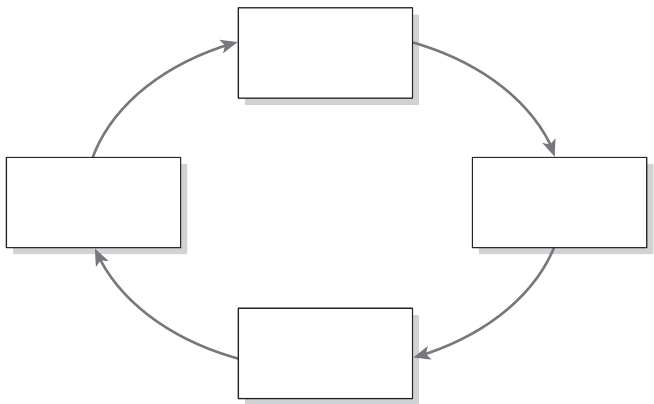
Background knowledge can be assessed or developed by visually identifying the steps of a lesson, a sequence of events, or a cyclical process. Two templates are provided in Figure 1.5: a flow chart and a cycle. At the beginning of a unit, either give students copies of one of the templates below or ask them to draw what you model on a chart or white board. Next, ask students to identify the potential steps or stages of the process—how one event leads to the final outcome—and to place the steps on the visual diagram. As they progress through their studies, students should correct earlier assumptions and elaborate on each component.

