Simpler Isn't Always Better: Comprehending Complex Text in Science and Technical Subjects

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Objectives

- Review features of informational texts that contribute to students' ability to understand information.
- Learn instructional strategies to implement in science and technical subjects.

2

Key Subjects

- Science
  - Biology
  - Chemistry
- Technical Subjects
  - Computer science
  - National Center for Construction Education and Research (NCCER)

3

Why Science and Technical Subjects?

- STEM fields
  - US economic success
  - Key growth fields
- Emphasis in short-term settings
  - Juvenile justice
  - Alternative schools
  - Foster care

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What Makes Texts in These Fields Difficult?: Vocabulary

- Technical
- Rare
- Knowledge of terms is inextricably linked to content knowledge

CCSS: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to *grade-specific texts and topics*.

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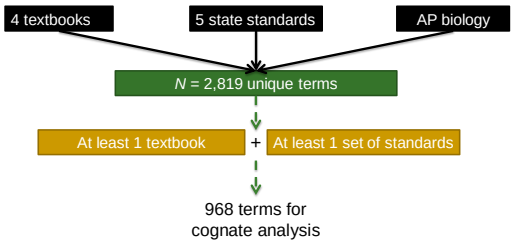
High School Biology Vocabulary

(Reed, Medina, Martinez, Veleta, 2013)



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Difficulty of High School Biology Vocabulary *(Reed, Medina, Martinez, Veleta, 2013)*

	Number of Terms	Word Frequency: LF English/ LF Spanish	HF English/ LF Spanish	HF English/ HF Spanish	LF English/ HF Spanish
All Biology Terms	968	839 86.7%	21 2.2%	70 7.2%	38 3.9%
Biology Terms by Cognate Type					
Full Cognates	829 85.5%	725	15	56	33
Partial Cognates	73 7.5%	72	1	0	0
No Shared Cognate	66 6.8%	42	5	14	5
False Cognates*	7 1%	0	1	1	5

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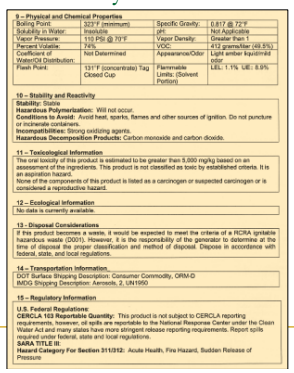
Vocabulary in Technical Subjects



9 – Physical and Chemical Properties

Boiling Point:	323°F (minimum)	Specific Gravity:	0.817 @ 72°F
Solubility in Water:	Insoluble	pH:	Not Applicable
Vapor Pressure:	110 PSI @ 70°F	Vapor Density:	Greater than 1
Percent Volatile:	74%	VOC:	412 grams/liter (49.5%)
Coefficient of Water/Oil Distribution:	Not Determined	Appearance/Odor:	Light amber liquid/mild odor
Flash Point:	131°F (concentrate) Tag Closed Cup	Flammable Limits: (Solvent Portion)	LEL: 1.1% UE: 8.9%

10 – Stability and Reactivity

Stability: Stable
Hazardous Polymerization: Will not occur.
Conditions to Avoid: Avoid heat, sparks, flames and other sources of ignition. Do not puncture or incinerate containers.
Incompatibilities: Strong oxidizing agents.
Hazardous Decomposition Products: Carbon monoxide and carbon dioxide.

11 – Toxicological Information

The oral toxicity of this product is estimated to be greater than 5,000 mg/kg based on an assessment of the ingredients. This product is not classified as toxic by established criteria. It is an aspiration hazard.
None of the components of this product is listed as a carcinogen or suspected carcinogen or is considered a reproductive hazard.

12 – Ecological Information

No data is currently available.

13 – Disposal Considerations

If this product becomes a waste, it would be expected to meet the criteria of a RCRA ignitable hazardous waste (D001). However, it is the responsibility of the generator to determine at the time of disposal the proper classification and method of disposal. Dispose in accordance with federal, state, and local regulations.

