ABRIDGED EDITION

A TAXONOMY FOR LEARNING, TEACHING, AND ASSESSING

A REVISION OF BLOOM'S TAXONOMY OF EDUCATIONAL OBJECTIVES

EDITORS

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Longman

3.1 The Taxonomy Table

The Knowledge Dimension	The Cognitive Process Dimension					
	1. Remember	2. Understand	3. Apply	4. Analyze	5. Evaluate	6. Create
A. Factual knowledge						
B. Conceptual knowledge						
C. Procedural knowledge						
D. Meta-cognitive knowledge						

4.1 The Knowledge Dimension

Major Types and Subtypes	Examples
A. Factual knowledge—The basic elements students must know to be acquainted with a discipline or solve problems in it	
Aa. Knowledge of terminology	Technical vocabulary, music symbols
Ab. Knowledge of specific details and elements	Major natural resources, reliable sources of information
B. Conceptual knowledge—The interrelationships among the basic elements within a larger structure that enable them to function together	
Ba. Knowledge of classifications and categories	Periods of geological time, forms of business ownership
Bb. Knowledge of principles and generalizations	Pythagorean theorem, law of supply and demand
Bc. Knowledge of theories, models, and structures	Theory of evolution, structure of Congress
C. Procedural knowledge—How to do something, methods of inquiry, and criteria for using skills, algorithms, techniques, and methods	
Ca. Knowledge of subject-specific skills and algorithms	Skills used in painting with water colors, whole-number division algorithm
Cb. Knowledge of subject-specific techniques and methods	Interviewing techniques, scientific method
Cc. Knowledge of criteria for determining when to use appropriate procedures	Criteria used to determine when to apply a procedure involving Newton's second law, criteria used to judge the feasibility of using a particular method to estimate business costs
D. Metacognitive knowledge—Knowledge of cognition in general as well as awareness and knowledge of one's own cognition	
Da. Strategic knowledge	Knowledge of outlining as a means of capturing the structure of a unit of subject matter in a text book, knowledge of the use of heuristics
Db. Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge	Knowledge of the types of tests particular teachers administer, knowledge of the cognitive demands of different tasks
Dc. Self-knowledge	Knowledge that critiquing essays is a personal strength, whereas writing essays is a personal weakness; awareness of one's own knowledge level

5.1 The Cognitive Process Dimension

Categories & Cognitive Processes	Alternative Names	Definitions and Examples
1. Remember—Retrieve relevant knowledge from long-term memory		
1.1 Recognizing	Identifying	Locating knowledge in long-term memory that is consistent with presented material (e.g., Recognize the dates of important events in U.S. history)
1.2 Recalling	Retrieving	Retrieving relevant knowledge from long-term memory (e.g., Recall the dates of important events in U.S. history)
2. Understand—Construct meaning from instructional messages, including oral, written, and graphic communication		
2.1 Interpreting	Clarifying, paraphrasing, representing, translating	Changing from one form of representation (e.g., numerical) to another (e.g., verbal) (e.g., Paraphrase important speeches and documents)
2.2 Exemplifying	Illustrating, instantiating	Finding a specific example or illustration of a concept or principle (e.g., Give examples of various artistic painting styles)
2.3 Classifying	Categorizing, subsuming	Determining that something belongs to a category (e.g., Classify observed or described cases of mental disorders)
2.4 Summarizing	Abstracting, generalizing	Abstracting a general theme or major point(s) (e.g. Write a short summary of the event portrayed on a videotape)
2.5 Inferring	Concluding, extrapolating, interpolating, predicting	Drawing a logical conclusion from presented information (e.g., In learning a foreign language, infer grammatical principles from examples)
2.6 Comparing	Contrasting, mapping, matching	Detecting correspondences between two ideas, objects, and the like (e.g., Compare historical events to contemporary situations)
2.7 Explaining	Constructing models	Constructing a cause-and-effect model of a system(e.g., explain the causes of important 18th Century events in France)
3. Apply—Carry out or use a procedure in a given situation		
3.1 Executing	Carrying out	Applying a procedure to a familiar task (e.g., Divide one whole number by another whole number, both with multiple digits)
3.2 Implementing	Using	Applying a procedure to an unfamiliar task (e.g., Use Newton's Second Law in situations in which it is appropriate)

5.1 The Cognitive Process Dimension (continued)

Categories & Cognitive Processes	Alternative Names	Definitions and Examples
4. ANALYZE—Break material into its constituent parts and determine how the parts relate to one another and to an overall structure or purpose		
4.1 Differentiating	Discriminating, distinguishing, focusing, selecting	Distinguishing relevant from irrelevant parts or important from unimportant parts of presented material (e.g., Distinguish between relevant and irrelevant numbers in a mathematical word problem)
4.2 Organizing	Finding coherence, intergrating, outlining, parsing, structuring	Determining how elements fit or function within a structure (e.g., Structure evidence in a historical description into evidence for and against a particular historical explanation)
4.3 Attributing	Deconstructing	Determine a point of view, bias, values, or intent underlying presented material (e.g., Determine the point of view of the author of an essay in terms of his or her political perspective)
5. EVALUATE—Make judgments based on criteria and standards		
5.1 Checking	Coordinating, detecting, monitoring, testing	Detecting inconsistencies or fallacies within a process or product; determining whether a process or product has internal consistency; detecting the effectiveness of a procedure as it is being implemented (e.g., Determine if a scientist's conclusions follow from observed data)
5.2 Critiquing	Judging	Detecting inconsistencies between a product and external criteria, determining whether a product has external consistency; detecting the appropriateness of a procedure for a given problem (e.g., Judge which of two methods is the best way to solve a given problem)
6. CREATE—Put elements together to form a coherent or functional whole; reorganize elements into a new pattern or structure		
6.1 Generating	Hypothesizing	Coming up with alternative hypotheses based on criteria (e.g., Generate hypotheses to account for an observed phenomenon)
6.2 Planning	Designing	Devising a procedure for accomplishing some task (e.g., Plan a research paper on a given historical topic)
6.3 Producing	Constructing	Inventing a product (e.g., Build habitats for a specific purpose)

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This book is a revision of *The Taxonomy of Educational Objectives, The Classification of Educational Goals, Handbook I: Cognitive Domain*, Benjamin S. Bloom (Ed.), Max D. Englehart, Edward J. Furst, Walker H. Hill, and David R. Krathwohl, published by David McKay Company, Inc., New York, 1956.

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This volume is dedicated to
those teachers who advance
the learning and development
of their students every day;
we hope they find it helpful.

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Preface

In 1956 a framework for categorizing educational objectives was published by B. S. Bloom (editor), M. D. Engelhart, E. J. Furst, W. H. Hill, and D. R. Krathwohl as *The Taxonomy of Educational Objectives, The Classification of Educational Goals, Handbook I: Cognitive Domain.*[1] Since its publication over 40 years ago, the *Handbook* has been translated into more than twenty languages (Krathwohl, 1994) and has provided a basis for test design and curriculum development not only in the United States but throughout the world (Chung, 1994; Lewy and Bathory, 1994; Postlethwaite, 1994). Shane (1981) conducted a survey on the significant writings that influenced curriculum in the first three-quarters of the twentieth century, and the *Handbook* was one of four that tied for eighth through eleventh place. More recently, a national panel was asked by the Museum of Education at the University of South Carolina to "identify the education books that 'had a significant influence, consequence or resonance' on American education during the 20th century" (Kridel, 2000, p. 5). Their list included both the *Handbook* and the affective domain taxonomy (Krathwohl, Bloom, and Masia, 1964) (Kridel, 2000, pp. 72–73). References to and examples from the *Handbook* have appeared in numerous measurement, curriculum, and teacher education textbooks. Its impact nationally and internationally was the subject of a National Society for the Study of Education yearbook (Anderson and Sosniak, 1994). This book is a revision of the *Handbook.*

Why a Revision?

Given the *Handbook*'s longevity and importance, one may reasonably ask Why would anybody tinker with a publication that has such a record? Why is a revision necessary? We have two reasons. First, there is a need to refocus educators' attention on the value of the original *Handbook,* not only as a historical document but also as one that in many respects was "ahead of its time" (Rohwer and Sloane, 1994). We believe that many of the ideas in the *Handbook* are valuable to today's educators as they struggle with problems associated

[1] Throughout this volume, Taxonomy refers to the classification system, and *Handbook* refers to the publication in which the classification system appears.

with the design and implementation of accountability programs, standards-based curriculums, and authentic assessments.

Second, there is a need to incorporate new knowledge and thought into the framework. Numerous changes in American society since 1956 have influenced the way we think about and practice education. Now we know more about how children develop and learn and how teachers plan for, teach, and assess their students. These increases in knowledge support the need for a revision.

After you have had a chance to consider our changes, you may decide that we should have left well enough alone. However, we hope you will withhold final judgment until you have read this book and have attempted to use our framework to inform your practice.

Intended Audiences

We hope to reach several audiences, and teachers are one of the most important. There is ample evidence that teachers determine what takes place in their classrooms through the curriculum they actually deliver to their students and the way in which they deliver it. Consequently, if our revision of the Taxonomy is to have an impact on the quality of education, it must dramatically influence the way teachers think and act. Toward this end, we have tried to make this revision much more practical and useful for teachers.

Curriculums are currently expected to be standards based (Glatthorn, 1998), and the majority of states have passed accountability legislation (Frymier, 1996; Gandal, 1996; Rebarber, 1991). Proponents of these approaches seek to improve substantially the quality of teachers' teaching and students' learning. Such approaches become classroom realities, however, only if they are embraced, understood, and acted upon by classroom teachers.

What can bring about this change? We suggest that teachers need a framework to help them make sense of objectives and organize them so that they are clearly understood and fairly easy to implement. This framework may help teachers plan and deliver appropriate instruction, design valid assessment tasks and strategies, and ensure that instruction and assessment are aligned with the objectives. The authors of the original *Handbook* believed their Taxonomy might be such a framework. In our revision, we have sought to (1) revise and extend their approach, (2) use common language, (3) be consistent with current psychological and educational thinking, and (4) provide realistic examples of the use of the framework.

For instance, in both Chapters 1 and 2 we explore the relationship between standards and objectives. The whole of Section III is devoted to demonstrating the application of our framework to the classroom. Chapters 8–13 consist of vignettes written by teachers describing units they have developed and taught, together with our analyses of how our framework might help teachers understand and ultimately improve the units. Chapter 14 gathers together some of the wisdom revealed by the vignette analyses for classroom practice. Our hope, then, is that many teachers will read this volume and find it of value.

Teachers are so busy teaching that they often get their information "second hand." In this regard, Bloom said the original *Handbook* was "one of the most widely cited yet least read books in American education" (Anderson and Sosniak, 1994, p. 9). Therefore, among our audiences we hope to include several groups that interact with and attempt to influence both practicing and prospective teachers. To more efficiently meet the needs of these groups, this book is published in two editions, one an abridged and the other a complete. The abridged edition includes in its 14 chapters the content that we believe to be of greatest interest, value, and immediate practical use to teachers. The complete edition includes three additional chapters and one additional appendix. One of these chapters describes alternative frameworks for categorizing objectives, one summarizes empirical studies of the structure of the original Taxonomy, and a final one discusses still unsolved problems (an abridged version appears as the final section of Chapter 14 of the abridged edition). We believe the complete edition will be of greater interest to those persons who are most familiar with the original *Handbook*, as well as university professors, educational researchers, and scholars who wish to learn more about this and other frameworks.

Our intended audiences include groups of people who influence teachers both directly and indirectly. Among those who interact with and have a direct effect on classroom teachers are teacher educators who plan and deliver preservice teacher education programs. For them, the abridged edition should provide important adjunct or supplementary reading for their primary textbooks. It follows that the authors of the textbooks used in teacher education courses, as they cite the Taxonomy and build upon it, provide another avenue for bringing the framework to teachers' attention. We anticipate that these educators will adapt their current coverage of the Taxonomy to the revision.

