CRITICAL THINKING

TOOLS FOR TAKING CHARGE OF YOUR LEARNING AND YOUR LIFE

THIRD EDITION

Richard Paul
Foundation for Critical Thinking

Linda Elder
Foundation for Critical Thinking

PEARSON

Boston Columbus Indianapolis New York San Francisco Upper Saddle River
Amsterdam Cape Town Dubai London Madrid Milan Munich Paris Montréal Toronto
Delhi Mexico City São Paulo Sydney Hong Kong Seoul Singapore Taipei Tokyo

Editor-in-Chief: Jodi McPherson
Editorial Assistant: Clara Ciminelli
Vice President, Director of Marketing: Margaret Waples
Executive Marketing Manager: Amy Judd
Production Editor: Annette Joseph
Manufacturing Buyer: Megan Cochran
Editorial Production Service and Electronic Composition: Integra
Art Director: Linda Knowles
Cover Designer: Jennifer Hart

Credits and acknowledgments borrowed from other sources and reproduced, with permission, in this textbook appear on appropriate page within text.

Library of Congress Cataloging-in-Publication Data

Paul, Richard.
Critical thinking : tools for taking charge of your learning and your life / Richard Paul, Linda Elder.—3rd ed.
p. cm.
Includes bibliographical references and index.
ISBN 978-0-13-218091-7 (alk. paper)
1. Critical thinking. I. Elder, Linda. II. Title.
B809.2.P38 2011
153.4'2—dc22

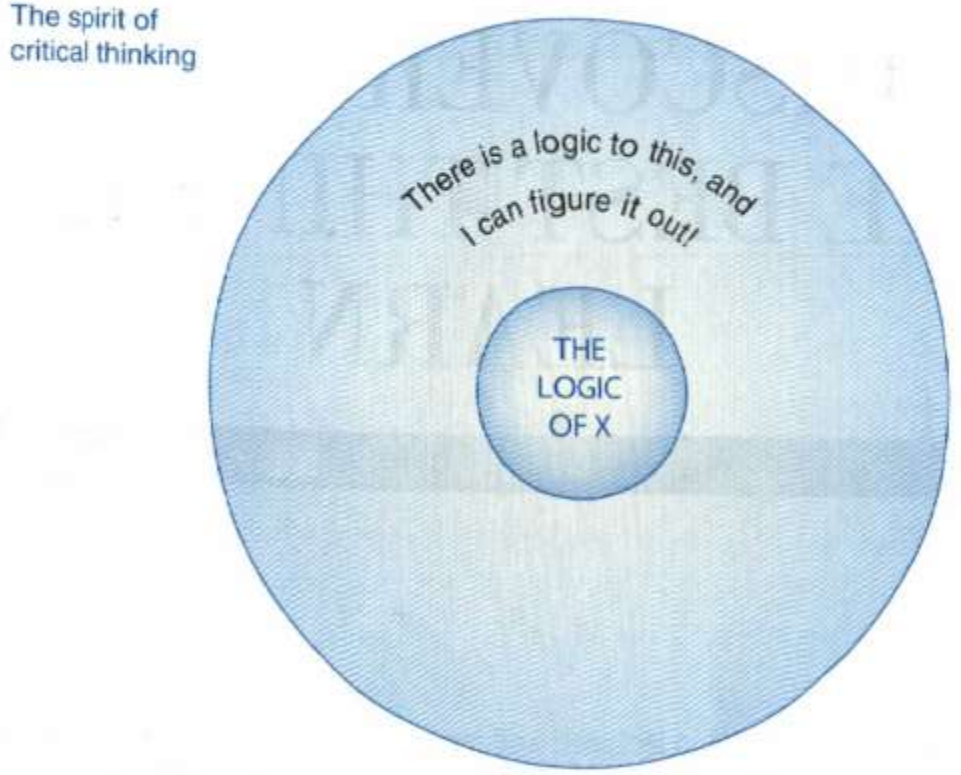
2011003890

10 9 8 7—V031—16 15

PEARSON

ISBN-10: 0-13-218091-X
ISBN-13: 978-0-13-218091-7

EXHIBIT 8.1 *Critical thinkers have confidence in their ability to figure out the logic of anything they choose.*



18 IDEAS FOR IMPROVING YOUR STUDIES

Idea # 1: Make sure you thoroughly understand the requirements of each class—how it will be taught and what will be expected of you. Ask questions about the grading policies and for advice on how best to prepare for class.

Idea # 2: Become an active learner. Begin to work ideas into your thinking by actively reading, writing, speaking, and listening.

Idea # 3: Think of each subject you study as a form of thinking. (If you are in a history class, your goal should be to think historically; in a chemistry class to think chemically; etc.)

Idea # 4: Become a questioner. Engage yourself in lectures and discussions by asking questions. If you don't ask questions, you probably won't discover what you do and do not know.

Idea # 5: Look for interconnections. The content in every class is a *system* of interconnected ideas, never a random list of things to memorize. Don't memorize like a parrot. Study like a detective, always relating new learning to previous learning.

Idea # 6: Think of your instructor as your coach. Think of yourself as a team member trying to practice the thinking exemplified by your instructor. For example, in an algebra class, think of yourself as going out for the algebra team and your teacher as demonstrating how to prepare for the games (thinking within the discipline).

Idea # 7: Understand the textbook as the thinking of the author. Your job is to think the thinking of the author. For example, role play the author frequently. Explain the main points of the text to another student as if you were the author.

Idea # 8: Consider class time as a time in which you *practice* thinking (within the subject) using the fundamental concepts and principles of the course. Don't sit back passively, waiting for knowledge to fall into your head like rain into a rain barrel. It won't.

Idea # 9: Relate content whenever possible to issues and problems and practical situations in your life. If you can't connect it to your life, you don't understand it at a deep enough level to use it in your thinking.

Idea # 10: Figure out what study and learning skills you need to develop. Practice those skills whenever possible. Remember that recognizing and correcting your weaknesses is a strength.

Idea # 11: Frequently ask yourself: Can I explain this to someone well enough for them to accurately understand it? (If not, you haven't learned it.)

Idea # 12: Seek the key concept of the course during the first couple of class meetings. For example, in a biology course, try explaining what biology is in your own words. Then relate that definition to each segment of what you learn afterward. Fundamental ideas are the basis for all other ideas.

Idea # 13: Routinely ask questions to fill in the missing pieces in your learning. Ask yourself: "Can I elaborate on this? Can I give an example?" If you cannot give examples of what you are learning you are not connecting what you are learning to your life.

Idea # 14: Test yourself before each class by trying to summarize, orally or in writing, the main points of the previous class meeting. If you cannot summarize the main points, you haven't learned them.

Idea # 15: Learn to test your thinking using intellectual standards: "Am I being clear? accurate? precise? relevant? logical? Am I looking for what is most significant?"

Idea # 16: Use writing as a tool for learning by writing summaries in your own words of important points from the textbook or other reading material. Formulate your own test questions. Then write out answers to your questions.

Idea # 17: Frequently evaluate your listening. Are you actively listening for main points? Can you summarize what your instructor is saying in your own words? Can you elaborate what is meant by key terms?

Idea # 18: Frequently evaluate the depth of your reading. Are you reading the textbook actively? Are you asking questions as you read? Can you distinguish what you understand from what you don't understand?

.1 *Think for Yourself*

WHERE DO YOU STAND?

To what extent have you "designed" any part of your learning (in high school or college)? Have you ever developed any strategies for learning? Can you name one? Did it work (if you can think of one)? If you can't think of any strategies you use to learn, why not? On a scale of 1 to 10, how skilled would you say you are as a learner?

THE LOGIC OF A TYPICAL COLLEGE CLASS

Because you are learning through the medium of college classes, it is helpful to understand the logic of college classes. To understand the logic of college classes, consider college in the light of its history and traditions.

College today is a product of college yesterday. Traditions alive in college instruction go back hundreds of years. For example, the most common way for professors to try to get students to learn a body of knowledge is to state that body of knowledge to them in a sequence of lectures and then to ask students, largely on their own, to internalize that knowledge outside of class. In this design, quizzes and examinations are usually interspersed among the lectures as means of assessing the extent to which the students have learned what the lectures covered.

Often a quiz is not given for six weeks or more. When this traditional teaching approach is used, students often revert to two strategies, neither of which is conducive to deep learning:

1. Taking random, but disconnected, notes during the lecture (focusing on points that might be on the test)
2. Intensive cramming one or two nights before the quiz or test (striving to store a large amount of information in short-term memory)

Under these conditions, many students go from the passive to the desperate learner, from being largely inactive as a learner to being frantic as a learner. On the other hand, students who are naturally "good" at memorization generally get higher grades in lecture-based classes than students who struggle to memorize content. Consequently, these students erroneously connect high grades with skilled learning. In other words, because memorization leads to high grades, they conclude that when they memorize content, they are learning at a deep level. In this model, students formulate a concept of learning that is superficial and transitory.

8.2 *Think for Yourself*

ARE YOU A PASSIVE LEARNER?

To what extent would you say that you match the traditional college student learning pattern above (largely passive, periodically frantic)? To what extent do you think this pattern is effective for deep learning? Why have you fallen into this pattern (if you have)? Or why haven't you fallen into this pattern (if you have not)?

Becoming a Skilled Thinker

The ideal of college can be expressed in a number of ways. However, no matter how it is expressed, certain basic skills and dispositions must be included in the definition for it to accurately characterize the educated person. The educated person, for example, must be:

1. proficient in close reading and substantive writing;
2. able to acquire and effectively use significant information, reason well, communicate effectively, solve problems, and exercise sound personal and professional judgment;
3. proficient in formulating and assessing goals and purposes, questions and problems, information and data, conclusions and interpretations, concepts and theoretical constructs, assumptions and presuppositions, implications and consequences, and points of view and perspectives;
4. able to think clearly, accurately, precisely, relevantly, deeply, broadly, and logically;
5. intellectually perseverant, intellectually responsible, intellectually disciplined, intellectually humble, intellectually empathic, and intellectually productive;
6. reasonable, ethical, and effective in reasoning through complex problems, both globally and in one's personal life;
7. a lifelong learner with the capacity to deal effectively with a world of accelerating change, intensifying complexity, and increasing interdependence.

It should be clear to you that these characteristics and skills will not emerge simply as the result of regularly taking notes in lecture and cramming for quizzes and exams. If you value the ends expressed in the above ideals, if you want to develop as an educated person, you will have to establish personal imperatives that set you apart from your fellow students. You will have to develop habits that few of your peers are developing. You must rise above peer group expectation (and possibly peer group scorn) and learn for reasons of your own and at a deeper level.

You must recognize that to acquire knowledge, you must construct it in your mind. You must translate it from the thoughts of someone else into your thoughts. To think it into your mind, you must be able to state it, elaborate upon it, exemplify it, and illustrate it. You must become proficient in taking ownership of ideas. Ideas may come from lectures, from textbooks, or from other sources. But do not

be deceived by your ability to restate ideas in the same words that the instructor or text originally expressed them. A parrot, a tape recorder, or a rote memorizer is not a knower. Until you can express an idea in your own words and exemplify it from your own experience, it is not yours; you do not *know* it.

3.3 *Think for Yourself*

DO YOU OWN THE IDEAL?

Which of the goals stated above do you most identify with? Which the least? Why? Note that goals 3, 4, and 5 presuppose some knowledge of critical thinking. Consider one of these goals—for example, learning to be more proficient in using "concepts and theoretical constructs." How could you begin to incorporate this goal more thoroughly into your strategies for learning?

The Design of a Typical College Class and the Typical College Student

Although all college students take college classes, few master the logic of any academic discipline they study. Few students understand how college classes get designed or what challenges they themselves face in the learning process. Here are some important background facts:

1. Every field of study is subject to continual and (in most cases) enormous expansion.
2. Textbooks, which are the basis for most college classes, are getting larger and larger, and lectures are, in turn, tending to cover more and more content.
3. Most students do not know how to organize content as a system of meanings, to bring content into their thinking as a connected, interrelated system.
4. Most students use periodic cramming to pass their exams.
5. Most students read, write, and listen at a superficial level.
6. Most students lack intellectual standards by which to assess their own thinking and learning.