14 – Transportation Information

DOT Surface Shipping Description: Consumer Commodity, ORM-D
IMDG Shipping Description: Aerosols, 2, UN1950

15 – Regulatory Information

U.S. Federal Regulations:
CERCLA 103 Reportable Quantity: This product is not subject to CERCLA reporting requirements, however, oil spills are reportable to the National Response Center under the Clean Water Act and many states have more stringent release reporting requirements. Report spills required under federal, state and local regulations.
SARA TITLE III:
Hazard Category For Section 311/312: Acute Health, Fire Hazard, Sudden Release of Pressure

NCCER Core Curriculum

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Elements of Effective Vocabulary Instruction

- Explicitly teach key terms
- Teach word learning strategies
- Make the words vivid
- Engage students in discussion about the words
- Provide pragmatic information
- Offer multiple exposures in different contexts
- Return to key terms regularly throughout lessons

(e.g., Nagy et al., 2006; Scammacca et al., 2007; Vaughn et al., 2009)

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Breaking Apart the Technical Words

(Reed & Vaughn, 2012)

- *Sedimentary*: sed (to settle); ment (a product of); ary (adjective, describing word)
  - *Evaporites*: e (out of); vapor (steam); ite (mineral or fossil)
  - *Breccia*: brec/brech (fragment, break); ia (plural noun)
- *Igneous*: ign (fire); eous (composed of, resembling)
  - *Diorite*: dior (to distinguish); ite (mineral or fossil)
  - *Granite*: gran (grainy, made of grains); ite (mineral or fossil)
  - *Extrusive*: ex (out); trus (to thrust or push); ive (describes something that has a tendency to)
- *Metamorphic*: meta (change); morph (shape, structure, form); ic (adjective, describing word)
  - *Foliated*: foli (leafy); ate (noun, naming word)
  - *Graphite*: graph (black lead, to write); ite (mineral or fossil)

Deep Processing of Terms

Ionic Compounds

Definition

A type of chemical bond between atoms formed by transferring electrons from a metal to a nonmetal

Characteristics

Solids
High Melting Point and Boiling Point
Conduct Electricity when heated
Dissolves in water (but not nonpolar liquid)
Made of metal and non-metal atoms
Molecules have charged ions
Form crystals
Hard and brittle
Atoms satisfied the octet rule
Held by ionic bond

Examples

NaCl (salt, sodium chloride)
CaBr2 (Calcium Bromide)
$[Cu]^{2+}[F]^{-1}$ CuF_2 (copper fluoride)
$[Li]^{+}[:\ddot{O}:]_2[Li]^{+}$ (lithium oxide)

Non-Examples

O2 (oxygen)
CO2 (Carbon Dioxide)
Non-metal + Non-metal
H—N—H (ammonia, NH_3)
|
H

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Cumulative Review of Terms/Concepts

	Thick sheets	Thin sheets	Narrow gap	Can be automated	Prevents oxidation	High speed	Lower speed		
Shielded metal arc welding	+	+			+		+		
Gas metal arc welding	+	+	+	+	+	+			
Flux core arc welding	+			+		+			
Gas tungsten arc welding		+	+				+		
Plasma arc welding	+	+	+	+		+			
Submerged arc welding	+		+	+		+			

(Reed, in preparation)

CCSS: Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., *force, friction, reaction force, energy*).