Curriculum coordinators and educational consultants who are involved in ongoing professional development activities and help teachers in their classrooms also have the potential to influence teachers directly. In designing programs, they may find it profitable to use our vignettes as case studies of how the framework relates to practice.

Several audiences that indirectly affect teachers may also find this revision of value. Test designers and test publishers have used the *Handbook* extensively as a basis for organizing the objectives their achievement tests are intended to measure. Our revised framework should be at least as useful and perhaps even more so.

Although the *Handbook* did not address policy makers (e.g., school boards and state legislators) and the media, these audiences are increasingly important. Our framework can offer policy makers perspectives on where the standards to be met by schools and graduates fall in the panorama of possible goals and whether their intentions are met. Similarly, the framework may enable journalists to raise questions about what achievement scores really represent.

Our final audience is the authors and publishers of the textbooks that elementary and secondary teachers use to teach their students. These authors and publishers have the greatest potential for influencing both teachers and students if, as many have in the past, they incorporate our framework in their texts and show how it can be used to help teachers analyze their objectives, instruction, and assessments and determine the alignment of the three.

This Book's Organization

Following this Preface is a Foreword describing the development of both the original *Handbook* and our revision. The remainder of the book is divided into four sections. Section I consists of two chapters. The first describes the need for taxonomies and the ways in which educators can use our Taxonomy. The second chapter discusses the nature of objectives, their relationship to standards, and their role in education.

The three chapters in Section II describe the structure of our revised Taxonomy. The two-dimensional table known as the Taxonomy Table is presented in Chapter 3. The next two chapters describe the structure of our revised framework and provide greater detail on the table's two dimensions: the knowledge dimension (Chapter 4) and the cognitive process dimension (Chapter 5). Each dimension consists of a set of categories that are defined and illustrated.

The nine chapters in Section III demonstrate the uses and usefulness of the Taxonomy Table. Chapter 6 describes how the Taxonomy Table can be used to develop learning objectives, plan instruction, design assessments, and align these three activities. Chapter 7 presents an overview of the vignettes, including how they can be analyzed and how they may be useful to teachers. Chapters 8–13 contain the vignettes themselves, which are descriptions of actual course units written by the teachers who developed and/or taught them. Each vignette is analyzed in terms of its objectives, instruction, assessment, and alignment using the Taxonomy Table. Finally, Chapter 14 discusses a series of generalizations derived from our analyses of the vignettes.

Section IV, which is available only in the complete version, examines the Taxonomy in perspective. In Chapter 15 we compare and contrast 19 alternative frameworks that have appeared since the publication of the original *Handbook*; we examine them in the context of the framework and our revision of it. In Chapter 16 we summarize and review the empirical data that bear on the assumed cumulative hierarchy of the original Taxonomy, and we discuss the implication of these data for our revision. Finally, in Chapter 17 we look ahead to some problems that remain to be solved by authors of future revisions. Both the abridged and complete editions contain two appendixes: one summarizes the changes the revision made in the original framework, and the other presents the framework of the original edition. A third appendix, which appears only in the complete edition, displays the data on which the meta-analysis in Chapter 16 is based.

Authors

A work of this duration and magnitude required numerous revisions of every chapter. The vast majority of the chapters retained primary authors throughout; several chapters had multiple "contributing" authors. The chapter authors are listed here:

Peter W. Airasian, Boston College—primary author, Chapter 2; contributing author, Chapter 1; vignette commentary, Chapters 10 and 11.

Lorin W. Anderson, University of South Carolina—primary author, Chapters 1, 6, and 14; contributing author, Chapters 3 and 7; vignette commentary, Chapters 8, 9, 10, 11, and 12.

Kathleen A. Cruikshank, Indiana University—contributing author, Chapter 1; vignette commentary, Chapters 9 and 12.

David R. Krathwohl, Syracuse University—primary author, Chapters 3, 15, 16, and 17; contributing author, Chapter 6.

Richard E. Mayer, University of California, Santa Barbara—primary author, Chapter 5; contributing author, Chapters 3 and 4.

Paul R. Pintrich, University of Michigan—primary author, Chapter 4; contributing author, Chapters 3 and 5.

James Raths, University of Delaware—contributing author, Chapters 1 and 7; vignette commentary, Chapter 13.

Merlin Wittrock, University of California, Berkeley—contributing author, Chapters 3, 4, and 5.

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We are especially grateful to these teachers, who wrote the descriptions of their teaching that are the "heart" of the vignettes in Chapters 8–13:

Chapter 8: Nancy C. Nagengast, Maple Lane Elementary School, Wilmington, Delaware.

Chapter 9: Margaret Jackson, A. C. Flora High School, Columbia, South Carolina.

Chapter 10: Jeanna Hoffman, Satchel Ford Elementary School, Columbia, South Carolina.

Chapter 11: Gwendolyn K. Airasian, Wilson Middle School, Natick, Massachusetts.

Chapter 12: Michael J. Smith, American Geographical Institute, Alexandria, Virginia.[2]

Chapter 13: Christine Evans, Brandywine (Delaware) School District, and Deanne McCredie, Cape Henlopen (Delaware) School District.

The authors of the vignettes were given the opportunity to see a late draft of the manuscript and were requested to send comments to the publisher on the draft in general and especially on the presentation and analysis of their own vignette. The authors of Chapter 13, which was added later, also had the opportunity to review their own vignette as it was presented and analyzed. The authors' comments and suggestions were used in preparing the final draft.

Copies of this manuscript in several stages of preparation were sent to various scholars, teachers, and educators. Many of these people returned

[2] Dr. Smith observed the teaching of the unit as part of a National Science Foundation project. An experienced teacher taught the unit.

comments that were extremely valuable to the authors in preparing this final version. We are grateful to all those who saw early drafts, including: Gwen Airasian, Wilson Middle School, Natick, MA; Patricia Alexander, University of Maryland; James Applefield, University of North Carolina, Wilmington; Richard Arends, Central Connecticut State; Hilda Borko, University of Colorado; Jere Brophy, Michigan State University; Robert Calfee, Stanford University; Nathaniel Gage, Stanford University; Robert Glaser, University of Pittsburgh; Thomas L. Good, University of Arizona; Jeanna Hoffman, Satchel Ford Elementary School, Columbia, SC; Margaret Jackson, A. C. Flora High School, Columbia, SC; James Johnson, Departments of Education and Labor, Washington, D.C.; Greta Morine-Dershimer, University of Virginia; Nancy Nagengast, Maple Lane Elementary School, Wilmington, DE; Melody Shank, Indiana Essential Schools Network; Wayne H. Slater, University of Maryland; Michael Smith, American Geographic Institute, Alexandria, VA; Susan Stodolsky, University of Chicago; and Anitia Woolfolk, Ohio State University.

We are most grateful to Dr. Virginia (Ginny) Blanford, formerly Education Acquisitions Editor of Addison Wesley Longman, for her strong support of the project from the beginning to the end. She was instrumental in getting funds from Longman for the first meeting of the editors and authors. Succeeding meetings over the years and in-between expenses were funded out of the royalties from the first edition.

Any revision inevitably treads the same ground as the original edition, and this book is no exception. We not only used ideas expressed in the first edition without continuously attributing them, which would get annoying, but in some instances used the original phrasing as well. As a group, we have been ever mindful of the debt we owe those on whose work this new effort has been based, and we are most grateful that they did the foundation work.

Finally, as editors, we are especially indebted to those who labored with us in this effort. It has been a special joy to work with them. We have had many spirited discussions and changed the manuscript so many times it has been hard to keep track of what went where. But through it all we've looked forward to our semiannual meetings and thoroughly enjoyed one another's contributions and company. One of the editors (DRK) especially thanks everyone for holding all the meetings in Syracuse when a family situation made it difficult for him to travel.

We are extremely sorry that Benjamin Bloom, who originated the idea of the Taxonomy, edited the original *Handbook*, and served as mentor to some of us, developed Alzheimer's disease and could not participate in our revision. Ben passed away shortly before this book was published. Most who worked on the original *Handbook* predeceased this revision's publication; the others are retired. One of the original authors, however, Dr. Edward Furst, supplied us with some useful materials and suggestions. Comments also came from Dr. Christine McGuire, a member of the original group. You'll also note that another member, Dr. Nathaniel Gage, was one of our helpful reviewers. We hope that all of them will consider this revision the improvement we intend it to be.

Lorin W. Anderson
David R. Krathwohl

Foreword

Although this Taxonomy, indeed the very idea of a taxonomy, may be new to many of our readers, it is a revision of a framework that has been in use for almost a half-century. For those unfamiliar with the *Handbook*, this Foreword provides some background on its original development and on the process of this revision.

In 1948 an informal meeting held in Boston was attended by a group of college and university examiners who believed that a common framework for classifying intended student learning outcomes could promote the exchange of test items, testing procedures, and ideas about testing. As examiners, these individuals were responsible for preparing, administering, scoring, and reporting the results of comprehensive examinations for undergraduate courses taught at their respective institutions.

Since developing good multiple-choice questions is time-consuming, the examiners hoped to create significant labor savings by facilitating the exchange of items. They proposed to establish a standard vocabulary for indicating what an item was intended to measure. Such regularized meanings were to result from a set of carefully defined categories and subcategories into which any educational objective and, therefore, any test item could be classified. Initially the framework would be limited to the mainstays of all instruction, cognitive objectives.

The original group always considered the framework a work in progress, neither finished nor final. Indeed, only the cognitive domain was developed initially. The affective domain was developed later (Krathwohl, Bloom, and Masia, 1964), and although both Simpson (1966) and Harrow (1972) provided frameworks for the psychomotor domain, the original group never did.

Furthermore, there was a great deal of concern among the members of the original group that the Taxonomy would freeze thought, stifling the development of new frameworks. That this did not occur is evident from the large number of alternative frameworks that have been advanced since the *Handbook* was published. A compilation of 19 of these frameworks appears in Chapter 15 of the complete version of this book.

In a memorandum circa 1971 Bloom stated: "Ideally each major field should have its own taxonomy of objectives in its own language—more detailed, closer to the special language and thinking of its experts, reflecting its own appropriate sub-divisions and levels of education, with possible new categories, combinations of categories and omitting categories as appropriate." [In his handwriting, a note refers the reader to Bloom, Hastings, and Madaus (1971), which showed how the Taxonomy could be so adapted.] There has always been and remains to this day an expectation that the Taxonomy would be adapted as educators in different fields used it, as education changed, and as new knowledge provided a basis for change. Our revision, then, is both overdue and expected.

REVISION OF THE *HANDBOOK*

The idea of revising the Taxonomy and the entire *Handbook* began with a series of discussions between David Krathwohl, one of the authors of the original *Handbook*, and Dr. Virginia Blanford, Senior Education Editor of Addison Wesley Longman, Inc. Since Longman owned the rights to the original *Handbook*, Dr. Blanford was aware of the need for a revision and was interested in marketing it. A group met to discuss revision and laid some plans, but little progress was made until the publication of *Bloom's Taxonomy: A Forty-Year Retrospective* (Anderson and Sosniak, 1994). Following its publication, David Krathwohl and Lorin Anderson began planning for an initial meeting of a new group of interested parties to discuss the desirability and feasibility of revising the Taxonomy and the *Handbook*.

As the plans for the meeting progressed, attention turned to who should participate. A decision was made to choose representatives of three groups: cognitive psychologists, curriculum theorists and instructional researchers, and testing and assessment specialists. An initial meeting, held in Syracuse, New York, in November 1995, was attended by these eight people (arranged by group):

Cognitive psychologists: Richard Mayer, Paul Pintrich, and William Rohwer. Merlin Wittrock was invited but could not attend.

Curriculum theorists and instructional researchers: Lorin Anderson and Kathleen Cruikshank. Jean Clandinin, Michael Connelly, and James Raths were invited but could not attend. Clandinin and Connelly later withdrew from the project.

Testing and assessment specialists: Peter Airasian, Linda Crocker, and David Krathwohl.