.4 *Think for Yourself*

RATING YOURSELF AGAIN

How would you rate yourself on items 3, 4, 5, and 6 above? Comment on each separately. Then comment on what you consider the implications of your answers to be. For example, for number 5, if you read at a superficial level, what is a consequence of your limited reading ability?

The facts presented above have a number of important implications:

. Most college exams are constructed so that the majority of students can pass them—that is, the majority of students can memorize well enough to pass them. (If a significant number of students were to fail the exams, the instructor would get low evaluations from the students.)

2. Grade inflation is rampant.

3. Most students probably could not pass the final exams for courses six months after the courses end.

4. Most students do not learn to think in the broader context of the course (e.g., they take history courses but do not learn to think historically; they take science courses but do not learn to think scientifically).

An important implication of these facts is that college generates a great deal f self-deception: Instructors who certify students as understanding subjects they o not truly understand; students who forget most of what they temporarily cram nto their heads; accrediting teams and accrediting departments that show no real vidence that students are learning what they claim they are learning.

Skilled thinkers want to do more than survive in college. They want their ollege education to help them become effective lifelong learners and thinkers.

8.5 *Think for Yourself*

THE PROBLEM OF SELF-DECEPTION

To develop as a critical thinker, you must be willing to face the fact that humans engage in a great deal of self-deception. Self-deception in college is part of the broader problem of self-deception in human life. Do you see any ways in which you have deceived yourself in terms of your learning? In your personal relationships? Do you see any ways in which teachers you have had in the past deceived themselves? Do you see any ways in which your friends are deceiving themselves?

For each class you take, it is important for you to understand how that course is designed. This includes figuring out the logic of the course through an analysis of the course syllabus, the textbook, and how the instructor has introduced the course. Every course in which you enroll has some essential things to look for. First, what are the official requirements of the class? What is the assigned reading, writing, and planned testing or assessment? When will papers, if any, be due? When will quizzes and tests occur? These are some obvious things to look for.

However you study, you want to meet the formal requirements at a high level. But there is something more important than merely getting passing grades. It is learning to think within the disciplines you study, internalizing core concepts, and gaining the most basic insights underlying the disciplines. It is important to make the mode

of thinking in the discipline a permanent part of your thinking. To aim at these high goals, you might routinely ask and pursue three interconnected key questions:

1. What is the central underlying concept of the course or subject?
2. What form(s) of thinking is (are) essential to this course or subject?
3. How can I begin to think within the logic of the subject?

Let us consider these in order.

FIGURE OUT THE UNDERLYING CONCEPT OF YOUR COURSES

If you look at the sequence of items a course covers as if they were random bits and pieces of information, the course will seem to lack any underlying unity. But virtually all courses have some inherent unity that, when understood, ties all the learning of the course together like a tapestry. This unity typically is found in foundational concepts that define the subject and its goals.

For example, if you understand that the important "facts" of history are the product of historical thinking, and recognize the basic patterns that underlie such thinking, you have a way of looking at everything covered in the textbook and lectures—namely, as products of historical thought. You then read the textbook and listen to the lectures in a special way, seeking to find components of historical thought. You recognize that, to understand any written history, you must understand

1. the historian's goals or purposes.
2. the questions or problems that are the primary focus of the historian.
3. the historian's specific selection of historical events he or she considers relevant to his or her questions.
4. the historian's interpretations of the events and the significance of those events.
5. the theoretical concepts the historian is using to interpret the events.
6. the underlying assumptions that help define the historian's perspective.
7. the implications of studying the historical events from a given perspective.
8. the historical point of view that shapes the historical reasoning throughout.

If, in addition, we recognize that everyone thinks historically every day of his or her life, we study history differently. For example, each and every day of our lives, we use in our thinking a story that entails our personal history. That story, or the way we view our past, determines the decisions we make today and the plans we make for the future. Our own personal history, then, reflects our historical assumptions, concepts, and point of view. It leads us to ask certain questions with certain purposes in mind. It leads us to make particular inferences, based on historical information, that then lead to implications.

When you see history in this richly interconnected way, you look for the historical goals and questions that are defining the construction of any and all historical accounts. You notice what events are included and look for what is left out of the historical account. You look at key historical conclusions historians come to, the key assumptions made, the underlying historical points of view. Yet, most history classes have little impact on the historical thinking of students. Therefore, most students lack the organizing idea behind the discipline of history. They lack insight into the logic of historical thinking. As a result, their own historical thinking remains unmodified by their "study" of history. They never internalize deep and important historical concepts that, if internalized, would enable them to think critically about the past and to apply historical concepts in everyday life.

Consider another subject—economics. If we understand the concept of scarcity as the underlying concept in economics, we study economics in a special way. We realize that all other concepts that economists use are related to this central idea behind economics: that it is not possible for any one of us to have everything we want (the fact of scarcity) and, as a result, all of us have to give up some things to get other things. What people are willing to give up to get something else forms the basis for their economic decision making. Power enters economics when some people control what is scarce and highly desired and can thereby "force" people who want what is scarce to make significant sacrifices to obtain such scarcities. This "power" is an important concept in economics.

Here is the skeleton for some other organizing ideas:

- *Mathematics* as the development of a language for quantification
- *Algebra* as arithmetic with unknowns
- *Sociology* as the study of how the life of humans is shaped by the groups in which they are members
- *Physics* as the study of mass and energy and the interrelations between the two
- *Philosophy* as the study of ultimate questions and their reasoned answers
- *Biochemistry* as the study of the chemistry of life at the molecular level

8.6 *Think for Yours*

GETTING THE KEY IDE

For practice, attempt to formulate the basic idea behind history, economics, or any other discipline. Explain that idea to a friend. Encourage him or her to ask you questions. See whether you can explain the significance of understanding the underlying idea behind a subject as an important first step in understanding the subject—and that every concept within the subject must be integrated into this key organizing idea. (We recommend that you use textbooks and/or encyclopedias in formulating core concepts.)

FIGURE OUT THE FORM OF THINKING ESSENTIAL TO COURSES OR SUBJECTS

The organizing concept behind a course is often the organizing concept behind a subject or discipline. If you understand this core concept, you should be able to formulate the eight central structures that define any form of thought:

1. What are the *goals* or objectives of the course or discipline?
2. What *questions* or problems will be central?
3. What *concepts* will be fundamental?
4. What *information* will I use in reasoning well within the subject?
5. What *point of view* or frame of reference do I need to learn to reason within?
6. What *assumptions* define the course or discipline?
7. What kinds of *conclusions* will I need to learn how to reason to?
8. What are the pay-offs (*implications*) of reasoning well within this discipline?

If we are correct in what we said about all subjects being forms of thought, each of your classes offers an invitation to think within one or more of those forms. Your ability to reason well within any subject will directly depend upon your ability to understand the *thinking* that defines the subject, to think the kind of thinking that professionals in the discipline think.

Consider the following thinking on the part of a student taking a course in history:

> To do well in this course, I must begin to think historically. I must read the textbook not as a bunch of disconnected stuff to remember but, instead, as the thinking of the historian. I must begin to think like a historian myself. I must begin to be clear about historical purposes. (What are historians trying to accomplish?) I must begin to ask historical questions (and recognize the historical questions being asked in the lectures and textbook). I must begin to sift through historical information, drawing some historical conclusions. I must begin to question where historical information comes from.
>
> I must notice the historical interpretations that historians form to give meaning to historical information. I must question those interpretations (at least sufficiently to understand them). I must begin to question the implications of various historical interpretations and begin to see how historians reason to their conclusions. I must begin to look at the world as historians do, to develop a historical viewpoint. I will read each chapter in the textbook, looking explicitly for the elements of thought in that chapter. I will actively ask historical questions in class from a critical-thinking perspective. I will begin to pay attention to my own historical thinking in my everyday life. In short, I will try to make historical thinking a more explicit and prominent part of my thinking.

Students who approach history classes as historical thinking begin to understand the historical dimension of other subjects as well. For example, they begin to recognize that every subject itself has a history and that the present state of the subject is a product of its historical evolution. What's more, historically thinking students notice

the overlap between history as a study of the relatively recent past of humans (in the past 30,000 years) and the much longer history of humans (canvassed in anthropology). They are able to place these past 30,000 years (which seem like such a long time when we first think about it) into the larger historical perspective of anthropology, which begins its study of the human past some 1.5 million or more years ago when our ancestors were small, hairy, apelike creatures who used tools such as digging sticks and clubs, walked upright, carried their tools, and lived on plant food.

Further, they see this longer history as breaking down into stages: from hunting and gathering civilizations to agricultural civilizations to industrial civilizations to post-industrial civilizations. And that's not all. They then are able to place this historical perspective into a still larger historical view by shifting from anthropological thinking to geographical thinking. They realize that human history is itself a small part of a much older history, that of mammals, and that the age of mammals was preceded by an age of reptiles, and that age by the age of coal plants, and that age by the age of fish, and that by the age of mollusks. They then can take the next step and grasp that geological history, even though reaching back thousands of millions of years, is comparatively short when compared to that of the solar system, and that of the solar system is comparatively short when compared to the galaxy, and that of the galaxy is comparatively short when compared to the history of the universe itself.

The capacity to think historically in larger and larger time spans continues to develop as the study of all subjects is transformed by a developing sense of the drama of time itself. Historical thinkers then are able to shift from history to prehistory, from prehistory to anthropological history, from anthropological history to geological history, and from geological history to astronomical history. In this ever-expanding perspective, the history of human knowledge is pitifully short: a millisecond geologically, a milli-millisecond astronomically. Only a second ago, astronomically speaking, did a species emerge—*Homo sapiens*, which drives itself and creates the conditions to which it itself must adapt, in new and unpredictable ways. Only a millisecond ago did a species emerge that has the capacity, but not the propensity, to think critically.

8.7 *Think for Yourse*

DEVELOPING YOUR THINKING

Examine in detail the extract quoting a student thinking about history (see page 162). Write out some thinking of your own about any subject you are studying. Construct parallel sentences if you wish, but try to begin to see how each of the parts fits and contributes to an organized way of understanding a body of content and learning within any system of thought.

Then read and explain to a classmate or a friend what you wrote. Encourage him or her to ask you questions whenever what you say is not clear. Only when you can accurately articulate the logic of a course in your own words and elaborate on that logic can you begin to use it in your thinking. Once you finish, you can begin to think about how your thinking within this discipline can help you gain insights into other disciplines as well.

THINK WITHIN THE LOGIC OF THE SUBJECT

Once you have some sense of what you are aiming at as a whole, when you can articulate the key organizing idea within a subject, begin to plan your learning in parts, in light of the order or sequence in which content is being presented in the class and in the textbook. Then go to class armed with questions generated by reading your class notes and the textbook. You also might read encyclopedia entries for help with the basic logic of a subject. Some possible start-up questions are:

What is the main *goal* of studying this subject?

What are people in this field trying to accomplish?

What kinds of *questions* do they ask? What kinds of problems do they try to solve?

What sorts of *information* or data do they gather?

How do they go about gathering information in ways that are distinctive to this field?

What is the most basic idea, *concept*, or theory in this field?

How should studying this field affect my *view* of the world?

How are the products of this field used in everyday life?

These questions can be contextualized for any given class day, chapter in the textbook, and dimension of study. For example, on any given day, you might ask one or more of the following questions:

What is our main *goal* today?

What are we trying to accomplish?

What kinds of *questions* are we asking? What kinds of problems are we trying to solve?

What sort of *information* or data do we need?

How can we get that information?

What is the most basic idea, *concept*, or theory that we need to understand to solve the problem we are most immediately posing?