What Makes Texts in These Fields Difficult?: Text Complexity

- Readability
  - Vocabulary
  - Sentence structure
- Coherence
  - Explicit connectives
  - Incidence of causal particles and verbs

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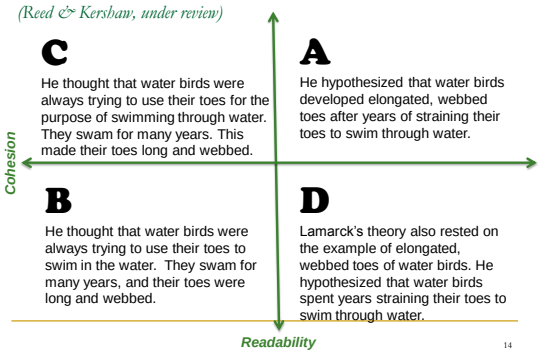
High School Science Text Complexity

(Reed & Kershaw, under review)



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How Students Performed

(Reed & Kershaw, under review)

- D: low readability level & high cohesion
- B: low readability level & low cohesion
- A: high readability level & high cohesion
- C: high readability level & low cohesion

Only significant difference: D vs. C

$F(3, 99) = 2.71, p = .049$

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How Complex is Text in the Technical Subjects?

- Readability: 11
- Deep cohesion: 0.148

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Scientific Discourse

- Few personal pronouns
- Few or no personal experiences
- Based on abstractions
- Generalize phenomena through nominalizations

CCSS:
- Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, defining the question the author seeks to address.
- Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem.

Supporting the Construction of Nominalizations: Rewrites *(Fang, 2006)*

Gravitational attraction is in direct proportion to the product of the objects' masses and inverse proportion to the square of their distance apart.

Suggested Re-write:

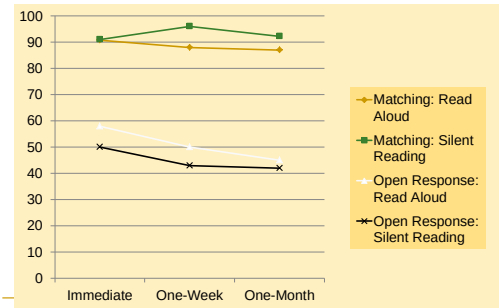
The pull of gravity is stronger when the objects are heavier and closer together.*

Tracing Arguments/Logic in a Scientific Text

Newton's law of universal gravitation states that gravitational force decreases with distance and mass. Newton's laws of motion describe the relationship between forces acting on a body and its motion due to these forces. Newton used *universal gravitation*, along with his *laws of motion*, to substantiate Kepler's laws of planetary motion.

Credit: NASA

Is There an Advantage to Reading the Text Aloud to Students?



(Reed, Swanson, & Vaughn, 2013)

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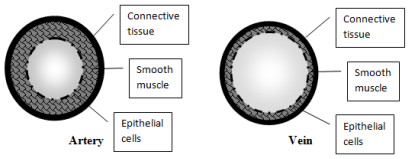
Justifying Responses

- Discussion as a key component of lessons
- CCSS: Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts.

Integration of Text and Graphics: Science *(Reed & Vaughn, 2012)*

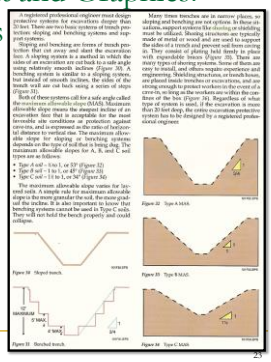
Both arteries and veins are structures that carry blood throughout the body. Their walls are made of three layers, but there is an important difference between the two types of blood vessels. The walls of arteries are much thicker than the walls of veins.

Cross-sectional View of Arterial and Venal Walls



The reason arteries need to be thicker is because they carry blood away from the heart under strong pressure exerted each time the heart muscle contracts or pumps. Blood moving back toward the heart in the veins has much less force.

Integration of Text and Graphics: Technical Subjects



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Supporting the Integration of Text and Graphics: Posing Open Questions *(Chin, 2007)*

- How is the diagram/graph/image related to the explanation of _____?
- What does ____ tell you about ____?
- What happens to _____ when _____?
- How can you tell if _____?
- How can you describe _____?

CCSS: Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

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Suggested Questions: NCCER Example

- How is the diagram/graph/image related to the explanation of safe sloping systems?
- What does the diagram tell you about the differences between the sloped and benched trench?
- What does the text tell you about the soil types associated with the different sloping systems?
- How can you tell if a text or diagram is referring to an MAS of 45º?
- How can you describe the difference between MAS Types A, B, and C?