The meeting resulted in a draft table of contents for the revision and writing assignments. Like the original *Handbook*, the revision was a group effort. Drafts of various documents were prepared during the remainder of 1996 and first distributed to all group members in late 1996 and early 1997. The group then met twice yearly in the spring and fall to review drafts; discuss strengths, weaknesses, omissions, and redundancies; and determine appropriate next steps. A draft of the framework was presented for public comment at a symposium at the American Educational Research Association in April 1998; it was generally well received. The reaction suggested the revision might be ready for more detailed review.

At a June 1998 meeting in Syracuse, plans were laid to prepare a draft for external review. Addison Wesley Longman was generous in lining up a large number of blind reviews, and a draft manuscript was distributed in November 1998. Based on the reviews, revisions were made during the summer of 1999. A revised draft manuscript was the focus of discussion at a final Syracuse meeting held in October 1999.

The revision during the summer of 1999 removed many references to the original *Handbook* that we had included not only because we gratefully give credit to the original group but also because we wished, at appropriate points, to show how our revision builds on the original framework. However, the reviewers reminded us that many of our readers would be totally unfamiliar with the original *Handbook*. Consequently, such references would likely convey little meaning, get in the way, and unduly complicate the text. Therefore, for the most part, this volume has been written as though the reader were coming to the topic fresh.

Some readers will nevertheless be curious to know how the revision differs from the original, especially those who are familiar with the original and have used it. For these readers, we have summarized in Appendix A 12 of the major changes that we made. In addition, we have included a condensed version of the original Taxonomy in Appendix B. We hope that we have conveyed the tremendous debt we owe the framers of the original Taxonomy.

SECTION I

The Taxonomy: Educational Objectives and Student Learning

CHAPTER 1

Introduction

In life, objectives help us to focus our attention and our efforts; they indicate what we want to accomplish. In education, objectives indicate what we want students to learn; they are "explicit formulations of the ways in which students are expected to be changed by the educative process" (*Handbook*, 1956, p. 26). Objectives are especially important in teaching because teaching is an *intentional* and *reasoned* act. Teaching is intentional because we always teach for some purpose, primarily to facilitate student learning. Teaching is reasoned because what teachers teach their students is judged by them to be worthwhile.

The reasoned aspect of teaching relates to *what* objectives teachers select for their students. The intentional aspect of teaching concerns *how* teachers help students achieve the teachers' objectives, that is, the learning environments the teachers create and the activities and experiences they provide. The learning environments, activities, and experiences should be aligned with, or be consistent with, the selected objectives.

Teachers' objectives may be explicit or implicit, clearly or fuzzily conceived, easily measurable or not. They may be called something other than objectives. In the past they were called aims, purposes, goals, and guiding outcomes (Bobbitt, 1918; Rugg, 1926a and b). Today they are more likely to be referred to as content standards or curriculum standards (Kendall and Marzano, 1996; Glatthorn, 1998). Regardless of how they are stated and what they are called, objectives are present in virtually all teaching. Stated simply, when we teach, we want our students to learn. What we want them to learn as a result of our teaching are our objectives.[1]

The Need for a Taxonomy

Consider a recent lament from a middle school teacher: "When I first heard about the possibility of statewide standards, I was intrigued. I thought that it

[1] Throughout this volume we use the term *objectives* to refer to intended student learning outcomes. Thus, *objectives, curriculum standards,* and *learning goals* all refer to intended student learning.

might be nice to have a clear idea of what students were expected to know and be able to do in each subject at each grade level. But when I saw the drafts of the standards, I was appalled. There were so many. There were 85 standards in sixth-grade English language arts (my specialty area); there were more than 100 in sixth-grade mathematics. And they were so vague. I remember one in particular. 'Describe connections between historical and cultural influences and literacy selections.' What connections? What influences? What selections? And what do they mean by describe? I asked myself, 'How can these things possibly help me teach better and my students learn better?'"

What can teachers do when confronted with what they believe to be an exceedingly large number of vague objectives? To deal with the vast number of objectives, they need to organize them in some way. To deal with the problem of vagueness, they need to make the objectives more precise. In a nutshell, then, these teachers need an organizing framework that increases precision and, most important, promotes understanding.

How can a framework help teachers make sense of such statements of objectives? A framework consists of a set of categories related to a single phenomenon (e.g., minerals, fiction). The categories are a collection of "bins" into which objects, experiences, and ideas can be placed. Objects, experiences, and ideas that share common characteristics are placed in the same "bin." The criteria that are relevant in the sorting process are determined by a set of organizing principles—principles that are used to differentiate among the categories. Once classified, the characteristics of each category as well as the characteristics of the other categories in the framework help teachers to better understand what is placed in the category.

Consider the phylogenetic framework (with categories of mammals, birds, arthropods, and so on). The organizing principles (or "sorting criteria") include body characteristics (e.g., presence and/or location of skeleton, warm-blooded vs. cold-blooded) and birth and care of young (e.g., eggs vs. live birth; absent vs. nurturing). To use the framework to enhance our understanding, we learn the defining features of each category. For example, what makes a mammal a mammal? We learn that mammals are air-breathing, are warm-blooded, nurse their young, provide more protection and training of their young than do other animals, and have a larger, more well-developed brain than do other animals. If we hear that a hyrax is a mammal, then we understand something about the hyrax by virtue of its placement in the framework. If we are then told that a giraffe is a mammal, we know that hyraxes and giraffes share some common characteristics because they are placed in the same category of the framework.

A taxonomy is a special kind of framework. In a taxonomy the categories lie along a continuum. The continuum (e.g., the wave frequencies underlying color, the atomic structure underlying the periodic table of the elements) becomes one of the major organizing principles of the framework. In our Taxonomy we are classifying objectives. A statement of an objective contains a verb and a noun. The verb generally describes the intended cognitive process. The noun generally describes the knowledge students are expected to acquire or construct. Consider the following example: "The student will learn to distinguish (the cognitive process) among confederal, federal, and unitary systems of government (the knowledge)."

In contrast with the single dimension of the original Taxonomy, the revised framework is two-dimensional. As suggested in the preceding paragraph, the two dimensions are cognitive process and knowledge. We refer to their interrelationships as the Taxonomy Table (see the inside front cover). The cognitive process dimension (i.e., the columns of the table) contains six categories: *Remember, Understand, Apply, Analyze, Evaluate,* and *Create.* The continuum underlying the cognitive process dimension is assumed to be cognitive complexity; that is, *Understand* is believed to be more cognitively complex than *Remember, Apply* is believed to be more cognitively complex than *Understand,* and so on.

The knowledge dimension (i.e., the rows of the table) contains four categories: *Factual, Conceptual, Procedural,* and *Metacognitive.* These categories are assumed to lie along a continuum from concrete (*Factual*) to abstract (*Metacognitive*). The *Conceptual* and *Procedural* categories overlap in terms of abstractness, with some procedural knowledge being more concrete than the most abstract conceptual knowledge.

To begin to see how the Taxonomy Table helps us understand objectives, consider the aforementioned objective regarding systems of government. The verb—"distinguish"—provides clues to the desired cognitive process. As will be seen in Chapter 5, "distinguish" is associated with the cognitive process category *Analyze.* The noun phrase—"confederal, federal, and unitary systems of government"—gives clues to the desired type of knowledge. As will be seen in Chapter 4, "systems" signify *Conceptual knowledge.* In terms of the Taxonomy Table, then, the objective involves *Analyze* and *Conceptual knowledge.*

Consider a second example, this one from mathematics: "The student will learn to differentiate between rational numbers and irrational numbers." Differentiating, like distinguishing, is a subcategory in the process category *Analyze.* The nouns, rational and irrational numbers, are numerical categories. Categories are concepts, and concepts lie at the heart of *Conceptual knowledge.* In terms of the Taxonomy Table, this second objective also involves *Analyze* and *Conceptual knowledge.*

In the Taxonomy Table, both objectives are placed in the cell where the row labeled *Conceptual knowledge* intersects the column labeled *Analyze.* Despite their different subject matter, then, these two objectives about social studies and mathematics are classified in the same cell of the Taxonomy Table. Both are grounded in *Conceptual knowledge;* both require students to engage in the process *Analyze.* Once we understand the meaning of *Conceptual knowledge* and the meaning of *Analyze,* we know a great deal about both of these objectives. Just as placing an animal into the phylogenetic framework helps us better understand the animal, placing an objective into our framework increases our understanding of that objective.

Using Our Increased Understanding

Although we may gain a better understanding of an objective using the Taxonomy Table, how does this increased understanding help us? Teachers traditionally have struggled with issues and concerns pertaining to education, teaching, and learning. Here are four of the most important organizing questions:

1. What is important for students to learn in the limited school and classroom time available? (the learning question)
2. How does one plan and deliver instruction that will result in high levels of learning for large numbers of students? (the instruction question)
3. How does one select or design assessment instruments and procedures that provide accurate information about how well students are learning? (the assessment question)
4. How does one ensure that objectives, instruction, and assessment are consistent with one another? (the alignment question)

These four organizing questions reappear throughout the book and provide a basis for showing how the Taxonomy framework can be used. We describe them in greater detail in the next four sections of this chapter.

The Taxonomy Table, Objectives, and Instructional Time

One of the most common and long-standing curriculum questions is What is worth learning? This is the first of the organizing questions. At an abstract level, the answer defines what it means to be an educated person. At a more concrete level, the answer defines the meaning of the subject matter being taught. Is mathematics, for example, a discrete body of knowledge to be memorized or an organized, coherent, conceptual system to be understood? Does reading consist of remembering a set of sound-symbol relationships or gaining meaning from the words on a printed page? Similar questions can be asked of science, history, art, music, and other fields.

Today's emphasis on state-level standards is intended to provide at least a partial answer to the learning question. But as our middle school teacher's comments suggest, simply having standards does not necessarily provide a sound, defensible answer. "Grocery lists" of standards may be more confusing and frustrating than enlightening and useful. Teachers must still answer the question What is worth learning? They answer it, in large part, by the way they allocate time in the classroom and by the emphasis they convey to their students about what is *really* important.

Over the past century, the number of possible answers to this fundamental curriculum question has increased as our collective knowledge and the amount of information available to us have increased. We continue to operate educationally, however, within virtually the same length of school year that we used a hundred years ago. If the difficult decisions are not made about what is worth learning, then teachers are likely to simply run out of time. When teachers operate within a textbook-based curriculum, for example, they complete as many chapters as time permits.

Looking through the lens of the Taxonomy Table, teachers can see more clearly the array of possible objectives as well as the relationships among them. Thus, when we analyze all or part of a curriculum in terms of the Taxonomy Table, we can gain a more complete understanding of the curriculum. Rows, columns, and cells that have numerous entries become evident, as do those that have no entries at all. An entire row or column that has no entries can alert us to the possibility of including objectives that heretofore had not been considered.

In sum, the Taxonomy framework obviously can't directly tell teachers what is worth learning. But by helping teachers translate standards into a common language for comparison with what they personally hope to achieve, and by presenting the variety of possibilities for consideration, the Taxonomy may provide some perspective to guide curriculum decisions.

THE TAXONOMY TABLE AND INSTRUCTION

Once an objective has been placed into a particular cell of the Taxonomy Table, we can begin systematically to attack the problem of helping students achieve that objective. Thus, the second organizing question involves instruction. We have used two objectives as examples:

- The student will learn to distinguish among confederal, federal, and unitary systems of government.
- The student will learn to differentiate between rational numbers and irrational numbers.

We placed both of these objectives in the cell that corresponds to the intersection of *Analyze* and *Conceptual knowledge*; that is, both are of the form *analyze conceptual knowledge*. How does this placement help us plan our instruction?

Categories and classifications form the basis of *Conceptual knowledge*. Thus, instruction related to these objectives must help students form the categories and classifications inherent in the objective: confederal, federal, and unitary systems of government, on the one hand, and rational and irrational numbers, on the other. From a variety of research studies we know that examples help students form categories and classifications (Tennyson, 1995). Thus, examples should be incorporated into instructional plans for objectives that involve *Conceptual knowledge*.