How should we look at this problem? What *point of view* should we adopt?

How does this problem relate to everyday life?

.8 *Think for Yourself*

ASKING GOOD QUESTIONS

Using these questions as a stimulus for your thinking, write out, for any class you are taking, a series of questions that enable you to think your way into the subject of the course. Compare your questions with the questions of another student.

THE LOGIC OF BIOCHEMISTRY

Let us now explicate the logic of one discipline by analyzing some key passages from the kind of text you might find in a book on the subject. Consider the following quote:

> [In biochemistry] ... attention is directed to the problems of finding out how molecular events underlie macroscopic phenomena, with special reference to the modes of action of vitamins, drugs, and genetic factors. One kind of job that biochemists undertake is, of course, to isolate compounds from living things and determine their structures. In this they share the preoccupation of other kinds of biologists with spatial form.
>
> Biochemistry includes a sort of submicroscopic anatomy that elucidates structure on the minute scale of molecules. The classical anatomists cut up bodies to describe the parts of which they are made insofar as they are visible to the naked eye. Microscopy revealed a whole new world of structure and organization smaller than this, and ... cells became the focus of interest. With the advance of chemistry, it gradually became possible to tackle biological architecture even on the molecular scale.
>
> The grand strategy remains the same—a better understanding of living things in terms of their constituent parts. The tactics, however, ... depend on the order of size of the parts being examined. For gross anatomy, the scalpel is appropriate; for cellular structure, the microscope; for parts as small as molecules, the relevant techniques are those we call chemical.... Seen in this light, biochemistry is the logical extrapolation of dissection. The idea is epitomized in the expression "molecular biology."...
>
> Merely to determine structure, however, is far from the summit of the ambitions of biochemists. They are interested not only in what the constituents of living things are like, but also in what they do—in the way that chemical processes underlie the more obvious vital manifestations. The continuous change that is one of the most striking characteristics of life rests on unceasing chemical activity inside living organisms. Biochemistry thus continues another classical tradition of biology in linking form with function. Like anatomy divorced from physiology, static divorced from dynamic biochemistry ... fails to ... increase man's power over nature. Life, after all, is a matter of keeping events going, not only of maintaining structures; and biochemists seek to elucidate events as well as structures by isolation.
>
> By and large, then, while the techniques of biochemistry are chemical, its problems are the basic ones of biology. Chemistry is its means, biology its end. It is the extreme extension of that approach to the phenomena of life that seeks to explain them in terms of the sub-units of which living organisms are composed. Of this kind of biological analysis, it represents the ultimate state—ultimate because pushing the analysis a stage further, from the molecular level down to the atomic, leaves no characteristically biological kind of organization, the atoms being the same in the inorganic realm.... Biochemistry concentrates on the farthest removal from immediate biological reality; insofar as it concerns itself with molecules, it remains remote from intact organisms. Data on the molecular level have to be related to observations made on more highly organized, less disrupted systems. (Jevons, 1964)

Biochemical Goals

It is clear from this passage that the goals of biochemistry are to determine the biochemical foundations of life and, through those means, to develop a rational

chemotherapy. It aims to be a fundamental kind of biology, to use chemistry and events on the molecular scale, typified by proteins and single enzyme reactions, and then "moves on to their collaboration and organization above the molecular level in subcellular particles."

Biochemical Questions

The chemical concepts address the phenomena of life. From isolated molecules and questions, biochemistry is concerned with these questions: What are we made of? How do our bodies work? What is life? More particularly: How do molecular events underlie macroscopic phenomena of life? What compounds underlie living things? What is their structure? And what do they do?

How do vitamins work in the body? How do drugs work? How do genetic factors influence both? What molecular parts of living organisms are the special concern of biochemistry? (What are proteins, carbohydrates, and fats? What do they do? What are nucleic acids? What do they do?) How do enzymes catalyze virtually every reaction in living organisms? What is the role of enzymes in biological thought? How can we understand the biochemical unity of living matter? What is the similarity of yeast and muscle? What do proteins do inside living organisms? How can we correlate observations made at different levels of organization? How can we design drugs and create a rational chemotherapy? How can we produce drugs that target undesirable events in living creatures?

Biochemical Information

From the questions above, we can begin to see the kinds of information that biochemists seek: information about proteins and enzymes as the kind of chemical units out of which life is constructed, about the process of catalysis as the means by which key chemical reactions essential to the construction of life take place, information about artificial lifelike reactions (such as the study of a single enzyme reaction in a test tube), information about the variety of enzymes in living cells, about the molecular structures within cells, about multi-enzyme systems and how they operate, and so on.

Biochemical Judgments

From the biochemical information above, biochemists clearly seek to make judgments about the important properties of enzymes, their protein nature, the agents that make things happen in living organisms, metabolism, the complex process of maintenance and growth of which life basically consists.

Biochemical Concepts

From the biochemical judgments above, we have to understand a number of essential concepts to understand the logic of biochemistry: the concept of levels of organization of life processes (at the molecular level, at the subcellular particle level, at the cellular level, at the organ level, and at the level of the total organism);

the concept of life structures and life processes; the concept of the dynamics of life; the concept of proteins, enzymes, catalysis, and metabolism as reducible to a consecutive series of enzyme-catalyzed reactions; the concept of the unity of life processes amid a diversity of life forms; and so on.

Biochemical Assumptions

From the biochemical concepts above, some key assumptions behind biochemical thinking are that life has biochemical foundations; that these foundations are found at the molecular level; that the techniques of chemistry are most fitting for the study of life at the molecular level; that it is possible to use chemical concepts to explain life; that it is possible to analyze and discover the structure and dynamics of isolated molecules and events on the molecular scale; that proteins and enzymes are key agents in fundamental life processes; that enzyme reactions are crucial to understanding life; and that it is possible, ultimately, to develop a rational chemotherapy that can be used in medicine and everyday life planning to kill unwanted life processes while strengthening or maintaining desirable ones.

Biochemical Implications

The present logic of biochemistry has specific and general implications. The specific implications have to do with the kind of questioning, the kind of information-gathering and information-interpreting processes that biochemists are using today. (For example, the state of the field implies the importance of focusing questions and analysis on the concepts above, of seeking key answers at the molecular level, involving proteins, enzymes, and catalyzed chemical reactions.) The general implications are that, if modern biochemical theory is on the right track, we will be increasingly able to enhance human and other forms of life and diminish disease and other undesirable states (by application of chemotherapy).

Biochemical Point of View

The biochemical viewpoint is directed at the molecular level of life and sees that level as providing for the most fundamental disclosures about the nature, function, and foundations of life. It sees the essential techniques to be chemical. It sees the essential problems to be biological. It sees life processes at the molecular level to be highly unified and consistent. It sees life processes at the whole-animal level to be highly diversified. It sees the processes at the molecular level to be the key, along with genetics, to the explanation of diversity at the macroscopic level.

Clearly, as soon as we understand the basic logic of biochemistry and situate ourselves somewhere in a course in biochemistry, the questions we bring to class will be contextualizations of this logic for the following generic types:

What is our main goal today?

What are we trying to accomplish?

What kinds of questions are we asking? What kinds of problems are we trying to solve?

What sort of information or data do we need?

How can we get that information?

What is the most basic idea, concept, or theory that we need to understand to solve the problem we are posing most immediately?

How should we look at this problem?

How does this problem relate to everyday life?

On one day, the class may be focusing on a particular concept such as catalysis, on another day big molecules, on another day subcellular particles, on another coenzymes, on another energy transactions, on another DNA. Understanding the overall logic of biochemistry will enable you to make sense of where you are, why it is significant, and how to relate it to what came before and what will come after.

THE LOGIC OF FOUR ADDITIONAL DISCIPLINES

Now consider the logic of biology that would likely be implicit in a standard biology textbook. This is followed by three additional logics: that of ecology, aerospace engineering, and electrical engineering.

The Logic of Biology

Biological Goals

Biology is the scientific study of all life forms. Its basic goal is to understand how life forms work, including the fundamental processes and ingredients of all life forms (i.e., 10,000,000 species in fragile ecosystems).

Biological Questions

The questions biology is concerned with are: What is life? How do living systems work? What are the structural and functional components of life forms? What are the similarities and differences among life forms at different levels (molecule, organelle, cell, tissue, organ, organism, population, ecological community, biosphere)? How can we understand the biological unity of living matter?

Biological Information

The kinds of information biologists seek are: information about the basic units out of which life is constructed, the processes by which living systems sustain themselves, the variety of living systems, and their structural and functional components.

Biological Judgments

Biologists seek to make judgments about the complex processes of maintenance and growth of which life basically consists.

Biological Concepts

A number of essential concepts are basic to understanding the logic of biology: the concept of levels of organization of life processes (at the molecular level, at the subcellular particle level, at the cellular level, at the organ level, and at the level of the total organism), the concept of life structures and life processes, the concept of the dynamics of life, the concept of the unity of life processes amid a diversity of life forms, etc.

Biological Assumptions

Some of the key assumptions behind biological thinking are: that there are foundations to life; that these foundations can be identified, studied, described, and explained; that it is possible to use biological concepts to explain life; that it is possible to analyze and discover the structure and dynamics of living systems and their components; that all forms of life reproduce, grow, and respond to changes in the environment; that there is an intricate and often fragile relationship between all living things; that all life forms, no matter how diverse, have common characteristics: 1) they are made up of cells, enclosed by a membrane that maintains internal conditions different from their surroundings, 2) they contain DNA or RNA as the material that carries their master plan, and 3) they carry out a process, called metabolism, which involves the conversion of different forms of energy by means of which they sustain themselves.

Biological Implications

There are specific and general implications of the present logic of biology. The specific implications have to do with the kind of questioning, the kind of information-gathering and information-interpreting processes being used by biologists today. For example, the state of the field implies the importance of focusing questions and analysis on the concepts above, of seeking key answers at all levels of life systems. The general implications are that we have the knowledge, if not always the will, to understand, maintain, and protect forms of life.

Biological Point of View

The biological viewpoint is focused on all levels and forms of life. It sees all life forms as consisting in structures and understood through describable functions. It sees life processes at the molecular level to be highly unified and consistent. It sees life process at the whole-animal level to be highly diversified.

The Logic of Ecology

Purposes of Ecologists

Ecologists seek to understand plants and animals as they exist in nature, with emphasis on their interrelationships, interdependence, and interactions with the

environment. They work to understand all the influences that combine to produce and modify an animal or given plant and, thus, to account for its existence and peculiarities within its habitat.

Questions Ecologists Ask

How do plants and animals interact? How do animals interact with each other? How do plants and animals depend on one another? How do the varying ecosystems function within themselves? How do they interact with other ecosystems? How are plants and animals affected by environmental influences? How do animals and plants grow, develop, die, and replace themselves? How do plants and animals create balances between each other? What happens when plants and animals become unbalanced?

Information Ecologists Use

The primary information used by ecologists is gained through observing plants and animals themselves, their interactions, and how they live within their environments. Ecologists note how animals and plants are born, how they reproduce, how they die, how they evolve, and how they are affected by environmental changes. They also use information from other disciplines, including chemistry, meteorology, and geology.

Judgments Ecologists Make

Ecologists make judgments about how ecosystems naturally function, about how animals and plants within them function, about why they function as they do. They make judgments about how ecosystems become out of balance and what can be done to bring them back into balance. They make judgments about how natural communities should be grouped and classified.

Concepts that Guide Ecologists' Thinking

One of the most fundamental concepts in ecology is ecosystem. Ecosystem is defined as a group of living things, dependent on one another and living in a particular habitat. Ecologists study how differing ecosystems function. Another key concept in ecology is ecological succession, the natural pattern of change occurring within every ecosystem when natural processes are undisturbed. This pattern includes the birth, development, death, and then replacement of natural communities. Ecologists have grouped communities into larger units called biomes. These are regions throughout the world classified according to physical features, including temperature, rainfall, and type of vegetation. Another fundamental concept in ecology is balance of nature, the natural process of birth, reproduction, eating and being eaten, which keeps animal and plant communities fairly stable. Other key concepts include imbalances, energy, nutrients, population growth, diversity, habitat, competition, predation, parasitism, adaptation, coevolution, succession and climax communities, and conservation.