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Connecting the Words and Symbols: Chemistry

Combustion: A combustion reaction is when [1]oxygen combines with another compound to form[2]water and[3]carbon dioxide. These reactions are exothermic, meaning they produce heat. An example of this kind of reaction is the burning of[4]napthalene:

$$C_{10}H_8 + 12\ O_2 \longrightarrow 10\ CO_2 + 4\ H_2O$$

4. napthalene — 1. oxygen — 3. carbon dioxide — 2. water

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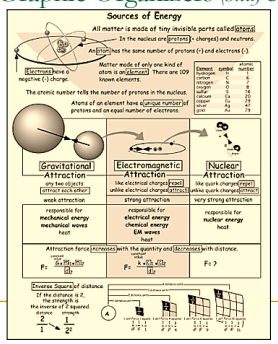
Supporting the Integration of Text and Graphics: Graphic Organizers *(Steely & Carnine, 2001)*



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What are the important reading skills in science?

- Understanding scientific arguments
- Connecting claims to evidence
- Providing precise and accurate explanations of scientific phenomena
- Integrating text and visual representations
- Following causal relations among ideas
- Encouraging the use of scientific language in writing and discussion activities

(Cromley, Snyder-Hogan, & Luciw-Dubas, 2010; Krajcik & Sutherland, 2010; León, & Peñalba, 2002; Moje, 2004)

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How Do the Key Ideas Relate to the CCSS?

- Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.
- Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.

Early Skills

- Main idea
- Details
- Summarizing

Topic/Title: Adaptations of Bacteria	**Pages: 490-493**
Section 1 Main Idea: Bacterial respiration can be aerobic, anaerobic, or both.	**Section 1 Details:** Obligate aerobes need oxygen – example: tuberculosis Obligate anaerobes are killed by oxygen – examples: C. botulinum and T. pallidum. Other bacteria can use both cellular respiration and fermentation.
Section 2 Main Idea: Forming endospores helps bacteria survive harsh environments.	**Section 2 Details:** Endospore = tiny structure containing bacterial DNA and cytoplasm encased in a tough covering. Endospores are at rest and do not reproduce. Germinate when environmental conditions improve. Can survive at temperatures of 100◦ C so difficult to kill.
Section 3 Main Idea: Harmful bacteria living on food and in the soil can cause deadly diseases.	**Section 3 Details:** C.botulinum: on food, so if improperly stored or in unsterilized containers, can germinate and produce toxins as grow. B. anthracis: in soil and commonly infects cattle/sheep; human get skin infections from handling animals; if airborne and inhaled in large quantities can be fatal.
Section 4 Main Idea: Helpful bacteria are more common and produce foods and medicine.	**Section 4 Details:** Help to fertilize fields, add nutrients on earth Convert nitrogen (gas) from air to ammonia and from ammonia to nitrites and nitrates that plants can use.
Summary: Bacteria have adapted over time and might use aerobic respiration, anaerobic respiration, or both. They can survive harsh conditions by producing endospores, which allow them to stay at rest and resist drying out, extreme temperatures, and harsh chemicals. That makes killing harmful bacteria, such as the anaerobic C. botulinum, difficult. It takes very high heat and proper food handling to prevent C. botulinum from germinating and causing food poisoning. Other bacteria are harmless in one location but harmful in others such the B. anthracis in soil that causes fatal damage to lungs if it becomes airborne. However, most bacteria are harmless and help living organisms by converting nitrogen in the air to nitrogen that plants can use, replenishing nutrients in the soil, and producing foods and medicines.	

(Reed et al., under review)

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(Reed et al., under review)

1.) Concept

Immune System

2.) Definition/description: Define or describe the concept in your own words.

the protection mechanism inside the human body designed to defend the body against bacteria, viruses, toxins and parasites that invade the body

3.) Does it make sense? Circle the sentence(s) that does not make sense. Explain why it does not make sense.