Looking back at the two objectives, we see that distinguishing and differentiating are both cognitive processes associated with *Analyze*. In fact, differentiating involves distinguishing the parts of a whole structure in terms of their relevance or importance. In the first objective the whole structure is "systems of government." The parts are confederal, federal, and unitary, and they differ in many respects. The question is What are the most relevant or important differences? Similarly, in the second objective the whole structure is the "real number system." The parts are rational and irrational numbers. Again, the question is What are the most relevant or important differences among the "parts" in the context of the "whole"?

Regardless of the specific objective, then, when instruction is directed at objectives classified as *Analyze Conceptual knowledge,* one might expect activities that:

- focus students' attention on categories and classifications;
- use examples and nonexamples to help students form the proper categories;
- help students see specific categories in relation to a larger classification system; and
- emphasize the relevant and important differences among the categories within the context of the larger system. (Tennyson, 1995)

Now consider a third objective: "Students will learn the names of the major works of American and British novelists." In our framework, "learn the names of" indicates *Remember,* and "names of the major works of American and British novelists" suggests *Factual knowledge.* Thus, this objective is of the form *remember factual knowledge.* Instruction designed for this objective is different from instruction designed for the first two objectives. Instructional plans for objectives classified as *Remember Factual knowledge* might lead one to expect the teacher to:

- periodically remind students of the specific details to be remembered (e.g., names, not plot or characters);
- give students strategies (e.g., rehearsal) and techniques (e.g., mnemonic devices) for helping them memorize the relevant knowledge; and
- provide opportunities for students to practice these strategies and techniques. (Pressley and Van Meter, 1995)

Two points should be made here. First, different types of objectives require different instructional approaches, that is, different learning activities, different curricular materials, and different teacher and student roles. Second, similar types of objectives—regardless of differences in the topic or subject matter—may require similar instructional approaches (Joyce and Weil, 1996). Given particular kinds of instructional goals, Romizowski (1981), for example, lists a variety of instructional characteristics that facilitate their achievement. Classifying a particular objective within our framework, then, helps teachers systematically plan a way of effectively facilitating students' learning of that objective.

The Taxonomy Table and Assessment

The two points made in the preceding paragraph apply to assessment as well, which brings us to the third organizing question. Different types of objectives (that is, objectives in different cells of the table) require different approaches to assessment. Similar types of objectives (that is, objectives in the same cells of the table) likely involve similar approaches to assessment. To illustrate these points, we continue with our three sample objectives.

To assess students' learning with respect to the systems of government objective, we could provide each student with a description of the system of government of an imaginary country and ask the student to answer questions about the government. An imaginary country is used to ensure that the student has not encountered it in the past and thus cannot answer the questions based on memory alone. Three example questions follow:

- What system of government is this (federal, confederal, or unitary)?
- How do you know that it is the type of government system you say it is?
- What changes would need to be made to transform the country's system into the other two systems? That is, if it is a federal system, what changes would make it a confederal system or a unitary system?

To assess students' learning with respect to the number systems objective, we could provide each student with a list of, say, six numbers, all of which are either rational or irrational numbers, and ask the student to answer questions about the list of numbers. The numbers selected should be as different as possible from the numbers in the textbook or discussed during class. Three example questions follow:

- To what number system, rational or irrational, do all of these numbers belong?
- How do you know that it is the type of number system you say it is?
- How could you change each number so it is an example of the other number system? That is, if it is an irrational number, change it to a rational number, and if it is a rational number, change it to an irrational number.

Note the parallelism in these two sets of questions. Both begin with an example or a set of examples in one of the categories. In both cases, the example or set of examples is different from examples included in the text or mentioned in class. This condition is needed to ensure that understanding, rather than remembering, is being assessed. The three questions are essentially the same: To what category does the example or examples belong? How do you know that? How can you change the example or examples so they belong to the other category or categories? This blueprint, then, can be used for designing assessments for many objectives of the form *analyze conceptual knowledge.*

The third sample objective was to learn the names of the major works of American and British novelists. Here, we want all of the works and novelists included in the assessment instrument to be those contained in the text or discussed in class. The emphasis is on remembering, not understanding. A frequently used assessment format for such objectives is matching. The names of the novels are listed in, say, column A, and the names of the American and British novelists are listed in column B. Students are asked to locate the novelist in column B who wrote each of the novels in column A. Notice that this format is appropriate for many objectives of the form *remember factual knowledge.*

THE CONCEPT OF ALIGNMENT

Alignment refers to the degree of correspondence among the objectives, instruction, and assessment; it is the topic of the fourth and last organizing question. In the systems of government example, the objective is of the form *analyze conceptual knowledge*. Instruction that focuses students' attention on the three specific categories, that uses examples to help students form the proper categories, that helps students see the three specific categories in relation to a larger system, and that emphasizes the relevant and important differences among the categories within the larger system is well aligned with the objective. Similarly, assessment tasks that provide students with information about an unfamiliar government and ask them to classify the government into one of the three types, defend the classification made, and describe the changes necessary to modify the government into the other two types are well aligned with the objective.

Severe misalignment can cause problems. If, for example, instruction is not aligned with assessments, then even high-quality instruction will not likely influence student performance on those assessments. Similarly, if assessments are not aligned with objectives, then the results of the assessments will not reflect achievement of those objectives.

Typically, the degree of alignment is determined by comparing objectives with assessment, objectives with instruction, and instruction with assessment. This comparison often results in a surface-level analysis, however. The Taxonomy Table offers an important alternative to facilitate comparisons. The table is a kind of touchstone; its carefully defined terms and organization provide precision across all three comparisons. Thus, a special Taxonomy Table can be prepared using different notations for objectives, for instruction, and for assessments as each is classified in the cells of the table. By determining whether notations for all three—objectives, instructional activities, and assessments—appear together in the individual cells of the table (strong alignment), or some cells contain only two of them (weaker alignment), or many cells contain only one of them (weakest alignment), we gain a deeper-level examination of alignment. The examination emphasizes consistency in terms of intended student learning. This approach is illustrated in the vignettes in Chapters 8–13 of this volume.

TEACHERS AS CURRICULUM MAKERS VERSUS TEACHERS AS CURRICULUM IMPLEMENTERS: A CLOSING COMMENT

> In the span of a hundred years, much of the control over what is taught has shifted from the schoolhouse to the statehouse—an often turbulent transition made reluctantly and grudgingly. State leaders, more than ever, are at the helm, still trying to fulfill the hope and promise for public education their counterparts were striving for a century ago. (Manzo, 1999, p. 21)

It should be clear from the introduction to this chapter that we expect our work to be used in the context of "teachers as curriculum implementers"; that is, teachers are given sets of objectives (e.g., in textbooks or increasingly state- or district-mandated standards) and are expected to deliver instruction that enables a large proportion of students to achieve those standards. The Taxonomy Table should help teachers do this and do it reasonably well.

At the same time, however, we recognize that some curriculum theorists, teacher educators, and teachers themselves believe teachers should be "curriculum makers" (see, for example, Clandinin and Connelly, 1992). Is our framework useful in this context as well? We believe it is. For these teachers, however, the framework is more likely to function as a heuristic than as a guide. For instance, the Taxonomy may suggest the range and types of cognitive objectives to consider. As further evidence for the framework's usefulness, we recommend examining the analyses of the vignettes to see how they facilitate curriculum development. These vignettes were prepared by teachers functioning as curriculum makers. Some of the teachers were quite free to design their units as they saw fit. Others were constrained to a greater or lesser degree by legislative regulations, state standards, district guidelines, textbook adoptions, and the like. Regardless of the degree of freedom available to the teachers, our framework provided us with a level of understanding of their teaching practices that was hitherto not evident. Strengths and areas in need of improvement were both apparent.

It is our hope that, whether the curriculum was given to the teachers or designed by them, this revision of the Taxonomy will help teachers make sense of the curriculum, plan instruction, and design assessments that are aligned with the objectives inherent in the curriculum and ultimately improve their teaching quality. Furthermore, our framework should provide a common way of thinking about and a common vocabulary for talking about teaching that enhances communication among teachers themselves and among teachers, teacher educators, curriculum coordinators, assessment specialists, and school administrators.

CHAPTER 2

The Structure, Specificity, and Problems of Objectives

Given the importance of objectives in education, in this chapter we address the structure, specificity, and criticisms of objectives. We recognize that objectives exist in many forms, ranging from highly specific to global and from explicit to implicit. We also recognize that there is debate over the merits and liabilities of objectives in their varied forms. We concentrate mainly on those objectives that we believe are most useful for identifying the intended cognitive outcomes of schooling, for guiding the selection of effective instructional activities, and for selecting or designing appropriate assessments. We understand that other types and forms of objectives may be useful in different ways.

THE STRUCTURE OF OBJECTIVES

The most commonly used model of educational objectives is based on the work of Ralph Tyler (1949). Tyler suggested that "the most useful form for stating objectives is to express them in terms which identify both the kind of *behavior* to be developed in the student and the *content* . . . in which this behavior is to operate" (p. 30) (emphasis ours). In Chapter 1 we indicated that a statement of an objective contains a verb and a noun. We went on to say that the verb generally describes the intended *cognitive process*, and the noun generally describes the *knowledge* students are expected to acquire or construct. In our formulation, then, we used "cognitive process" in place of "behavior" and "knowledge" in place of "content." Because these substitutions were intentional, let us consider them in greater detail.

CONTENT VERSUS KNOWLEDGE

In the educational literature, content is often discussed but rarely defined. We read of content domains and disciplinary content (Doyle, 1992), content knowledge and pedagogical content knowledge (Shulman, 1987). The *Merriam-Webster Dictionary* (online at *www.m-w.com/home*) contains several definitions of *content*. The one most pertinent to our discussion is "matter dealt with in a field of study." This definition suggests that content is equivalent to what has traditionally been referred to as "subject matter" (that is, a content domain).

The dictionary lists as a synonym, "substance." When applied to a particular subject matter, then, content is its substance.

Who determines the substance of a given subject matter? Traditionally, this task has fallen to scholars who have spent their lives studying and working in a field: mathematicians, scientists, historians, and the like. Over time they reach a consensus on what might be termed the "historically shared knowledge" that defines the subject matter of their academic discipline. This "historically shared knowledge" is not static; changes are made as new ideas and evidence are accepted by the scholarly community. In this context, then, content is "historically shared knowledge." Accordingly, we use the term *knowledge* to reflect our belief that disciplines are constantly changing and evolving in terms of the knowledge that shares a consensus of acceptance within the discipline.

"Knowledge" and "subject matter content" are also related in another way, however. Confusion often arises between subject matter as the knowledge in an academic discipline and subject matter as the materials used to convey the knowledge to students. For educational purposes, subject matter content must be "packaged" in some way. Examples of packaging include textbooks, grade levels, courses, and, increasingly, multimedia "packages." Packaging involves selecting and organizing content so it can be presented in "forms that are pedagogically powerful and yet adaptive to the variations in ability and background presented by the students" (Shulman, 1987, p. 15). This confusion between subject matter as the content of a discipline and "packaged subject matter" designed to promote learning is largely eliminated by referring to the former as knowledge and the latter as curricular materials, instructional materials, or simply materials.

In summary, then, we have two reasons for substituting "knowledge" for "content." The first is to emphasize the fact that subject matter content is "historically shared knowledge" that is arrived at through a currently shared consensus within a discipline and is subject to change over time. The second reason is to differentiate the subject matter content of an academic discipline from the materials in which the content is embedded.

Behavior Versus Cognitive Processes

In retrospect, Tyler's choice of the word *behavior* was unfortunate for at least two reasons. First, because behaviorism was the predominant theory of psychology at the time, many people incorrectly equated Tyler's use of the term *behavior* with behaviorism. From Tyler's perspective, a change in behavior was the intended result of instruction. Specifying student behavior was intended to make general and abstract learning goals more specific and concrete, thus enabling teachers to guide instruction and provide evidence of learning. If the teacher could describe the behavior to be attained, it could be recognized easily when learning occurred.