Key Assumptions Ecologists Make

Ecologists assume that patterns exist within animal and plant communities; that these communities should be studied and classified; that animals and plants often depend on one another and modify one another; and that balances must be maintained within ecosystems.

Implications of Ecology

The study of ecology leads to numerous implications for life on earth. By studying balance of nature, for example, we can see when nature is out of balance, as in the current population explosion. We can see how pesticides, designed to kill pests on farm crops, also lead to the harm of mammals and birds, either directly or indirectly through food webs. We can also learn how over-farming causes erosion and depletion of soil nutrients.

The Point of View of Ecologists

Ecologists look at plants and animals and see them functioning in relationship with one another within their habitats and needing to be in balance for the earth to be healthy and sustainable.

The Logic of Aerospace Engineering

Purpose

Aerospace engineering develops aerial and space-based systems for defense, scientific, commercial, civil, and recreational markets and missions. General mission needs within those markets include transportation, earth and space sensing, and communications. Typically, the products are vehicles such as rockets, airplanes, missiles, satellites, and spacecraft, although the products may also include the ground support equipment or imbedded hardware or software.

Key Questions

What are the detailed design features of the system that best satisfy the stated mission or market requirement? How will we design, build, test, and support aerospace vehicles?

Point of View

The conceptual mission profile typically provides the organizing framework for all design requirements and design decisions. The attempt is to define value principally from the perspective of the organizational leader who is sending the vehicle on some mission flight (and paying for the flight). Other perspectives may also be relevant: pilots, maintainers, manufacturing, and logisticians, as well as technologists (structural engineers, aerodynamicists, controls engineers,

propulsion engineers, and relevant others). Politicians will likely be influential in large aerospace programs. Public opinion, concerned with ethical or environmental issues, are often relevant and, if so, must be considered.

Key Concepts

These include all those concepts associated with classical physics, with some particular emphases: Newtonian and orbital mechanics, conservation of mass, momentum and energy, low- and high-speed aerodynamics, material properties and lightweight structures, and propulsion technologies.

Key Assumptions

Assumptions are in part shared by all scientists and engineers. One assumption is that the universe is controlled by pervasive laws that can be expressed in mathematical terms and formulas. Additionally, aerospace engineers assume that an aerospace solution will invariably entail the integration of multiple technological disciplines and the resolution of competing design tensions, including aerodynamics, astrodynamics, stability and control, propulsion, structures, and avionics. Furthermore, the aerospace system will be a system of systems, which must also fit and interface with a larger system. (For instance, air cargo airplanes must fit and communicate with the air traffic control structures; missiles must fit with existing launch rails; satellites must fit on independently developed launch vehicles.)

Data or Information

Aerospace engineers employ experimental and computational data, legacy designs, regulatory requirements, market studies, or mission needs statements.

Inferences, Generalizations, or Hypotheses

The conclusion of most aerospace engineering activity is a product ready for delivery to a customer.

Implications

Aerospace engineering products and services have wide-ranging implications linked with global, national, and local economics; ethics; defense; security; environmental effects such as noise and pollution; and infrastructure such as airports, any of which may impact the quality of life in communities and regions.

The Logic of Electrical Engineering

Purpose

Electrical engineering develops electrical and electronic systems for public, commercial, and consumer markets. It is tremendously broad, spanning many domains,

ncluding recreational electronics, residential lighting, space communications, and lectrical utilities.

Key Questions

What are the detailed design features of the system that best satisfy the stated nission or market requirements? How will we conceive, design, implement, and perate electrical and electronic products and systems?

Point of View

The point of view is commonly that of the design and manufacturing team. Other elevant points of view include the customer, stockholders, marketing, maintainers, nd operators.

Key Concepts

These concepts include electromagnetism (Maxwell's equations), electrochemical properties of materials, discrete and analog mathematics, resistance, current, charge, voltage, fields and waves, and so on.

Key Assumptions

Assumptions are in part shared by all scientists and engineers. One assumption is that the universe is controlled by pervasive laws that can be expressed in mathematical terms and formulas and that those principles can be used to model electrical systems. Electrical engineers assume that some important market needs can be best met through electrical and electronic products. Additionally, electrical engineers frequently assume that their work must be integrated with other engineering disciplines (such as mechanical, chemical, and so forth) in the design and implementation of a product.

Data or Information

Electrical engineers employ experimental and computational data, legacy designs, regulatory requirements, market studies, or mission needs statements.

Inferences, Generalizations, or Hypotheses

The conclusion of most electrical engineering activity is a product ready for delivery to a customer.

Implications

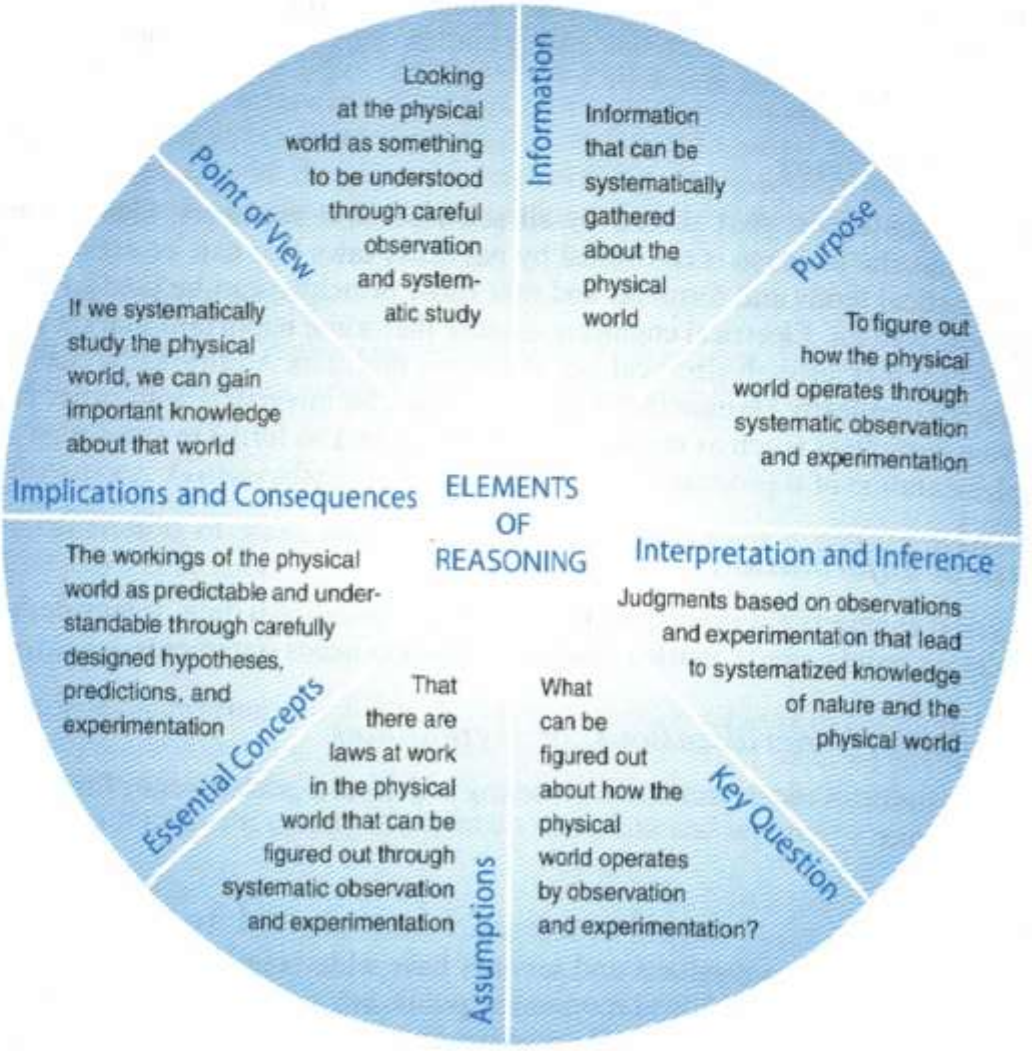
Electrical engineering products and services have wide-ranging implications that span global, national, and local economics; public infrastructure; health care; and communications, with potential for positive and negative quality-of-life impacts on communities and regions.

MAKE THE DESIGN OF THE COURSE WORK FOR YOU

At the beginning of any course you take, ask yourself: How am I going to learn so as to make the design of the class work for me? What am I going to do to get actively involved? How am I going to develop essential insights, understandings, knowledge, and abilities? How am I going to learn to reason my way to the answers to questions in the field?

Early in the course, seek an explanation of the most fundamental concept of the course. As you proceed through the course, you should seek to integrate all features of the course into a comprehensive understanding to see the course, and the subject, as a comprehensive whole.

EXHIBIT 8.2 *The logic of science*



8.9 *Think for Yourself*

WRITING OUT THE LOGIC OF A COURSE

Using the examples of biochemistry, biology, ecology, aerospace engineering, and electrical engineering, as well as the more abbreviated logic of American history on pages 176–177, write out the logic of a course you are now taking or have taken in the past. Use textbooks, encyclopedias, and other resources as references. You might also refer to Exhibits 8.2–8.7, which give the basic logic of several subjects.