1. The immune system protects your body from being dismantled until after death.
2. Your immune system will attack and kill your own cells if they become infected with a virus.
3. Your immune system protects you from allergies.

Allergies are caused by your immune system overreacting to stimuli that other people don't react to at all.

4.) Scientific argument: Use the text information to support the argument.

We know the human system is able to deal with most germs because…

- You eventually recover from the cold or flu
- It protects your from invaders when you have a break in the skin or mosquito bite
- You do not get food poisoning every time you eat

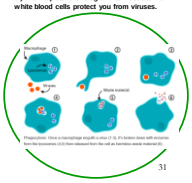
5.) Text structure: Use the text to complete the template and show the relationship among the important ideas.

Effects of Your Body Recognizing a Virus

Immune system detects a virus

- viral antigens stimulate production of antibodies
- Antibodies block virus from penetrating host cells
- Antipbidies or white blood cells attack and kill virus and virus-infected cells
- Helper T cells cause production of proteins to help immune system fight viruses

6.) Draw a picture or diagram to illustrate how white blood cells protect you from viruses.



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ADDED CHALLENGE OF NCCER TEXTS

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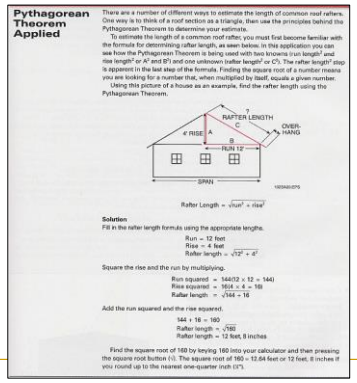
Math



Pythagorean Theorem Applied

There are a number of different ways to estimate the length of common roof rafters. One way is to think of a roof section as a triangle, then use the principles behind the Pythagorean Theorem to determine your estimate.

To estimate the length of a common roof rafter, you must first become familiar with the formula for determining rafter length, as seen below. In this application you can see how the Pythagorean Theorem is being used with two knowns (run length² and rise length² or A^2 and B^2) and one unknown (rafter length² or C^2). The rafter length² step is apparent in the last step of the formula. Finding the square root of a number means you are looking for a number that, when multiplied by itself, equals a given number.

Using this picture of a house as an example, find the rafter length using the Pythagorean Theorem.

$$\text{Rafter Length} = \sqrt{\text{run}^2 + \text{rise}^2}$$

Solution

Fill in the rafter length formula using the appropriate lengths.

$$\text{Run} = 12 \text{ feet}$$
$$\text{Rise} = 4 \text{ feet}$$
$$\text{Rafter length} = \sqrt{12^2 + 4^2}$$

Square the rise and the run by multiplying.

$$\text{Run squared} = 144(12 \times 12 = 144)$$
$$\text{Rise squared} = 16(4 \times 4 = 16)$$
$$\text{Rafter length} = \sqrt{144 + 16}$$

Add the run squared and the rise squared.

$$144 + 16 = 160$$
$$\text{Rafter length} = \sqrt{160}$$
$$\text{Rafter length} = 12 \text{ feet, } 8 \text{ inches}$$

Find the square root of 160 by keying 160 into your calculator and then pressing the square root button (√). The square root of 160 = 12.64 feet or 12 feet, 8 inches if you round up to the nearest one-quarter inch (¼").

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Science

9 – Physical and Chemical Properties

Boiling Point:	323°F (minimum)	Specific Gravity:	0.817 @ 72°F
Solubility in Water:	Insoluble	pH:	Not Applicable
Vapor Pressure:	110 PSI @ 70°F	Vapor Density:	Greater than 1
Percent Volatile:	74%	VOC:	412 grams/liter (49.5%)
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Hazard Category For Section 311/312: Acute Health, Fire Hazard, Sudden Release of Pressure

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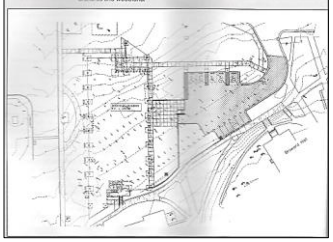
Social Studies

Topo-graphic Maps

Topographic (topo) maps provide a representation of vertical dimension that allows you to get a feel for the shape or contour of a piece of land. Topo maps identify physical features such as mountains, lakes, and streams. Three maps indicate where highways and railroads run. They often include information on drainage and land use such as orchards and woodland.