Behaviorism, in contrast, was a means by which desired ends could be achieved. Principles of instruction, within the context of behaviorism, included instrumental conditioning and the formation of stimulus-response associations. It was not surprising then that critics who confused behaviors with behaviorism suggested that Tyler's objectives were oriented mainly toward teaching through manipulation and control.

Second, aided by the popularity of management-by-objectives, task analysis, and programmed instruction in the 1950s and 1960s, *behavior* became an adjective modifying objectives. The level of specificity and detail of these new "behavioral objectives" went well beyond Tyler's original concept of objectives to include the conditions under which students were to demonstrate their learning and the standards of performance that would indicate that successful learning had taken place. Consider this typical behavioral objective of the 1950s and 1960s: "**Given a map or chart,** the student will correctly define *six of the eight* representational devices and symbols on it." The bold print indicates the conditions; the italicized material indicates the standard of performance. It is understandable that critics who equated Tyler's more generally stated objectives with behavioral objectives saw them as narrow and inadequate.

In part to eliminate confusion, we have replaced "behavior" with the term "cognitive process." This change reflects the fact that cognitive psychology and cognitive science have become the dominant perspectives in psychology and education. We can make better sense of the verbs in objectives by using the knowledge gained from cognitive research. To illustrate this point, consider the following set of verbs: *list, write, state, classify, explain,* and *attribute.*

The first three verbs—*list, write,* and *state*—are staples of traditional behavioral objectives (e.g., "The students will be able to list three reasons for the rise of communism in Eastern Europe"). However, these verbs are vague in terms of their underlying cognitive processes. How, for example, did the students arrive at their lists? Did they remember a list provided by the teacher or encountered in a textbook? Or, did they analyze material contained in several books to develop their lists? In this case, a single verb—*list*—can be associated with two very different Taxonomy categories—*Remember* and *Analyze.*

In contrast, the second set of three verbs—*classify, explain,* and *attribute*—have specific meanings within our framework. *Classify* means to determine whether something belongs to a particular category. *Explain* means to construct a cause-and-effect model of a system. *Attribute* means to determine the point of view, bias, values, or intent underlying presented material. This increased specificity helps us focus on what we want students to learn (e.g., "classify") rather than on how we expect them to demonstrate their learning (e.g., "list"). Our use of the term "cognitive process" in place of "behavior" thus not only eliminates the confusion with behaviorism but also reflects our effort to incorporate cognitive psychological research findings into our revision of the framework.

Accordingly the two main dimensions of the Taxonomy Table are the four types of knowledge and the six major cognitive process categories.

Specificity of Objectives

The general domain of objectives is best represented as a continuum ranging from quite general to very specific. Along this continuum, Krathwohl and Payne (1971) identified three levels of specificity called global, educational, and instructional guidance objectives, with the latter now more commonly referred to as instructional objectives. As we discuss these three levels, you should bear in mind that they represent three positions on a continuum of specificity, so that classifying any objective involves a judgment about the level in which it best fits.

Global Objectives

Global objectives are complex, multifaceted learning outcomes that require substantial time and instruction to accomplish. They are broadly stated and encompass a large number of more specific objectives. Here are three examples of global objectives:

- All students will start school ready to learn.
- All students will leave Grades 4, 8, and 12 having demonstrated competency over challenging subject matter.
- All students will learn to use their mind well, so they will be prepared for responsible citizenship, further learning, and productive employment in our nation's economy.

These global objectives are taken from *Goals 2000*, a set of goals for U.S. education to be achieved by the year 2000 (U.S. Department of Education, 1994).

The function of global objectives, or goals, is to provide a vision of the future and a rallying cry for policy makers, curriculum developers, teachers, and the public at large. The goals indicate in a broad-brush way what is deemed relevant in a good education. Thus, a global objective is "something presently out of reach; it is something to strive for, to move toward, or to become. It is an aim or purpose so stated that it excites the imagination and gives people something they want to work for" (Kappel, 1960, p. 38).

Educational Objectives

For teachers to use global objectives in their planning and teaching, the objectives must be broken down into a more focused, delimited form. The very generality of global objectives that is necessary to "excite the imagination" makes them difficult to use to plan classroom activities, define suitable assessment procedures, and evaluate student performances in a meaningful way. More specific objectives are necessary for those tasks.

One of the main aims of the original *Handbook* was to focus attention on objectives somewhat more specific than global objectives. These were called educational objectives. The following objectives, taken from the *Handbook*, illustrate the nature and increased specificity of educational objectives:

- "The ability to read musical scores" (p. 92)
- "The ability to interpret various types of social data" (p. 94)
- "Skill in distinguishing facts from hypotheses" (p. 146)

Consistent with Tyler's description of educational objectives, each of these objectives describes a student behavior (e.g., to read, to interpret, to distinguish) and some content topic (e.g., musical scores, various types of social data, facts and hypotheses) on which the behavior will be performed.

Educational objectives occupy the middle range on the objective continuum. As such, they are more specific than global objectives but more general than the objectives needed to guide the day-to-day classroom instruction that teachers provide.

Instructional Objectives

Subsequent to publication of the *Handbook*, educational trends created a need for even more specific objectives (Airasian, 1994; Sosniak, 1994). The purpose of these instructional objectives was to focus teaching and testing on narrow, day-to-day slices of learning in fairly specific content areas. Examples of instructional objectives follow:

- The student is able to differentiate among four common punctuation marks.
- The student learns to add two one-digit numbers.
- The student is able to cite three causes of the Civil War.
- The student is able to classify objectives as global, educational, or instructional.

Instructional objectives have substantially greater specificity than educational objectives.

Summary of Levels of Objectives

Table 2.1 compares the scope, time dimension, function, and use of the three levels of objectives. In terms of scope, global objectives are "broad," whereas instructional objectives are "narrow"; that is, global objectives do not deal with specifics, and instructional objectives deal only with specifics. Global objectives may require one or even many years to learn, whereas instructional objectives can be mastered in a few days. Global objectives provide vision that quite often becomes the basis for support for educational programs. At the other end of the spectrum, instructional objectives are useful for planning daily lessons.

In the middle of the continuum lie educational objectives. They are moderate in scope and provide the basis for planning units containing objectives that

TABLE 2.1 Relationship of Global, Educational, and Instructional Objectives

	LEVEL OF OBJECTIVE		
	GLOBAL	EDUCATIONAL	INSTRUCTIONAL
SCOPE	Broad	Moderate	Narrow
TIME NEEDED TO LEARN	One or more years (often many)	Weeks or months	Hours or days
PURPOSE OR FUNCTION	Provide vision	Design curriculum	Prepare lesson plans
EXAMPLE OF USE	Plan a multiyear curriculum (e.g., elementary reading)	Plan units of instruction	Plan daily activities, experiences, and exercises

require weeks or months to learn. Our framework is designed to facilitate working with educational objectives.

WHAT OBJECTIVES ARE NOT

To this point we have discussed what objectives are. We now discuss what objectives are *not*. Some educators have a tendency to confuse means and ends. Objectives describe ends—intended results, intended outcomes, intended changes. Instructional activities, such as reading the textbook, listening to the teacher, conducting an experiment, and going on a field trip, are all means by which objectives are achieved. Stated simply, instructional activities, if chosen wisely and used properly, lead to the achievement of stated objectives. To emphasize the difference between means and ends—between instructional activities and objectives—the phrases "be able to" or "learn to" are either included or implied in our statements of objectives. Thus, for example, "Students will learn to apply the criteria for writing coherent paragraphs" is a statement of an objective. The act of writing paragraphs is an activity that may or may not lead to the objective. Similarly, "Students will learn the algorithm for solving simultaneous equations in two unknowns" is an objective. The act of working on simultaneous equations is an activity. Once again, students may or may not learn to solve simultaneous equations by working on them.

When objectives are not stated explicitly, they are often implicit in the instructional activity. For example, an activity might be for students to "read *The Sun Also Rises*." To determine the objective associated with this activity, we can ask the teacher, "What do you want your students to learn by reading *The Sun Also Rises*?" The answer to this question is the objective (e.g., "I want my students to understand Hemingway's skill as a writer"). If multiple answers are given, there are likely to be multiple objectives.

Just as instructional activities are not objectives, neither are tests or other forms of assessment. For example, "Students should be able to pass the statewide high school proficiency test" is not an educational objective. To determine the educational objective, we must seek out the knowledge and cognitive processes students must learn or possess to pass the test.

In summary, it is important not to confuse objectives with instructional activities or assessments. Although each of these can be used to help identify and clarify intended student learning outcomes, it is only after an activity or assessment is articulated in terms of intended student learning that the objective becomes evident.

A Changing Vocabulary of Objectives

As mentioned in Chapter 1, *objective* is not the only term used to describe an intended student learning outcome. The vocabulary of intended student learning is ever-changing. Today's terminology is driven by the current emphasis on school improvement through standards-based education. At the heart of the standards-based movement is the state-level specification of intended student learning outcomes in different subject matters at each grade level. Generally, statewide assessment programs linked to the standards are intended to monitor the extent to which individual students and entire schools have achieved them.

Despite the recent changes in vocabulary, the various terms used in conjunction with state standards fit nicely into the three levels of objectives: global, educational, and instructional. The following two standards are taken from South Carolina's primary grades mathematics curriculum. In primary mathematics, students will:

- Establish a strong sense of number by exploring concepts such as counting, grouping, place value, and estimating; and
- Develop the concepts of fractions, mixed numbers, and decimals and use models to relate fractions to decimals and to find equivalent fractions.

Though not quite as general as earlier examples of global objectives, these standards are best considered global objectives because they include broad topics (e.g., sense of number) or multiple topics (e.g., fractions, mixed numbers, decimals) and rather vague processes (e.g., establish, explore, and develop).

To assess the attainment of these standards, teachers in South Carolina are provided with more specific objectives called "indicators" for each standard. For the first standard above, sample indicators include:

- Students will be able to write whole numbers in standard form, expanded form, and words; and
- Students will learn to estimate the number of objects in a variety of collections.

For the second standard, sample indicators include:

- Students will understand the meaning of fractions, mixed numbers, and decimals; and

- Students will interpret concrete or pictorial models that represent fractions, mixed numbers, decimals, and their relationships.

These indicators most closely resemble educational objectives, insofar as they narrow the specificity of the global standards to the unit level but not to the lesson level.

Objectives are used not only in standards-based curriculums but also in statewide and district-wide accountability programs designed to determine, among other things, whether a student will be placed in a remedial class, awarded a high school diploma, or promoted to the next grade. When the results of testing are consequential for students or teachers, litigation becomes a possible threat. An accountability program that is linked to clear, publicly stated objectives and standards provides some legal protection.

Objectives, in the form of subject matter standards, have been produced by a variety of professional organizations and associations (e.g., American Association for the Advancement of Science, 1993; National Council for the Social Studies, 1994; National Council of Teachers of English and International Reading Association, 1996; National Research Council, 1996). The National Council of Teachers of Mathematics (NCTM) (1989) was the first association to recommend what were called content standards. One of the NCTM standards states: "In grades 5–8, the mathematics curriculum should include explorations of algebraic concepts and processes." Note that this "standard" describes what the curriculum should include (i.e., the content), not what students are to learn from it (i.e., the objective). Thus, this content standard does not meet our criteria for objectives. However, this content standard can quite easily be translated into an educational objective. Examples include: "The student should understand the concepts of variable, expression, and equation"; "The student should learn to analyze tables and graphs to identify properties and relationships"; and "The student should be able to apply algebraic methods to solve a variety of real-world and mathematical problems."