EXHIBIT 8.3 *The logic of history.*

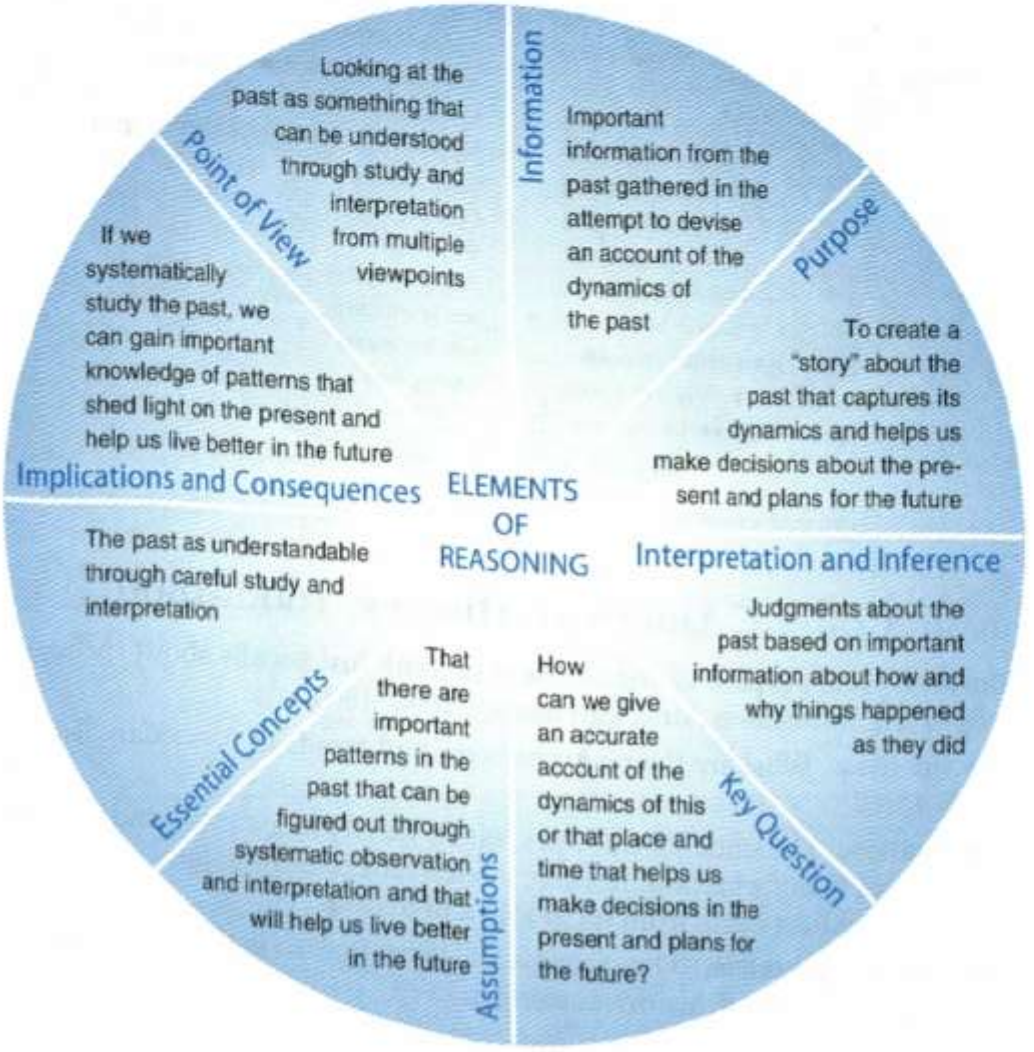
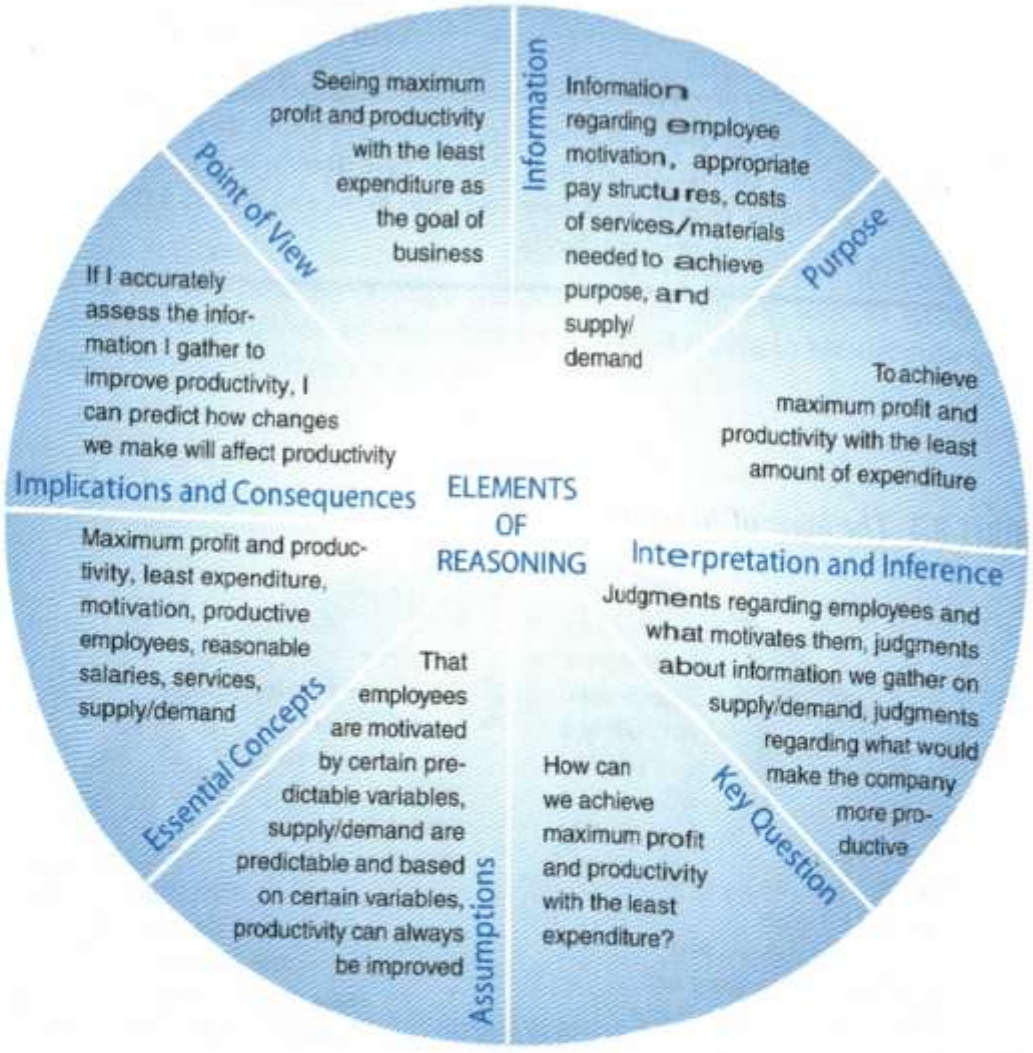


EXHIBIT 8.4 *The logic of business.*



Sample Course: American History, 1600–1800

1. **Purpose.** The purpose of the course is to think historically about the major trends and patterns in American history, 1600–1800.
2. **Key question.** What are the major patterns and trends in American history, 1600–1800?
3. **Information.** The students will work with a variety of primary and secondary sources of information: records, diaries, letters, biographies, newspapers, and historical accounts from textbooks and articles.
4. **Skills of interpretation.** The students will learn how to gather and interpret data from a variety of historical sources.

5. **Essential concepts.** The students will need to learn how to use basic historical, economic, political, and religious concepts, as well as those from social life and values.
6. **Assumptions.** The fundamental assumption behind this course is that it is possible for entry-level students to gain insight into the patterns and events in American life, 1600–1800, that shed light on contemporary problems.
7. **Implications.** Students who reason well about events in 17th- and 18th-century American life should be able to see connections with events in the 20th century.
8. **Point of view.** Students will learn how to reason as both a conservative and a liberal historian, integrating economic, political, and social analyses.