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English Language Arts

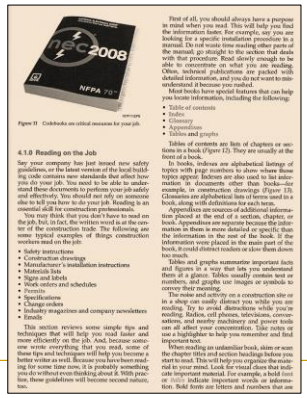

Figure 11 Codebooks are critical resources for your job.

4.1.0 Reading on the Job

Say your company has just issued new safety guidelines, or the latest version of the local building code contains new standards that affect how you do your job. You need to be able to understand these documents to perform your job safely and effectively. You should not rely on someone else to tell you how to do your job. Reading is an essential skill for construction professionals.

You may think that you don't have to read on the job. Not, in fact, the written word is at the center of the construction trade. The following are just a few examples of things construction workers read on the job:

- Safety instructions
- Construction drawings
- Manufacturer's installation instructions
- Materials lists
- Signs and labels
- Work orders and schedules
- Permits
- Specifications
- Change orders
- Industry magazines and company newsletters
- Emails

This section reviews some simple tips and techniques that will help you read faster and more efficiently on the job. And, because you will write everything that you read, some of these tips and techniques will help you become a better writer as well. Because you have been reading for some time now, it is probably something you do without even thinking about it. With practice, these guidelines will become second nature, too.

First of all, you should always have a purpose in mind when you read. This will help you find the information faster. For example, say you are looking for a specific installation procedure in a manual. Do not waste time reading other parts of the manual; go straight to the section that deals with that procedure. Read slowly enough to be able to concentrate on what you are reading. Often, technical publications are packed with detailed information, and you do not want to misunderstand it because you rushed.

Most books have special features that can help you locate information, including the following:

- Table of contents
- Index
- Glossary
- Appendices
- Tables and graphs

Tables of contents are lists of chapters or sections in a book (Figure 12). They are usually at the front of a book.

In books, indexes are alphabetical listings of topics with page numbers to show where those topics appear. Indexes are also used to list information in documents other than books—for example, in construction drawings (Figure 13). Glossaries are alphabetical lists of terms used in a book, along with definitions for each term.

Appendices are sources of additional information placed at the end of a section, chapter, or book. Appendices are separate because the information in them is more detailed or specific than the information in the rest of the book. If the information were placed in the main part of the book, it would distract readers or slow them down too much.

Tables and graphs summarize important facts and figures in a way that lets you understand them at a glance. Tables usually contain text or numbers, and graphs use images or symbols to convey their meaning.

The noise and activity on a construction site or in a shop can easily distract you while you are reading. Try to avoid distractions while you're reading. Radios, cell phones, televisions, conversations, and nearby machinery and power tools can all affect your concentration. Take notes or use a highlighter to help you remember and find important information.

When reading an unfamiliar book, skim or scan the chapter titles and section headings before you start to read. This will help you organize the material in your mind. Look for visual clues that indicate important material. For example, a bold font or italic indicate important words or information. Bold fonts are letters and numbers that are

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And… Construction Trades

- Safety techniques
- Tools and equipment
- Building procedures
- Welding procedures
- Etc…

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Summary Points

- Explicitly teach vocabulary
- Increase text complexity—but provide appropriate supports
- Explicitly teach how to integrate text and graphics
- Scaffold comprehension from more basic to advanced skills

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