As mentioned earlier, most standards-based curriculums include both global objectives (i.e., standards) to provide general expectations and educational objectives (i.e., indicators) to guide the design of curriculum units. Since it is difficult to make statewide or national pronouncements regarding the specifics of classroom teaching, standards-based approaches leave the development of instructional objectives to classroom teachers. To develop instructional objectives from indicators, a teacher continues to narrow the cognitive process and content knowledge. Consider, for example, the following educational objective/indicator: "Students will understand the meaning of fractions, mixed numbers, and decimals." Associated instructional objectives might include: "Students will learn to write decimals as fractions and fractions as decimals"; "Students will be able to write equivalent fractions"; and "Students will learn to write mixed numbers as improper fractions and decimals."

When there are no specific instructional objectives, teachers often turn to the assessment instruments to clarify the meaning and instructional focus of global and educational objectives. In these situations, assessment tasks *de facto* become the educational or instructional objectives. Although this is a time-honored practice, it often leads to concerns about teaching to the test.

PROBLEMS WITH OBJECTIVES

Despite the many and widespread uses of objectives in education, authors have raised concerns about their adequacy and consequences (Furst, 1981; De-Landsheere, 1977; Dunne, 1988). In this section we explore some of these concerns, addressing particular issues related to the specificity of objectives, their relationship to teaching, and their claimed value-free status vis-à-vis educational philosophy and curriculum.

SPECIFICITY AND INCLUSIVENESS

Even before the publication of the *Handbook* in 1956, a debate was ongoing about how specific objectives should be. Because global objectives are too general to be of practical use in guiding instruction and assessment, the main debate has focused on educational and instructional objectives.

Like global objectives, educational objectives are criticized as being too general to guide teaching and assessment. They do not provide teachers the specific direction they need to plan, facilitate, and assess student learning (Mager, 1962; Popham, 1969). This argument has some truth. As noted earlier, however, it is also true that educational objectives convey a more open, richer sense of intended student learning than that conveyed by narrower instructional objectives. The authors of the *Handbook* recognized this point and consciously rejected overly narrow objectives, seeking instead objectives that had "a level of generality where the loss by fragmentation would not be too great" (p. 6). Educational objectives were to provide a path to more specific instructional objectives, but the authors aimed to identify the forest before proceeding to the trees.

Moreover, educational objectives allow for classroom teachers to interpret and select the aspects of the educational objective that fit their particular students' needs and readiness. This benefit is consistent with the current emphasis on teacher judgment and empowerment. Many who criticize objectives for being overly specific, constraining, and "behavioral" may not adequately differentiate educational objectives from instructional objectives.

Although the specificity of instructional objectives provides a focus for instruction and assessment, such specificity can lead to large numbers of atomistic, narrow objectives. The question then becomes whether these specific objectives will coalesce into broader, integrated understandings that are more than the sum of the individual objectives (Broudy, 1970; Dunne, 1988; Hirst, 1974).

On a related matter, critics have argued that not all important learning outcomes can be made explicit or operational (Dunne, 1988; Armstrong, 1989; Marsh, 1992) and that the role of tacit understanding and open-ended situations was underrepresented in the *Handbook*. There is, for example, a difference between learning experiences that are expected to lead to common learning outcomes and those that are intended to lead to idiosyncratic learning. Objectives are meant to describe the former. Although learning does result from the latter experiences, it is virtually impossible to specify the nature of that learning in advance.

The lesson from discussions about intended versus unintended learning outcomes is that not all important learning outcomes can, should, or must be stated as a priori objectives. This assertion, however, should not deter efforts to articulate important intended student learning outcomes, even though these may not be the only outcomes that result from classroom instruction.

The Lock-Step Nature of Objectives

A variation on the theme above is the criticism of the lock-step nature of objectives that prescribe the same intended learning outcomes for all students. Eisner (1979) pointed out that not all objectives need to produce the same student learning. In fact, Eisner identifies "expressive outcomes," which he defines as "the consequences of curriculum activities that are intentionally planned to provide a fertile field for personal purposing and experience" (p. 103). An expressive outcome may derive from an experience or activity such as visiting a museum, seeing a play, or listening to classical music. Expressive outcomes result from activities that have no a priori intended learning outcome except that each student will be uniquely changed in some way from exposure to the experience or activity. Such outcomes are evocative, not prescriptive, in the sense that purpose does not precede the activity but rather uniquely grows from it.

Expressive outcome activities result in learning, but what students are expected to learn from participating in these activities cannot be stated in advance. Furthermore, what is learned will likely differ from one student to another. Note that expressive objectives may be more applicable to certain subject areas than others and to more complex forms of cognition than less complex ones. They provide a *direction* for learning but not a particular *destination.*

To some extent, all objectives are expressive, in that not all students learn the same things from the same instruction even when the intended objective is the same. Ancillary learning is always going on. The current emphasis on performance assessment or authentic assessment encourages the use of assessment procedures that allow students to produce a variety of acceptable responses to the same assessment task or set of tasks. Although these newer forms of assessment do not quite mirror the nature of expressive objectives, they are clearly intended to do so. We merely point out that these forms of assessment are more likely to be appropriate for educational objectives than for global and instructional objectives.

What Does an Objective Represent—Learning or Performance?

At the heart of many criticisms of objectives is the question of what an objective really represents (Hirst, 1974; Ginther, 1972). For example, the more specific an objective is, the easier it is to assess, but also the more likely we are to blur the distinction between the intended meaning of the objective and its assessment. Stated simply, the assessed performance is used to make inferences about intended student learning as it is described in the objectives. So-called performance objectives to the contrary, performance is not the objective per se.

Furthermore, with few exceptions, the tasks (e.g., questions, test items, problems) used to assess an objective are only a sample of the possible tasks that could be used. Consider the following instructional objective: "The student will learn to add three two-digit numbers with regrouping." This objective can be assessed by many items because of the many possible two-digit combinations from which to select (e.g., 25 + 12 + 65; 15 + 23 + 42; 89 + 96 + 65). Inevitably, teachers select a sample of the possible tasks and use students' performance on that sample to infer how they would do on other similar, but unassessed, tasks. The more general an objective, the larger the universe of possible assessment tasks.

Now compare the relatively narrow range of evidence needed to assess the two-digit addition objective with the broader range of evidence needed to assess learning of the following educational objective: "The student will learn to apply various economic theories." The specificity of the first objective permits inferences to be made about student learning from relatively few assessment tasks. In contrast, the second objective is much broader, thereby allowing for an almost unlimited set of assessment tasks. Because any single assessment can sample only a small portion of the assessment tasks, the more general an objective, the less confident one is about how adequately a student's performance validly represents his or her learning across its full breadth. Again, this concern is particularly salient when objectives emphasize more general knowledge categories or more complex cognitive processes.

The Restricted Use of Objectives

Critics have pointed out that the ease of stating objectives differs greatly from one subject matter to another (Stenhouse, 1970–71; Seddon, 1978; Kelly, 1989). Stating objectives in creative writing, poetry, and art interpretation, for example, may be difficult. When required to formulate objectives, teachers in these areas may select lower-level objectives that are easy to state but do not really represent what they believe to be important for their students to learn. Alternatively, objectives that appear to call for complex student learning may not actually do so in light of how the objectives are taught and/or assessed. Correctly classifying an objective requires either knowing or inferring how the objective was taught by the teacher and learned by the student.

In some subject areas, it may be easy to state objectives but difficult to obtain broad community endorsement for the objectives. Especially in subjects such as social studies, sex education, and religion, differences in values and political views lead to difficulties in reaching a consensus about the appropriateness of stated objectives. In these cases it is usually easier to obtain agreement on global objectives (e.g., good citizenship) than on more specific educational and instructional ones.

Difficulty is inherent in stating objectives in some areas and in obtaining consensus on objectives in others. In fact, these are the two reasons that objectives in some subject areas are limited, if they are stated at all. Given the importance of objectives, however, these problems are to be overcome, not avoided.

Concluding Comment

Our framework is a tool to help educators clarify and communicate what they intend students to learn as a result of instruction. We call these intentions "objectives." To facilitate communication, we have adopted a standard format for stating objectives: "The student will be able to, or learn to, *verb noun*," where the verb indicates the cognitive process and the noun generally indicates the knowledge. Furthermore, although objectives can range from very broad to highly specific, we prefer and advocate the use of the midrange, that is, educational objectives.

Our focus on objectives does not encompass all possible and important student learning outcomes, in part because we focus exclusively on cognitive outcomes. In addition, we do not deny that incidental learning takes place in every school and classroom. Where learning cannot be anticipated, however, it lies beyond the scope of our work. Similarly, expressive experiences produce a myriad of unanticipated reactions and responses that depend largely on the students themselves. Our omission of incidental learning and expressive experiences does not mean they are not important or useful in many situations.

In sum, our emphasis is on student-oriented, learning-based, explicit, and assessable statements of intended cognitive outcomes. By adopting this emphasis, we are following the lead of the authors of the original *Handbook*. We have, like them, endeavored to produce a framework that we anticipate will be used in many but not all ways, by many but not all educators.

SECTION II

The Revised Taxonomy Structure

CHAPTER 3

The Taxonomy Table

As we mentioned in Chapter 1, our framework can be represented in a two-dimensional table that we call the Taxonomy Table (see Table 3.1. For convenient reference, it is also reproduced on the inside front cover). The rows and columns of the table contain carefully delineated and defined categories of knowledge and cognitive processes, respectively. The cells of the table are where the knowledge and cognitive process dimensions intersect. Objectives, either explicitly or implicitly, include both knowledge and cognitive processes that can be classified in the Taxonomy framework. Therefore, objectives can be placed in the cells of the table. It should be possible to place any educational objective that has a cognitive emphasis in one or more cells of the table.

CATEGORIES OF THE KNOWLEDGE DIMENSION

After considering the various designations of knowledge types, especially developments in cognitive psychology that have taken place since the original framework's creation, we settled on four general types of knowledge: *Factual, Conceptual, Procedural,* and *Metacognitive.* Table 3.2 summarizes these four major types of knowledge and their associated subtypes.

Factual knowledge is knowledge of discrete, isolated content elements—"bits of information" (p. 45). It includes knowledge of terminology and knowledge of specific details and elements. In contrast, *Conceptual knowledge* is knowledge of "more complex, organized knowledge forms" (p. 48). It includes knowledge of classifications and categories, principles and generalizations, and theories, models, and structures.

Procedural knowledge is "knowledge of how to do something" (p. 52). It includes knowledge of skills and algorithms, techniques and methods, as well as knowledge of the criteria used to determine and/or justify "when to do what" within specific domains and disciplines. Finally, *Metacognitive knowledge* is "knowledge about cognition in general as well as awareness of and knowledge about one's own cognition" (p. 55). It encompasses strategic knowledge; knowledge about cognitive tasks, including contextual and conditional knowledge; and self-knowledge. Of course, certain aspects of metacognitive knowledge are

3.1 The Taxonomy Table

The Knowledge Dimension	The Cognitive Process Dimension					
	1. Remember	2. Understand	3. Apply	4. Analyze	5. Evaluate	6. Create
A. Factual knowledge						
B. Conceptual knowledge						
C. Procedural knowledge						
D. Meta-cognitive knowledge						

3.2 The Major Types and Subtypes of the Knowledge Dimension*

Major Types and Subtypes	Examples
A. Factual knowledge—The basic elements students must know to be acquainted with a discipline or solve problems in it	
Aa. Knowledge of terminology	Technical vocabulary, musical symbols
Ab. Knowledge of specific details and elements	Major natural resources, reliable sources of information
B. Conceptual knowledge—The interrelationships among the basic elements within a larger structure that enable them to function together	
Ba. Knowledge of classifications and categories	Periods of geological time, forms of business ownership
Bb. Knowledge of principles and generalizations	Pythagorean theorem, law of supply and demand
Bc. Knowledge of theories, models, and structures	Theory of evolution, structure of Congress
C. Procedural knowledge—How to do something, methods of inquiry, and criteria for using skills, algorithms, techniques, and methods	
Ca. Knowledge of subject-specific skills and algorithms	Skills used in painting with watercolors, whole-number division algorithm
Cb. Knowledge of subject-specific techniques and methods	Interviewing techniques, scientific method
Cc. Knowledge of criteria for determining when to use appropriate procedures	Criteria used to determine when to apply a procedure involving Newton's second law, criteria used to judge the feasibility of using a particular method to estimate business costs
D. Metacognitive knowledge—Knowledge of cognition in general as well as awareness and knowledge of one's own cognition	
Da. Strategic knowledge	Knowledge of outlining as a means of capturing the structure of a unit of subject matter in a textbook, knowledge of the use of heuristics
Db. Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge	Knowledge of the types of tests particular teachers administer, knowledge of the cognitive demands of different tasks
Dc. Self-knowledge	Knowledge that critiquing essays is a personal strength, whereas writing essays is a personal weakness; awareness of one's own knowledge level

not the same as knowledge that is defined consensually by experts. This issue is discussed in more detail in Chapter 4.