EXHIBIT 8.5 *The logic of abnormal psychology.*

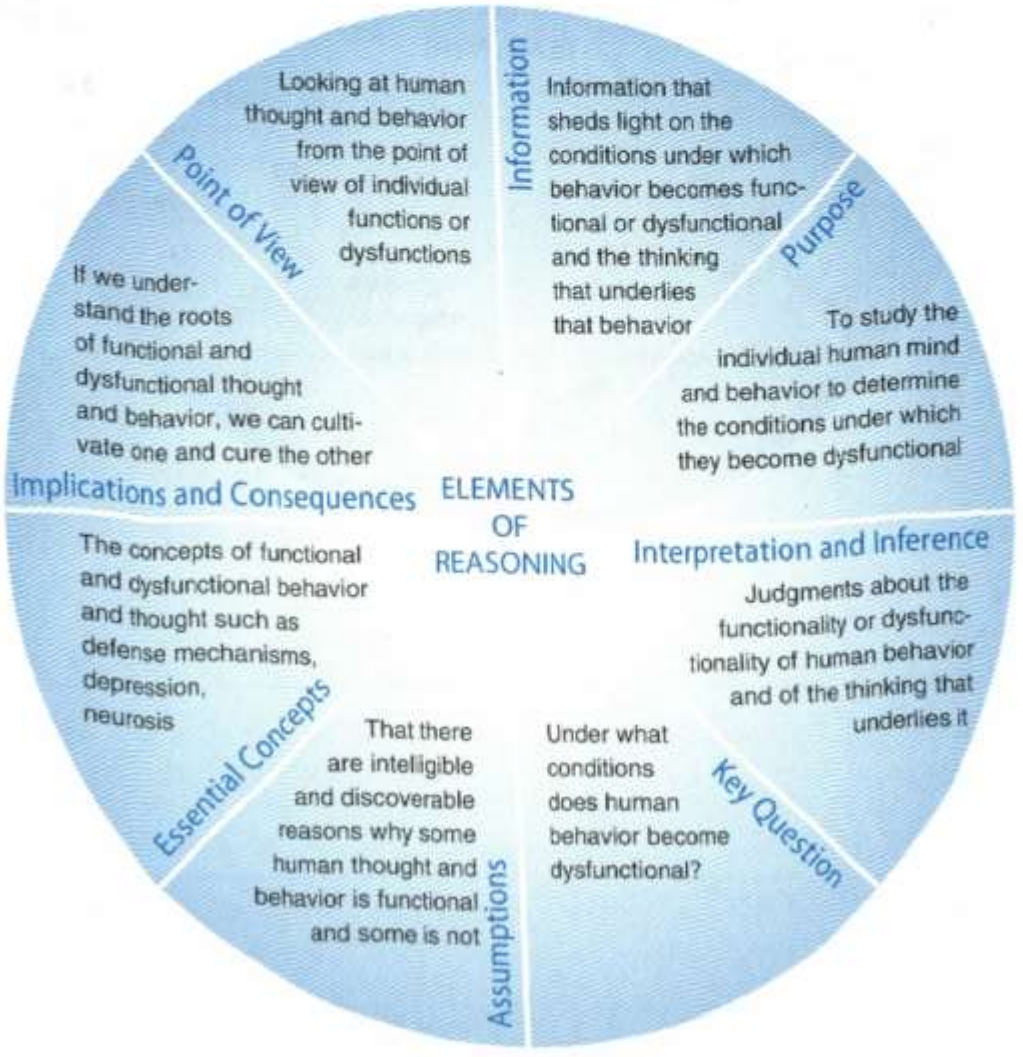


EXHIBIT 8.6 *The logic of philosophy.*

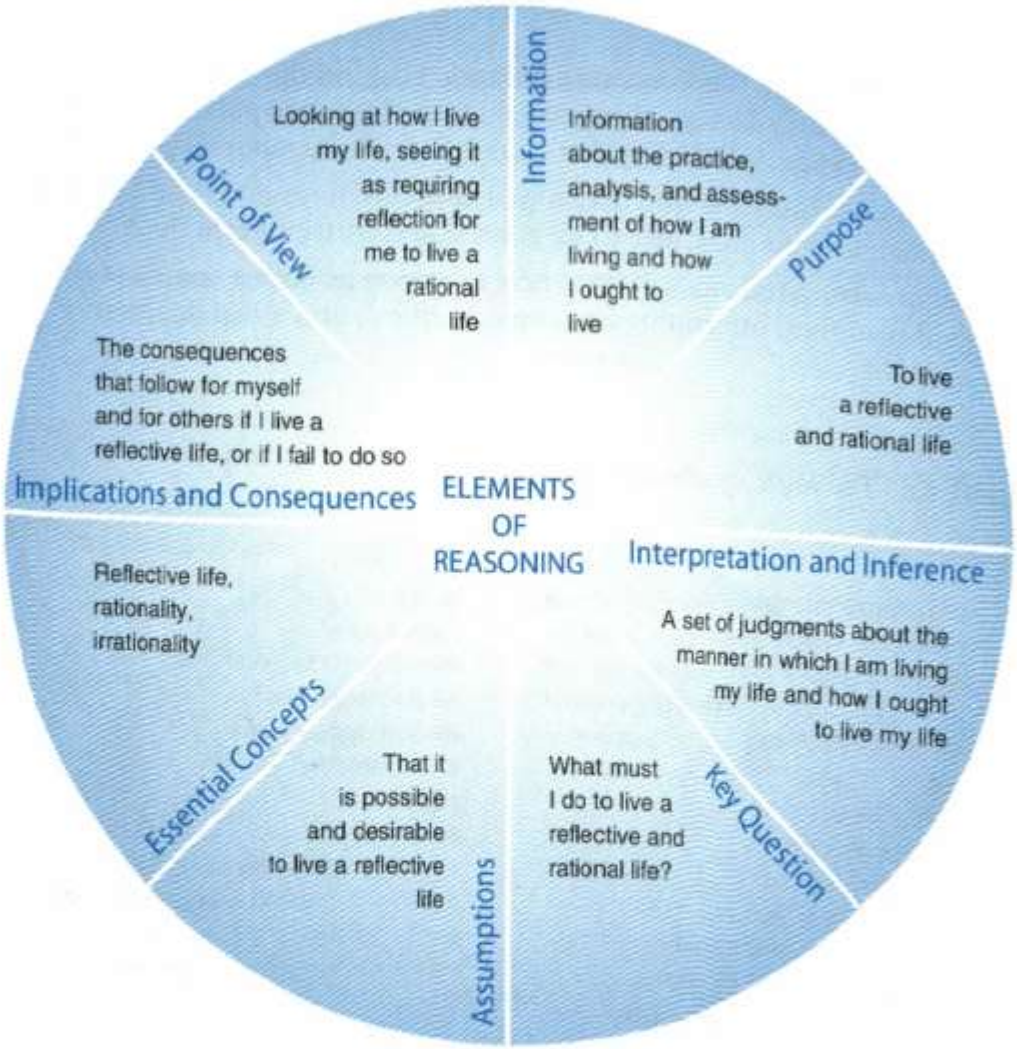
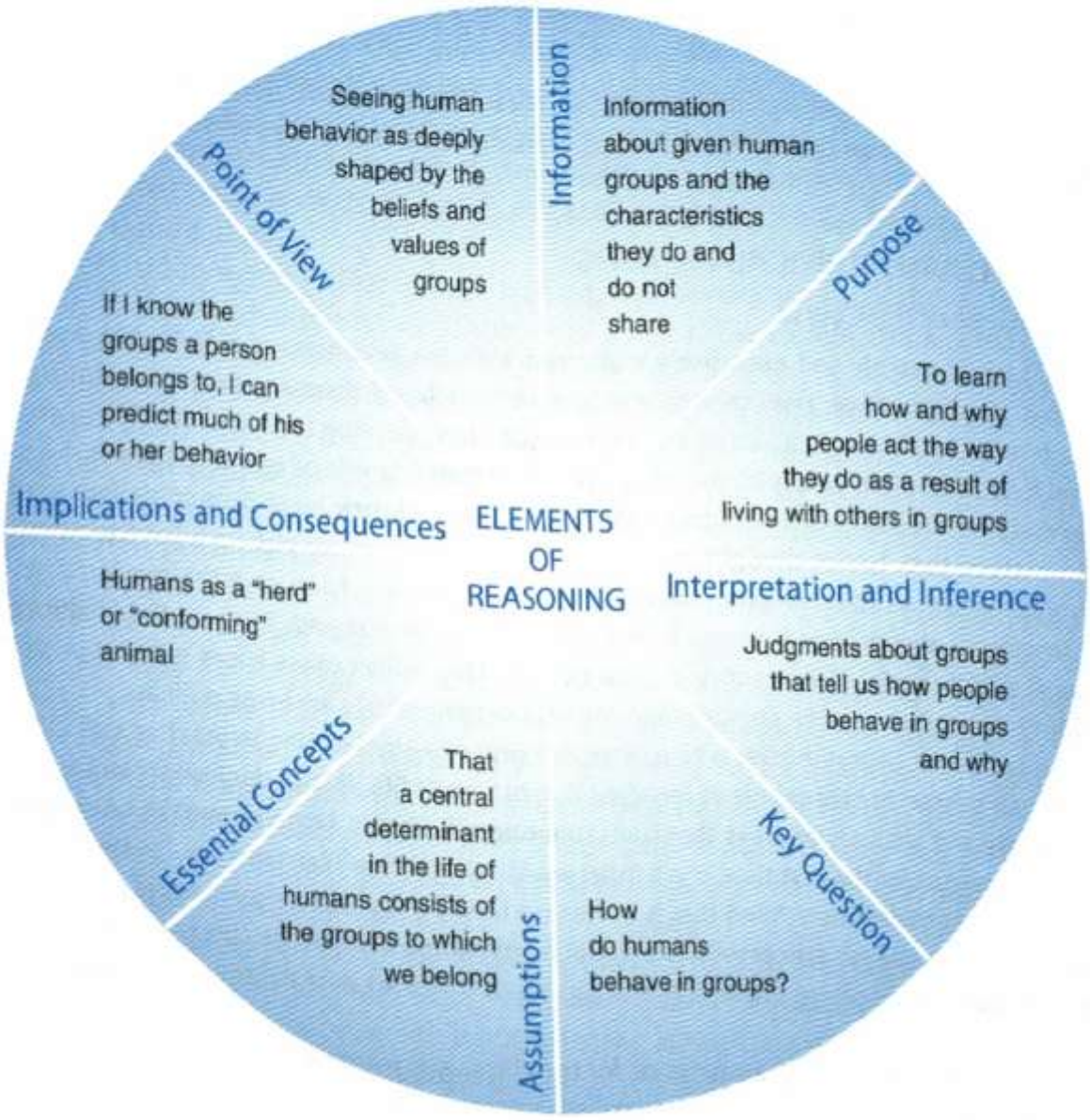


EXHIBIT 8.7 *The logic of sociology.*



_10 *Think for Yourself*

VALUATING THE LOGIC OF A COURSE

Examine the course description below for a Critical Thinking course. To what extent do you think it is based on the concept of critical thinking in this book? Support your conclusions with reasons.

CLASS SYLLABUS: CRITICAL THINKING

Key Concept of the Course

This course is entirely and exclusively concerned with the development of potential capacities that all of you have, even though you have not developed them—capacities in that part of your mind known as your "intellect." Most people don't develop their intellect. They use it ineffectively and often mainly to rationalize or justify their infantile or egocentric drives. Most people are not in charge of their ideas and thinking. Most of their ideas have come into their mind without their having thought about them. They unconsciously pick up what the people around them think. They unconsciously pick up what is on television or in the movies. They unconsciously absorb ideas from the family in which they were reared. They are the products, through and through, of forces they did not choose. They reflect those forces without understanding them. They are like puppets that don't know their strings are being pulled.

To become a critical thinker is to reverse that process—by learning to practice skills that enable one to start to take charge of the ideas that run one's life. It is to think consciously and deliberately and skillfully in ways that transform oneself. It is to begin to remake one's own mind. It is to run for the first time one's inner workings and to understand the "system" one is running. It is to develop a mind that is analogous to the body of a person who is physically fit. It is like an excellent dancer who can perform any dance that can be choreographed. It is like a puppet that discovers the strings and figures out how to gain control of the way they are pulled.

Whenever you are doing a task in or for the class, ask yourself: Would an independent observer watching me closely conclude that I am engaged in taking charge of my mind, of my ideas, of my thinking, or would such a person conclude that I am merely going through the motions of formally doing an assignment, trying to get by with some formula or procedure memorized by rote?

General Plan

The class will focus on practice, not on lecture. It will emphasize using your own mind to figure things out, not memorizing what is in a textbook. On a typical class day, you will be in small groups practicing "disciplined" thinking. You will be regularly responsible for assessing your own work, using criteria and standards discussed in class. If at any time in the semester you feel unsure about your grade, you should request an assessment from the professor. For every class day, you will have a written assignment that involves disciplined thinking. Out of class, you will enter disciplined reflections in a journal, using a special format.

EADING, WRITING, SPEAKING, STENING, AND THINKING

et us turn now to reading, writing, speaking, and listening. Clearly, these activities are important to your success as a student. If you are a skilled *reader*, you are able to master a subject from a textbook alone, without benf lectures or class discussion. Many excellent readers have become educated ough reading alone.

Or consider *writing*. The art of writing well forces us to make explicit the as we understand and how we understand those ideas in relation to each other. ten, we have the illusion that we understand an idea until we try to place our derstanding into written words. Suddenly we see problems. We discover that cannot state what we understand clearly, or we have trouble elaborating, or we d it difficult to give apt examples or illustrations. Writing to learn is a powerful ol in learning deeply and well. Those who cannot write out what they are learng are often poor learners.

Speaking is another powerful tool in learning. If we can explain to another rson what we are learning, we typically take our learning to a deeper level. This why we have the saying, "In teaching, you will learn." Entering into an oral alogue with other learners is a powerful tool in learning—if the speaking in at dialogue is skilled. Of course, poorly discussed ideas may lead to "activated norance," the illusion that we understand when we do not. In this case, speaking lidifies misunderstanding rather than furthering understanding. For this reason, u want to make sure that you acquire oral skills so you can express yourself well, k appropriate questions, and assess your learning.

Listening well is probably the least understood of the four modalities of communication we are considering. Much student listening is unskilled—passive, assocional, unquestioned, superficial. Poor listening leads to incomplete internalization d even to blatant misunderstanding.

Reading, writing, speaking, and listening are all modes of *thinking*. Your rimary goals as a student should be to learn how to think like a good reader while reading), like a good writer (while writing), like an effective speaker (while peaking), and like an insightful listener (while listening). Happily, these four ifferent modes of thinking are interrelated, so that learning to take charge of ne is significantly related to learning to take charge of the other three. This is ue precisely because each is a form of thinking, and all forms of thinking share eneric characteristics—as we have emphasized throughout this book.

Irrespective of whether you are reading, writing, speaking, or listening, you ant your thinking to be clear, precise, accurate, relevant, responsive to complexy, as broad as the issue requires, and focused on the appropriate point(s) of view. ood readers, writers, speakers, listeners, and thinkers recognize that they each ave agendas, deal with questions and problems, use information, make inferences nd draw conclusions, make assumptions, and reason within a point of view. And ey consider the implications and consequences of their reasoning.

Consider writing as an example. All intellectual deficiencies in writing can be explained as deficiencies in the elements of thinking reflected. These deficiencies are, typically, in violations of the standards for thinking. Consider:

- When you write sentences that can be interpreted in many different ways and you do not make clear which meaning you intend, you demonstrate that you are writing, and presumably thinking, in a vague way.
- When you do not give concrete examples and illustrations to make your point clear, you demonstrate that you do not know how to clarify your thought or, for some reason, have chosen not to.
- When you do not make clear—with appropriate transitional words and critical vocabulary—the logical relations between the sentences you write, you make evident that you are not thinking in terms of the logic of your thought, that you do not fully understand the structure of your own reasoning.
- When you do not analyze key concepts and lay bare their logic, you make evident that you are weak at conceptual analysis.
- When you do not make clear the question or issue you are dealing with or you drift, for no apparent reason, from one issue to another, you reveal that you lack the intellectual discipline and focus to appreciate what each issue you raise requires of you. You demonstrate that you lack a sense of relevance.
- When you make sweeping judgments about a philosophical position that you have not sufficiently analyzed empathetically, you demonstrate intellectual arrogance.

Take reading as another example. All intellectual deficiencies in reading can be explained as deficiencies in the elements of thinking reflected, typically, in violations of the standards for thinking. Consider:

- When you are unable to identify the *agenda* of a text, there is a problem in your reading (or in the text).
- When you are unable to identify the *key questions* of a text, there is a problem in your reading (or in the text).
- When you are unable to identify the *key information* in a text, there is a problem in your reading (or in the text).
- When you are unable to identify the *key concepts* in a text, there is a problem in your reading (or in the text).
- When you are unable to identify the *key assumptions* in a text, there is a problem in your reading (or in the text).
- When you are unable to identify the *key implications* in a text, there is a problem in your reading (or in the text).
- When you are unable to identify the *key point of view* in a text, there is a problem in your reading (or in the text).

Speaking and listening can be analyzed in a similar way. Let us now apply these principles to the reading of an article or essay.

FIGURE OUT THE LOGIC OF AN ARTICLE OR ESSAY

One important skill for understanding an essay or article is the analysis of the parts of the author's reasoning. Once you have done this, you can evaluate the author's reasoning by using intellectual standards.

8.11 *Think for Yourself*

ANALYZING THE LOGIC OF AN ARTICLE

Take an article that you have been assigned to read for class, completing the logic of it using the template below. When you become practiced in using this approach, you will have a powerful intellectual tool for understanding the reasoning of any author.