Figure 1.5 Flow Charts

Linear flow chart



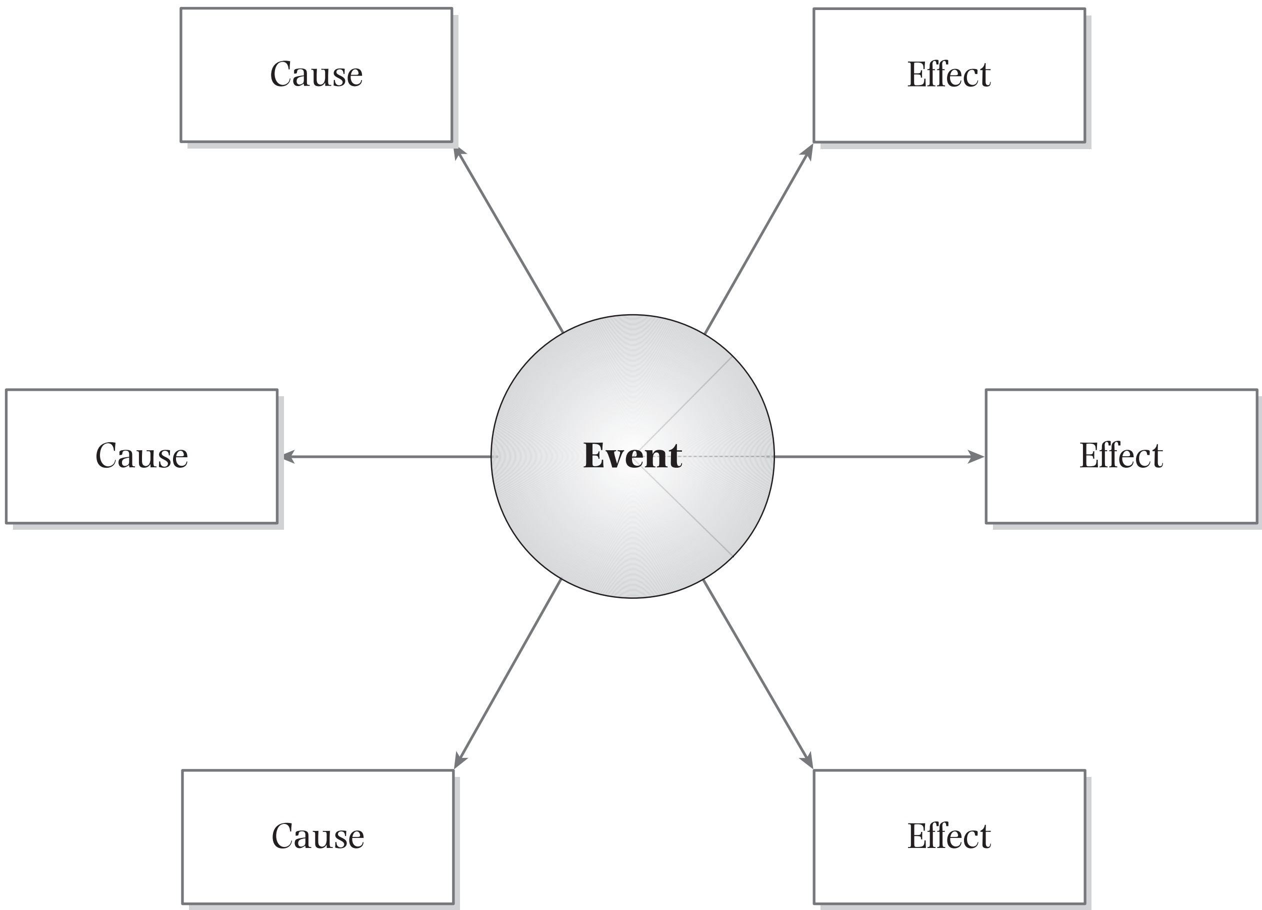
Cycle flow chart



#6: VISUALIZING CAUSE AND EFFECT

Students can be asked to explain their assumptions about the causes and effects of a particular event. Later, as they study the phenomena, they can compare and contrast their previous notions with what they learned. Cause and effect charts (see Figure 1.6) are helpful when analyzing a social phenomenon, historical event, or scientific process.

Figure 1.6 Cause and Effect Chart



#7: SEEING SIMILARITIES AND DIFFERENCES

Visually identifying similarities and differences among concepts can increase student thinking and understanding. Teachers can use simple graphic forms such as visual analogies in Figure 1.7A or Venn diagrams in Figure 1.7B to engage student prior knowledge, to associate new content with topics students already know, and to compare and contrast their notions before and after instruction. Students can also make copies of these or other visuals and use them to track their learning.

Figure 1.7A A Visual Analogy of Similarities

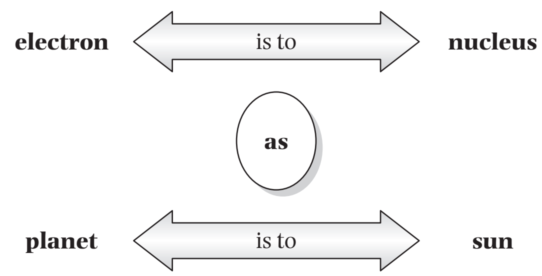
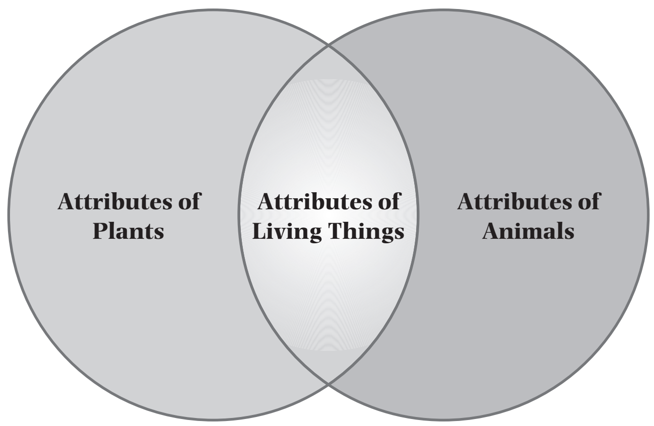


Figure 1.7B A Venn Diagram of Similarities and Differences



#8: THE WHOLE PIE

Many students benefit from a quick overview of a new concept they are about to learn. An advance organizer taps their prior knowledge to see where it fits into the overall topic. Figure 1.8 below shows a simple way to introduce any concept and its subcategories. In this case, the human body's major systems are identified. The circle itself represents the human body. Each major system is written in the borders of the circle's six sections. Each system is further divided by dotted lines that delineate the subcomponents of the system. Students can be asked to draw the first shape in Figure 1.8. Then questions can be asked to elicit prior knowledge, such as: What is the concept we are considering? Why are we studying this topic? What are its main parts? What are some of its subparts? Students can fill in the details as shown in the second shape in Figure 1.8.

Figure 1.8 The Whole Pie