CATEGORIES OF THE COGNITIVE PROCESS DIMENSION

The categories of the cognitive process dimension are intended to provide a comprehensive set of classifications for those student cognitive processes that are included in objectives. As shown in Table 3.1, the categories range from the cognitive processes most commonly found in objectives, those associated with *Remember,* through *Understand* and *Apply,* to those less frequently found, *Analyze, Evaluate,* and *Create. Remember* means to retrieve relevant knowledge from long-term memory. *Understand* is defined as constructing the meaning of instructional messages, including oral, written, and graphic communication. *Apply* means carrying out or using a procedure in a given situation. *Analyze* is breaking material into its constituent parts and determining how the parts are related to one another as well as to an overall structure or purpose. *Evaluate* means making judgments based on criteria and/or standards. Finally, *Create* is putting elements together to form a novel, coherent whole or to make an original product.

Each of the six major categories is associated with two or more specific cognitive processes, 19 in all, also described by verb forms (see Table 3.3). To differentiate the specific cognitive processes from the six categories, the specific cognitive processes take the form of gerunds, ending in "ing." Thus, *recognizing* and *recalling* are associated with *Remember; interpreting, exemplifying, classifying, summarizing, inferring, comparing,* and *explaining* are associated with *Understand; executing* and *implementing* with *Apply;* and so on.

THE TAXONOMY TABLE AND OBJECTIVES: A DIAGRAMMATIC SUMMARY

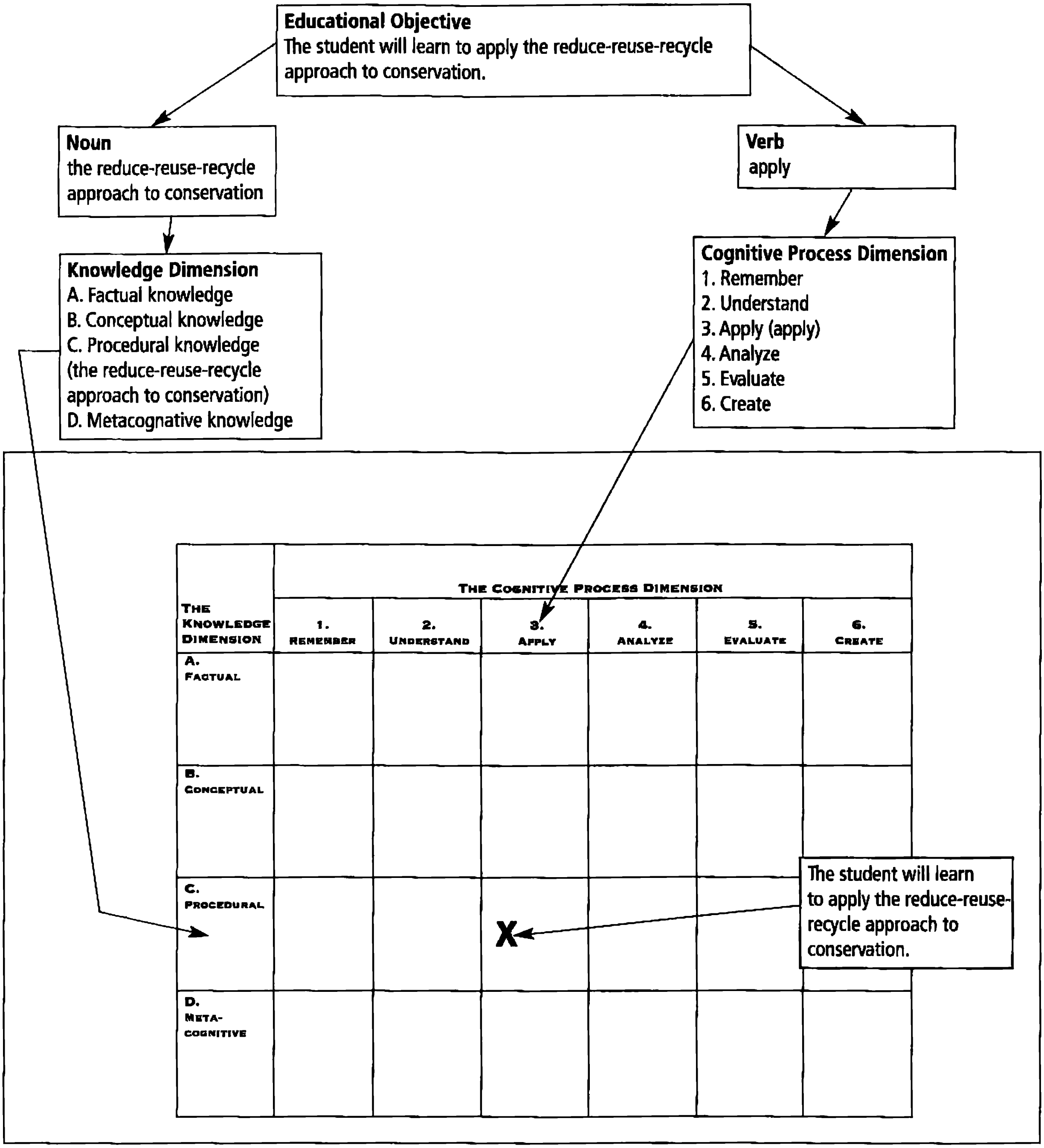
Figure 3.1 depicts the analytic journey from the statement of an objective to its placement in the Taxonomy Table. The journey begins by locating the verb and noun in the objective. The verb is examined in the context of the six categories of the cognitive process dimension: *Remember, Understand, Apply, Analyze, Evaluate,* and *Create.* Placing the verb into the appropriate category is usually facilitated by focusing initially on the 19 specific cognitive processes, rather than on the larger categories. Likewise, the noun is examined in the context of the four types in the knowledge dimension: *Factual, Conceptual, Procedural,* and *Metacognitive.* Again, focusing initially on the subtypes within the knowledge categories typically aids in the proper placement. One can classify the objective as initially stated, as it was taught, and as it was assessed, and ask whether these classifications are aligned. This latter process is illustrated in the vignettes in Chapters 8–13.

Consider the rather straightforward example shown in Figure 3.1: "The student will learn to apply the reduce-reuse-recycle approach to conservation."

3.3 THE SIX CATEGORIES OF THE COGNITIVE PROCESS DIMENSION AND RELATED COGNITIVE PROCESSES*

PROCESS CATEGORIES	COGNITIVE PROCESSES AND EXAMPLES
1. REMEMBER—Retrieve relevant knowledge from long-term memory.	
1.1 RECOGNIZING	(e.g., Recognize the dates of important events in U.S. history)
1.2 RECALLING	(e.g., Recall the dates of important events in U.S. history)
2. UNDERSTAND—Construct meaning from instructional messages, including oral, written, and graphic communication.	
2.1 INTERPRETING	(e.g., Paraphrase important speeches and documents)
2.2 EXEMPLIFYING	(e.g., Give examples of various artistic painting styles)
2.3 CLASSIFYING	(e.g., Classify observed or described cases of mental disorders)
2.4 SUMMARIZING	(e.g., Write a short summary of the events portrayed on videotapes)
2.5 INFERRING	(e.g., In learning a foreign language, infer grammatical principles from examples)
2.6 COMPARING	(e.g., Compare historical events to contemporary situations)
2.7 EXPLAINING	(e.g., Explain the causes of important eighteenth-century events in France)
3. APPLY—Carry out or use a procedure in a given situation.	
3.1 EXECUTING	(e.g., Divide one whole number by another whole number, both with multiple digits)
3.2 IMPLEMENTING	(e.g., Determine in which situations Newton's second law is appropriate)
4. ANALYZE—Break material into constituent parts and determine how parts relate to one another and to an overall structure or purpose.	
4.1 DIFFERENTIATING	(e.g., Distinguish between relevant and irrelevant numbers in a mathematical word problem)
4.2 ORGANIZING	(e.g., Structure evidence in a historical description into evidence for and against a particular historical explanation)
4.3 ATTRIBUTING	(e.g., Determine the point of view of the author of an essay in terms of his or her political perspective)
5. EVALUATE—Make judgments based on criteria and standards.	
5.1 CHECKING	(e.g., Determine whether a scientist's conclusions follow from observed data)
5.2 CRITIQUING	(e.g., Judge which of two methods is the best way to solve a given problem)
6. CREATE—Put elements together to form a coherent or functional whole; reorganize elements into a new pattern or structure.	
6.1 GENERATING	(e.g., Generate hypotheses to acount for an observed phenomenon)
6.2 PLANNING	(e.g., Plan a research paper on a given historical topic)
6.3 PRODUCING	(e.g., Build habitats for certain species for certain purposes)

FIGURE 3.1 HOW AN OBJECTIVE (THE STUDENT WILL LEARN TO APPLY THE REDUCE-REUSE-RECYCLE APPROACH TO CONSERVATION) IS CLASSIFIED IN THE TAXONOMY TABLE



The verb is "apply." Since *Apply* is one of the six cognitive process categories, we have to look no further than the six categories in this example. The noun phrase is "the reduce-reuse-recycle approach to conservation." An approach is a method or technique, and in Table 3.2 methods and techniques are associated with *Procedural knowledge.* Thus, this objective is placed in the cell corresponding to the intersection of *Apply* and *Procedural knowledge.*

Unfortunately, classifying objectives is often more difficult than this example suggests. There are two reasons for this difficulty. The first is that statements of objectives may contain more than verbs and nouns. In the objective "The student will be able to give examples of the law of supply and demand in the local community," for example, the phrase "in the local community" is extraneous for our classification. The verb is "exemplify" (i.e., "to give examples") and the noun phrase is "the law of supply and demand." The phrase "in the local community" establishes the conditions within which the examples must be selected.

Consider a third objective: "The student will be able to produce original works that meet the criteria of appropriate oral and written forms." The verb is "produce" and the noun is "criteria." The phrase "of appropriate oral and written forms" simply clarifies the meaning of "criteria." So, modifying phrases or clauses should be ignored in classifying the objective; they may cause confusion when one is attempting to identify relevant parts for categorizing.

The second reason for the difficulty in classifying objectives is that the verb may be ambiguous in terms of the intended cognitive process or the noun may be ambiguous in its intended knowledge. Consider the following objective: "The student will learn to describe changes in matter and the causes of those changes." "Describe" can mean many things. Students can describe what they have recalled, interpreted, explained, or generated. *Recalling, interpreting, explaining,* and *generating* are quite different processes. One would have to infer which process the teacher intended in order to classify the objective.

Similarly, in some statements of objectives, the noun tells us little if anything about the relevant knowledge. This is a particular problem with objectives that address more complex cognitive processes. Consider the following objective: "The student will be able to evaluate editorials in newspapers and news magazines." The verb is "evaluate," and the noun phrase is "editorials in newspapers and news magazines." As we discussed in Chapter 2, editorials are curricular or instructional materials, not knowledge. In this case, the knowledge is implicit—namely, the criteria students should use to evaluate the editorials (e.g., presence or absence of bias, clarity of point of view, logic of the argument). So, the objective should be classified as *Evaluate* and *Conceptual knowledge.*

It should now be evident that the people who are classifying objectives must make inferences. Consider the following two objectives; the first is rather straightforward, and the second requires more inference.