THE LOGIC OF "*<NAME OF THE ARTICLE>*"

1. The main *purpose* of this article is _____. *(Here you are trying to state as accurately as possible the author's purpose for writing the article. What was the author trying to accomplish?)*
2. The key *question* that the author is addressing is _____. *(Your goal is to figure out the key question that was in the author's mind when he or she wrote the article. What was the key question the article addressed?)*
3. The most important *information* in this article is _____. *(You want to identify the key information the author used, or presupposed, in the article to support his or her main arguments. Here you are looking for facts, experiences, data the author is using to support his or her conclusions.)*
4. The main *inferences/conclusions* in this article are _____. *(You want to identify the most important conclusions the author comes to and presents in the article.)*
5. The key *concept(s)* we need to understand in this article is (are) _____. By this concept, the author means _____. *(To identify the concept, ask yourself: What are the most important ideas that you would have to understand to understand the author's line of reasoning? Then elaborate briefly on what the author means by these concepts.)*
6. The main *assumption(s)* underlying the author's thinking is (are) _____. *(Ask yourself: What is the author taking for granted that might be questioned? The assumptions are generalizations that the author does not think he or she has to defend in the context of writing the article, and they are usually unstated. This is where the author's thinking logically begins.)*
7. a. If we take this line of reasoning seriously, the *implications* are _____. *(What consequences are likely to follow if people take the author's line of reasoning seriously? Here you are to follow the logical implications of the author's position. You should include implications that the author states, if you believe them to be logical, but you should do your best thinking to determine what you think the implications are.)*
   b. If we fail to take this line of reasoning seriously, the *implications* are _____. *(What consequences are likely to follow if people ignore or reject the author's reasoning?)*

8. The main *point(s) of view* presented in this article is (are) _____. *(The main question you are trying to answer here is: What is the author looking at, and how is he or she seeing it? For example, in this book, we are looking at education and seeing it as involving the development of intellectual skills. We also are looking at learning as the responsibility of students.)*

FIGURE OUT THE LOGIC OF A TEXTBOOK

Just as you can understand an essay or article by analyzing the parts of the author's reasoning, so can you figure out the logic of a textbook by focusing on the parts of the author's reasoning within it. To understand the parts of the textbook author's reasoning, use the template in Think for Yourself 8.12, below.

12 *Think for Yourself*

FIGURING OUT THE LOGIC OF A TEXTBOOK

Using the template below, figure out the logic of a textbook from a current class you are taking or any textbook you choose. Be as detailed as is necessary for someone new to the field of study you are focused on to understand the logic of the textbook.

1. The main *purpose* of this textbook is _____. *(Here you are trying to determine the author's purpose for writing the textbook. What was the author trying to accomplish?)*
2. The key *question(s)* that the author is addressing in the textbook is (are) _____. *(You are trying to figure out the key question(s) in the author's mind when he or she wrote the textbook. What is the key question the textbook answers? Here, you might identify the broadest question the textbook answers, along with the most important sub-questions it focuses on.)*
3. The most important kinds of *information* in this textbook are _____. *(You want to identify the types of information the author uses in the textbook to support his or her main arguments [e.g., research results, observations, examples, experience].)*
4. The main *inferences/conclusions* in this textbook are _____. *(You want to identify the most important conclusions the author comes to and presents in the textbook. Focus on this question: What are the most important conclusions the author presents, conclusions that, if you understand them, shed important light on key beliefs in the field?)*
5. The key *concept(s)* in this textbook is (are) _____. By these concepts, the author means _____. *(To identify these concepts, ask yourself: What are the most important ideas that you would have to understand to understand the textbook? Then precisely elaborate on what the author means by these basic concepts. Begin with the most fundamental concept presented, such as science, biology, or psychology. These usually can be found in the first chapter. Then identify the other significant concepts that are deeply tied into the most fundamental concept.)*

6. The main *assumption(s)* underlying the author's thinking is (are) _____. *(Ask yourself: What is the author taking for granted that might be questioned? Assumptions are sometimes generalizations that the author does not think he or she has to defend in the context of writing the textbook. The assumptions are sometimes stated in the first chapter as the key assumptions underlying the subject area.)*
7. a. If people take the textbook seriously, the *implications* are _____. *(What consequences are likely to follow if readers take the textbook seriously? Here you are to follow the logical implications of the information and ideas in the textbook. You should include implications that the author argues for, if you believe them to be well founded, but you should do your best thinking to determine what you think the implications are.)*
   b. If people fail to take the textbook seriously, the *implications* are _____. *(What consequences are likely to follow if the author's thinking is ignored in a situation when it is relevant?)*
8. The main *point(s) of view* presented in this textbook is (are) _____. *(The main question you are trying to answer here is: What is the author looking at, and how is he or she seeing it? For example, the author might be looking at science and seeing it as "our main tool in helping us to better understand the physical world and how it operates.")*

CRITERIA FOR EVALUATING AN AUTHOR'S REASONING

Now that you have worked through the logic of an article, a textbook, or both, you are ready to assess the author's reasoning by focusing on how well the author uses each of the elements of reasoning within the article or book. Choose the logic of either the article or the textbook. For the one you choose, go through each of the elements, or parts, of the author's reasoning and evaluate them using the intellectual standards outlined here:

1. Focusing on the author's *purpose:* Is the purpose well stated? Is it clear and justifiable?
2. Focusing on the key *question* that the written piece answers: Is the question at issue well stated (or clearly implied)? Is it clear and unbiased? Does the expression of the question do justice to the complexity of the matter at issue? Are the question and purpose directly relevant to each other?
3. Focusing on the most important *information* the author presents: Does the writer cite relevant evidence, experiences, and information essential to the issue? Is the information accurate and directly relevant to the question at issue? Does the writer address the complexities of the issue?
4. Focusing on the most fundamental *concepts* at the heart of the author's reasoning: Does the writer clarify key concepts when necessary? Are the concepts used justifiably?

5. Focusing on the author's *assumptions:* Does the writer show a sensitivity to what he or she is taking for granted or assuming (insofar as those assumptions might reasonably be questioned)? Or does the writer use questionable assumptions without addressing problems that might be inherent in those assumptions?
6. Focusing on the most important *inferences* or conclusions in the written piece: Do the inferences and conclusions the author makes follow clearly from the information relevant to the issue, or does the author jump to unjustifiable conclusions? Does the author consider alternative conclusions where the issue is complex? Does the author use a sound line of reasoning to come to logical conclusions, or can you identify flaws in the reasoning somewhere?
7. Focusing on the author's *point of view:* Does the author show a sensitivity to alternative relevant points of view or lines of reasoning? Does he or she consider and respond to objections framed from other relevant points of view?
8. Focusing on *implications:* Does the writer show a sensitivity to the implications and consequences of the position he or she is taking?

A TEST TO REPEAT IN EVERY CLASS AND SUBJECT

We have shown how every academic field has its own logic or system of meanings. To learn the field is to learn to think within the system. This is true whether one is talking of poems or essays, paintings or choreographed dances, histories or anthropological reports, experiments or scientific theories, philosophies or psychologies, specific events or general theories. Whether we are designing a new screwdriver or working out a perspective on religion, we must create a system of meanings that makes sense to us. To learn the system underlying a discipline is to create it in our mind. This requires that our thinking be permanently re-shaped and modified. As you study a subject, periodically ask yourself:

Can I explain the underlying system of ideas that defines this subject? (This is like writing the encyclopedia entry for it.)

Can I explain its most basic ideas to someone who doesn't understand it (answering their questions about it)?

Could I write a glossary of its most basic vocabulary (minimizing technical terms in my explanations of meaning)?

Have I written out the basic logic of the subject? (Its key goal is . . . etc.)

Can I compare and contrast the logic of the subject I am learning with that of other subjects I have learned?

To what extent can I relate this subject to significant problems in the world?

To what extent has thinking in this field helped me become more intellectually humble, persevering, autonomous . . .?

CHAPTER 9

REDEFINE GRADES AS LEVELS OF THINKING AND LEARNING

The best learners, like the best thinkers, continually assess their learning against standards of excellence. Being passionate about learning, they welcome standards they can use to strive for excellence. The best learners are not dependent on instructors to tell them how well they are doing. They have universal criteria that they apply across all dimensions of learning. To the extent that you need instructors to tell you how well you are doing, and have no independent sense yourself, you are not thinking critically. The best learners avoid being overly dependent on teachers and, rather, seek to develop an independent, disciplined, thinking mind.

Each step in learning, like the process of thinking critically, is tied to a self-reflective step of self-assessment. As a skilled learner, you do not simply have goals in learning; you know what your goals are. Your primary goal is to think within the logic of the subject, to think like a scientist, to think like a psychologist, to think like an artist, and so forth.

The best learners seek to enter the foundations of any subject they study and use that foundation to understand everything else within the subject. They seek to understand the most fundamental questions asked within the subject. They seek to identify the most basic kinds of information used by professionals within the field, the most basic concepts the field employs, the most fundamental assumptions that underlie it, the most basic point of view that defines it.

The best learners do not memorize random bits and pieces of information. Their learning is problem- or question-based. But they do not simply state a problem; they assess that formulation for its clarity. They do not simply gather information; they gather it and check it for its relevance and significance. They do not simply form an interpretation; they check their interpretation to see what it is based on and whether that basis is adequate.

DEVELOP STRATEGIES FOR SELF-ASSESSMENT

In Chapter 5, you were introduced to a host of universal intellectual standards that you can use to assess your thinking independent of what you are thinking about. Here we look at more holistic standards for assessing your learning within subjects. Virtually every day of study, for example, you should seek to assess the quality of your work as a learner. You should use intellectual standards regularly and explicitly. But you should go further. You also should regularly examine your learning to determine the extent to which you are constructing in your mind the system that defines the subject or subjects you are studying.

In what follows, you will find a set of performance criteria that you can use in any course to assess your studying overall, irrespective of the specific subject. You can use these criteria to give yourself grades independently of your instructor. Of course, your instructor may officially adopt these criteria as grade profiles in the class.

USE PROFILES TO ASSESS YOUR PERFORMANCE

Performance profiles for five levels of quality in thinking and learning are: exemplary student, high-performing student, mixed-quality student, low-performing student, and (alas) incompetent student. Your thinking stands at one of these levels in every class you take and can be shown—if we have adequate documentation of your thinking on the tests and assignments in the class.

Most students have no sense that these levels of performance exist, even though these profiles are based on common-denominator academic values. You should get into the habit of reviewing your work with these criteria in mind. If you do so, you will grow as a learner and thinker. If you learn how to routinely perform at the high-performing or exemplary level, you will do well in every class you take.

As you read through these profiles, notice that you can take any statement in the criteria—for example, the statement that the exemplary student

> often raises important questions and issues, analyzes key questions and problems clearly and precisely, recognizes key questionable assumptions, clarifies key concepts effectively, uses language in keeping with educated usage, frequently identifies relevant competing points of view, and demonstrates a commitment to reasoning

carefully from clearly stated premises in the subject, as well as marked sensitivity to important implications and consequences.

—and transform that statement into specific questions about your own performance:

To what extent do I:

raise important questions and issues in the class?

analyze key questions and problems clearly and precisely?

recognize key assumptions?

clarify key concepts?

use language in keeping with educated usage?

identify competing points of view?

reason carefully from clearly stated premises?

note important implications and consequences?

Exemplary Students (Grade of A)

Exemplary performance in thinking (within academic subjects) implies excellence in thinking within the domain of a subject (e.g., sound historical thinking, sound biological thinking, sound mathematical thinking). It also involves developing a range of knowledge acquired through exercising thinking skills and abilities. Exemplary work, on the whole, is clear, precise, and well-reasoned as well as insightful and well-informed. Basic terms and distinctions are learned at a level that implies insight into basic concepts and principles.

The exemplary student has internalized the basic intellectual standards appropriate to the assessment of his or her own work in a subject and is highly skilled at self-evaluation. Exemplary students regularly

raise important questions and issues,

analyze key questions and problems (clearly and precisely),

recognize questionable assumptions,

clarify key concepts effectively,

use language in keeping with educated usage,

identify relevant competing points of view,

display sensitivity to important implications and consequences, and

demonstrate a commitment to reasoning carefully from clearly stated premises in the subject.

Exemplary students display excellent reasoning and problem-solving within a field and work consistently at a high level of intellectual excellence. They usually interrelate ideas within and among fields of study. They regularly apply what they are learning to issues and problems in their lives.

High-Performing Students (Grade of B)

High performance in thinking through a subject implies sound thinking within the domain of a subject along with the development of a range of knowledge acquired through the exercise of thinking skills and abilities. High-level student thinking is, on the whole, clear, precise, and well-reasoned but sometimes lacks depth of insight (especially into opposing points of view). Basic terms and distinctions are learned at a level that implies comprehension of basic concepts and principles.

High-level students internalize the basic intellectual standards appropriate to the assessment of their thinking in a subject and demonstrate competence in self-evaluation. High-level students

often raise questions and issues,

commonly analyze questions and problems clearly and precisely,

recognize most questionable assumptions,

clarify key concepts well,

typically use language in keeping with educated usage,

commonly identify relevant competing points of view,

display sensitivity to many important implications and consequences, and

frequently demonstrate the beginnings of a commitment to reasoning carefully from clearly stated premises in a subject.

High-performing students display sound reasoning and problem-solving within a field and work consistently at a commendable level of intellectual performance. They often interrelate ideas within and among fields of study. They often apply what they are learning to issues and problems in their lives.

Mixed-Quality Students (Grade of C)

Thinking of mixed quality implies inconsistent performance within the domain of a subject and course along with limited development of knowledge acquired through the exercise of thinking skills and abilities. The mixed-quality student often tries to use memorization as a substitute for understanding. Thinking of mixed quality is—inconsistently—clear, precise, and well-reasoned. Moreover, except rarely, it does not display depth of insight. Basic terms and distinctions are learned at a level that implies the beginnings of, but incomplete comprehension of, basic concepts and principles.

Although thinkers of mixed quality have internalized a few of the basic intellectual standards appropriate to the assessment of their own work in a subject, they demonstrate inconsistency in self-evaluation. Mixed-quality students

sometimes raise questions and issues,

sometimes analyze questions and problems clearly and precisely,

recognize some questionable assumptions,

clarify some concepts competently,

sometimes use language in keeping with educated usage,

sometimes identify relevant competing points of view,

sometimes demonstrate a clear commitment to reasoning carefully from clearly stated premises in a subject, and

are inconsistently sensitive to important implications and consequences.

Mixed-quality students display inconsistent reasoning and problem-solving within a field and work, at best, at a competent level of intellectual performance. They sometimes interrelate ideas within and among fields of study. They sometimes apply what they are learning to issues and problems in their lives.

Low-Performing Students (Grade of D or F)

Low-performing students reason poorly within the domain of a subject and course. On the whole, they try to get through courses by means of rote recall, attempting regularly to acquire knowledge by memorization rather than through comprehension and understanding. Low-performing students do not develop critical thinking skills or insights requisite to understanding course content. They produce work that is typically unclear, imprecise, and poorly reasoned. Low-performing students achieve competence only at the lowest order of performance. They often use basic terms and distinctions incorrectly, reflecting superficial or mistaken comprehension of basic concepts and principles.

Low-performing students have not internalized the basic intellectual standards appropriate to the assessment of their own work in a subject. They also do poorly in self-evaluation. Low-performing students

rarely raise questions and issues,

superficially analyze questions and problems,

do not recognize their assumptions,

clarify concepts only partially,

rarely use language in keeping with educated usage,

rarely identify relevant competing points of view,

show no understanding of the importance of a commitment to reasoning carefully from clearly stated premises in a subject, and

are insensitive to important implications and consequences.

Low-performing work displays poor reasoning and problem-solving within a field and works, at best, at a deficient level of intellectual performance. Low-performing students fail to interrelate ideas within and among fields of study. They rarely apply what they are learning to issues and problems in their lives because they fail to see any relationship between course content and real-life situations.

.1 *Think for Yourself*

HOW WOULD YOU RATE YOURSELF AS A THINKER?

Now that you have read through the student profiles for each competency level, rate yourself as a student. Write a brief paper, completing and elaborating on the following statements:

1. I see myself at the following skill level as a student (exemplary, high-performing, mixed-quality, or low-performing):
2. I support my position with the following evidence from my work in one or more classes (examples should include excerpts from papers, etc., that directly relate to the skills discussed in the profiles. For example, if you say that you are a mixed-quality student, you might give an equal number of examples of written work that are clear as well as unclear):
3. To improve as a student, I need to do the following (focus on the skills discussed at the exemplary or high-performing level to formulate a plan):

APPLY STUDENT PROFILES TO ASSESS YOUR PERFORMANCE WITHIN SPECIFIC DISCIPLINES

As a thinker developing your ability to apply knowledge to new situations, you can apply the skill levels you have been learning in this chapter to any subject you study. To provide an example, we apply these competency levels to the study of psychology.

Exemplary Thinking as a Student of Psychology (Grade of A)

Exemplary thinking as a student of psychology demonstrates real achievement in grasping what psychological thinking is along with the clear development of a range of specific psychological thinking skills or abilities. The work at the end of the course is clear, precise, and well-reasoned. In exemplary work, the student uses psychological terms and distinctions effectively. The work demonstrates a mind that is taking charge of psychological ideas, assumptions, and inferences. The exemplary student of psychology

analyzes psychological issues clearly and precisely,
formulates psychological information accurately,
distinguishes the relevant from the irrelevant,
recognizes key questionable psychological assumptions,
clarifies key psychological concepts and checks their use for justifiability,

uses psychological language in keeping with established professional usage, while at the same time questioning inappropriate conceptualizations of human behavior within the field of psychology,

thinks within competing psychological points of view, accurately representing each view,

shows a pronounced tendency to reason carefully from clearly stated premises, and

displays sensitivity to important psychological implications and consequences.

Exemplary work displays excellent psychological reasoning and problem-solving skills and is consistently at a high level of intellectual excellence. Students functioning at the exemplary level routinely interrelate ideas within psychology and between psychology and related fields of study such as history, sociology, anthropology, and philosophy. When relevant, they regularly apply psychological principles and concepts to issues and problems in their lives.

High-Performing Thinking as a Student of Psychology (Grade of B)

Students of psychology who function at the high-performing level demonstrate achievement in grasping what psychological thinking is, as well as in a range of specific psychological thinking skills and abilities. At the end of the course, high-performing work is, on the whole, clear, precise, and well-reasoned, though with occasional lapses into weak reasoning. On the whole, the high-performing student of psychology uses psychological terms and distinctions effectively. The student's work demonstrates a mind that is beginning to take charge of psychological ideas, assumptions, and inferences. The high-performing student of psychology

often raises important questions and issues,

commonly analyzes psychological questions and problems clearly and precisely,

recognizes most questionable psychological assumptions,

often clarifies key psychological concepts and checks their use for justifiability,

typically uses psychological language in keeping with established professional usage, while at the same time often questioning inappropriate conceptualizations of human behavior within the field of psychology,

commonly thinks within competing psychological points of view,

displays sensitivity to many important psychological implications and consequences, and

frequently demonstrates a commitment to reasoning carefully from clearly stated psychological premises.

High-performing students of psychology demonstrate sound psychological reasoning and problem-solving skills. They often interrelate ideas within psychology and between psychology and related fields of study such as history, sociology, anthropology, and philosophy. When relevant, they often apply psychological principles and concepts to issues and problems in their lives.

Mixed-Quality Thinking as a Student of Psychology (Grade of C)

Students of psychology who function at the mixed-quality level illustrate some, but inconsistent, achievement in grasping what psychological thinking is along with the development of modest psychological thinking skills and abilities. Mixed-quality work at the end of the course shows some emerging psychological thinking skills but pronounced weaknesses as well. Though some assignments are done reasonably well, others are done poorly or at best are mediocre. Lapses in reasoning are more than occasional. Although psychological terms and distinctions are sometimes used effectively, they are sometimes used ineffectively. Only on occasion does a thinker of mixed quality display a mind taking charge of psychological ideas, assumptions, and inferences. Only occasionally does mixed-quality thinking display intellectual discipline and clarity. The thinker of mixed quality sometimes

analyzes psychological issues clearly and precisely,

formulates psychological information accurately,

distinguishes the relevant from the irrelevant,

recognizes key questionable assumptions,

clarifies key psychological concepts effectively and can identify when psychological concepts are being used justifiably,

uses psychological language in keeping with established professional usage,

identifies relevant psychological competing points of view,

recognizes important psychological implications and consequences, and

reasons carefully from clearly stated psychological premises.

Sometimes the thinker of mixed quality (in psychology) seems to be simply going through the motions of the assignment, carrying out the form without getting into the spirit of it. On the whole, work of mixed quality shows only modest (and inconsistent) psychological reasoning and problem-solving skills and often displays weak reasoning and problem-solving skills. Students at the mixed-quality level sometimes interrelate ideas within psychology and between psychology and related fields of study. When relevant, mixed-quality students sometimes apply psychological principles and concepts to issues and problems in their lives.

ow-Performing Thinking as a Student f Psychology (Grade of D or F)

ow-performing work shows little, if any, understanding of psychological thinking nd. at best, demonstrates low-level psychological thinking skills or abilities. Low-erforming work at the end of the course shows only occasional (if any) psycholog-al thinking skills combined with frequent uncritical psychological thinking. Most ssignments are done poorly. There is little evidence that the student is reasoning rough the assignment. Usually the student seems to be merely going through the otions of the assignment, carrying out the form without getting into the spirit f it. Low-performing work in psychology rarely shows any effort to take charge f psychological ideas, assumptions, and inferences. In general, low-performing ought lacks discipline and clarity. In low-level work, the student generally

- does not analyze psychological issues clearly and precisely,
- does not formulate psychological information accurately,
- does not distinguish the relevant from the irrelevant,
- does not recognize key questionable assumptions,
- does not clarify key psychological concepts effectively,
- does not use psychological language in keeping with established professional usage,
- does not identify relevant competing psychological points of view, and
- does not reason carefully from clearly stated premises or recognize important implications and consequences.

Low-performing work rarely, if ever, demonstrates sound psychological rea-oning and problem-solving skills and frequently displays poor reasoning and roblem-solving skills. Students at this level almost never interrelate ideas within sychology and between psychology and related fields of study. They rarely, if ever, pply psychological principles and concepts to issues and problems in their lives.

9.2 *Think for Yourself*

SELF-EVALUATION IN A SUBJECT YOU ARE STUDYING

Transform the example of thinking within the field of psychology that you have just read into a set of questions that you can use to assess the quality of your learning within a subject you are currently studying or have studied. For example, if you are taking a course in biology, you might formulate the following types of questions:

- Am I gaining command over a range of biological thinking skills and abilities that I use to acquire biological knowledge?
- Is my work (papers, exams) clear, precise, and well-reasoned?

- Am I gaining command of the key biological terms and distinctions?
- To what extent have I developed the ability to identify and solve fundamental biological problems?

Then answer each question, stating your answer and then elaborating upon it and giving an example of it.

CONCLUSION

To be a skilled learner, you must be a skilled thinker. To learn most effectively in the context of college, you must take charge of your learning. You must design it—plan it out. You plan learning by becoming clear as to what your goals are, what questions you have to—or want to—answer, what information you need to acquire, what concepts you need to learn, what you need to focus on, and how you need to understand it.

In this chapter, we have laid out profiles that you can use throughout your college experience to assess how well you are functioning as a learner in each class you take, within each academic subject you study. With these profiles clearly in mind, you become the master of your own assessment in each class. You realize that your ability to think within a subject is determined by the skills you develop in thinking through that subject, not by a grade the instructor gives you. Simply, you take command of your learning. You know how well you are doing in thinking through the content because you can assess your own development. You develop as an independent thinker.