The first objective is "The student should be able to plan a unit of instruction for a particular teaching situation" (*Handbook,* p. 171). This objective combines the unit plan (the noun) with the act of planning (the verb). Where does this objective fit in the Taxonomy Table? Plans are *models* that guide future actions. Referring back to Table 3.2, we see that "models" appears in the third subtype of *Conceptual knowledge,* the second row of the Taxonomy Table (i.e., row B). Referring to Table 3.3, we see that "planning" is the second cognitive process within *Create,* the sixth column of the Taxonomy Table (i.e., column 6). Our analysis suggests that the objective falls into the cell corresponding to the intersection of row B, *Conceptual knowledge,* and column 6, *Create.* This objective, then, has to do with students *creating conceptual knowledge.*

The second objective is "The student should be able to recognize the point of view or bias of a writer of a historical account" (*Handbook,* p. 148). In this case, the noun is "historical account." Like textbooks and essays, a historical account is best considered curricular or instructional material. The question remains, then, what type of knowledge is involved. We suggest two possibilities: *Factual knowledge* or *Conceptual knowledge.* Which type it is depends on (1) the structure of the account, (2) the way the account is "introduced" to the students, or most likely (3) some combination of these. The verb phrase is "recognize the point of view or bias." The verb is *not* "recognize." If it were "recognize," we would place it in the category *Remember.* However, the act of recognizing (i.e., determining) a point of view or bias defines the cognitive process *attributing* (see Table 3.3). *Attributing* is associated with *Analyze,* a category at a much higher level of complexity. So we place the objective somewhere in the fourth column, *Analyze.* Since the knowledge could be either of two types, *Factual knowledge* or *Conceptual knowledge,* we place the objective in two cells, one corresponding to the intersection of *Analyze* and *Factual knowledge* (cell A4) and the other to the intersection of *Analyze* and *Conceptual knowledge* (cell B4).

To confuse matters even further, the teacher could teach students **how to** recognize points of view or biases, and this would be *Procedural knowledge.* Since students would be expected to **use** the *Procedural knowledge* (as taught to them) with the historical account, the cognitive process category would likely shift from *Analyze* to *Apply.* Now the objective would be placed in cell C3.

In summary, then, the Taxonomy Table can be used to categorize objectives, provided that the person or persons doing the categorization make correct inferences. Because inference is involved and because each person may have access to different information, individuals may disagree about the correct classification of an objective. As seen throughout this chapter, the most obvious source of information is the objective as stated, but the stated objective and the objective as taught and assessed may differ. So, other sources of information to be considered are observations of classrooms, examinations of test items and other assessment tasks, and discussions with or among teachers. From our experience, using multiple sources of information is likely to result in the most valid, defensible classification of objectives.

WHY CATEGORIZE OBJECTIVES?

Why would anyone want to categorize objectives? What is the point of using our framework to guide the classification? We offer six answers to these questions. The first is that *categorization within our framework permits educators to examine objectives from the student's point of view.* What is it that students must know and be able to do in order to achieve a particular objective? Will a "grocery list" of discrete facts suffice (*Factual knowledge*), or do students need some cohesive structure that holds these facts together (*Conceptual knowledge*)? Do students need to be able to classify (*Understand*), to differentiate (*Analyze*), or to do both? We typically ask these questions as we work with objectives within our framework in an attempt to answer the "learning question" (see Chapter 1).

Our second answer is that *categorization within our framework helps educators consider the panorama of possibilities in education.* This was one of the primary values of the original *Handbook,* raising the possibility of teaching for so-called higher-order objectives. Our revision adds the possibility and desirability of objectives that emphasize *Metacognitive knowledge.* Metacognitive knowledge is empowering to students and is an important basis for "learning how to learn" (Bransford, Brown, and Cocking, 1999). Classifying objectives for this purpose once again helps us address the "learning question."

The third answer is that *categorization within our framework helps educators see the integral relationship between knowledge and cognitive processes inherent in objectives.* Can students realistically be expected to *apply factual knowledge,* or is it easier for them if they are helped to *understand procedural knowledge* before they attempt to apply it? Can students learn to *understand conceptual knowledge* by having them *analyze factual knowledge*? These are the types of questions we ask as we struggle to answer the "instruction question."

Our fourth answer to the question of why anyone would want to categorize objectives is consistent with the original *Handbook: It makes life easier!* With the Taxonomy in place, examiners do not have to approach every objective as a unique entity. Rather, they can say to themselves, "Oh, this is an analysis objective. I know how to write examination items for analysis objectives." They can pull out their "templates" (the sample test items in the *Handbook*) and, with modifications dictated by differences in subject matters, write several items in a fairly short time. Thus, by classifying objectives we are more able to deal with the "assessment question."

Likewise, we expect those who use the Taxonomy Table to come to a common realization: "Oh, this is an objective that emphasizes *understanding conceptual knowledge.* I know how to teach for *Conceptual knowledge* objectives. I could focus on critical attributes of the concept. For many kinds of *Conceptual knowledge,* I could include examples and nonexamples. I may want to embed a particular concept within a larger conceptual framework and discuss similarities and differences within the framework." Similar statements can be made for assessment: "I could design assessment tasks that require students to *exemplify* and *classify.* I need to ensure that the assessment tasks are not identical to those in the textbook or those I used during class." So, once again, classifying objectives helps us deal with the "instruction and assessment questions."

Our fifth answer is that *categorization makes more readily apparent the consistency, or lack of it, among the stated objectives for a unit, the way it was taught, and how learning was assessed.* Comparisons of the categorizations based on stated objectives, instructional activities, and assessment tasks show whether these phases of the educational experience are congruent with one another both in their nature and in their relative emphasis. An important caveat was suggested, however, by a teacher, Melody Shank, who reviewed an earlier draft of our revision (personal communication, 1998):

> I can imagine teachers fretting over whether they placed their objectives, activities, and assessments in the proper cell . . . instead of thoughtfully examining their implicit and explicit objectives, planned activities, and assessments. Becoming aware of whether their planned activities are aligned with their intended (stated or intuited) objectives and how they might adjust those activities is the important activity, not whether they have each component instructional part in the proper cell. . . . I would want teachers to have thoughtful, productive discussion throughout the analysis, rather than arguments about the proper placement of the items in the table.

This comment states well the emphasis that we place on the use of the Taxonomy Table and that will be exemplified in the later analysis of the vignettes. So, classifying objectives helps educators deal with the "alignment question."

The sixth and final answer is that *categorization within our framework helps educators make better sense of the wide variety of terms that are used in education.* Our 19 cognitive processes have very specific meanings. *Inferring* requires that students recognize some pattern in the information given, whereas *explaining* requires a search for causality in that pattern. *Implementing* requires adjusting a process to a new situation; *executing* does not. *Generating* requires divergent thinking, whereas *organizing* requires convergence. *Checking* concerns internal consistency; *critiquing,* consistency with external criteria. To the extent that we can associate other words and terms with our framework, then, we increase their level of precision. With increased precision comes the likelihood for better communication.

Our Use of Multiple Forms of Definition

To be useful, the definitions of the knowledge types and subtypes and the process categories and specific cognitive processes must be understood clearly and precisely. Since multiple kinds of definition tend to contribute to greater understanding, we present four definitional forms in the chapters that follow: verbal descriptions, sample objectives, sample assessment tasks, and sample instructional activities.

Verbal Descriptions

Verbal descriptions are similar to good dictionary definitions. Furthermore, "the exact phrasing of these definitions has been the subject of much debate among us and while the present definitions are far from ideal, every effort has been made to describe the major aspects of each category as carefully as possible" (*Handbook,* p. 44). That statement made by the original group applies to this volume as well. The verbal descriptions are given in Chapters 4 and 5.

Sample Objectives

Sample objectives provide a second means of understanding the categories. The sources of the sample objectives are attributed where they appear. Some were taken from publicly available statements, like those of *Goals 2000* and of the National Council of Teachers of Mathematics, because they typify objectives of interest and concern to many teachers at present. Teachers' editions of textbooks, test publishers' manuals, and vignettes prepared by teachers (see Section III) were additional sources.

Sample Assessment Tasks

The sample assessment tasks in Chapter 5 and the assessments in the vignettes provide yet another means of understanding the categories in our framework. The tasks were chosen to illustrate some ways of assessing combinations of knowledge and cognitive processes. Some people consider the means used to assess learning as the "real" goals of instruction because, regardless of fancy statements, the concrete representation of objectives in tests and other assessments often determines what students study as well as how they study it.

Sample Instructional Activities

The illustrative instructional activities in the vignettes offer our fourth and final way of understanding the categories of the framework. These vignettes provide additional examples of both knowledge and cognitive processes and, perhaps more important, their interplay. In addition to aiding in the understanding of the categories, the vignettes are designed to make the Taxonomy Table more useful and usable for teachers, teacher educators, curriculum developers, assessment specialists, and educational administrators.

Closing Comment: A Look Ahead

Having examined the classification of objectives in the Taxonomy Table, we now turn to a detailed examination of the two dimensions that make up the table: knowledge and cognitive process. The four types of knowledge together with their subtypes are described in Chapter 4. The six major cognitive process categories and the 19 cognitive processes that help define them are described in Chapter 5.

The Knowledge Dimension

Current conceptions of learning focus on the active, cognitive, and constructive processes involved in meaningful learning. Learners are assumed to be active agents in their own learning; they select the information to which they will attend and construct their own meaning from this selected information. Learners are not passive recipients, nor are they simple recorders of information provided to them by parents, teachers, textbooks, or media. This move away from passive views of learning toward more cognitive and constructivist perspectives emphasizes what learners **know** (knowledge) and **how they think** (cognitive processes) about what they know as they actively engage in meaningful learning.

In instructional settings, learners are assumed to construct their own meaning based on their prior knowledge, their current cognitive and metacognitive activity, and the opportunities and constraints they are afforded in the setting, including the information that is available to them. Learners come into any instructional setting with a broad array of knowledge, their own goals, and prior experiences in that setting, and they use all of these to "make sense" of the information they encounter. This constructivist process of "making sense" involves the activation of prior knowledge as well as various cognitive processes that operate on that knowledge.

It is important to keep in mind that students can and often do use the information available to them to construct meanings that do not coincide with authentic aspects of reality or with well-accepted, normative conceptions of the information. In fact, much of the literature on conceptual change and student learning is concerned with how students come to construct conceptions of everyday phenomena, such as heat, temperature, and gravity, that **do not** match the commonly accepted scientific knowledge and models of these phenomena. Of course, there are different stances to take on these "personal" conceptions, "naive" conceptions, or "misconceptions." In our opinion, educators should guide students toward the authentic and normative conceptions that reflect the most commonly accepted and best current knowledge and thinking in the academic disciplines and subject matter areas.

Accordingly, we are fully aware that students and teachers construct their own meanings from instructional activities and classroom events and that their own constructions of the subject matter content may differ from authentic or normative conceptions. Nevertheless, adopting this cognitive and constructivist perspective does not imply that there is no knowledge worth learning or that all knowledge is of equal worth. Teachers can, do, and should make decisions about what is worth teaching in their classrooms. As we pointed out in Chapters 1 and 2, a key question concerns what students should learn in school. Educational objectives offer teachers some guidance as they try to determine what to teach.

The four types of knowledge described in this chapter can help educators distinguish what to teach. They are designed to reflect the intermediate level of specificity associated with educational objectives. As such, their level of generality allows them to be applied to all grade levels and subject matters. Of course, some grade levels or subject matters may be more likely to have a greater number of objectives that can be classified as, say, *Conceptual knowledge.* This is most likely a function of the content of the subject matter, beliefs about students and the way they learn, the way in which the subject matter is viewed by the teacher, or some combination of these factors. Nonetheless, we argue that the four types of knowledge included in our framework are useful for thinking about teaching in a wide variety of subject matters as well as at different grade levels.

A Distinction Between Knowledge and Subject Matter Content: A Tale of Four Teachers

We begin by illustrating the important distinction between knowledge and content made on pages 12–13. The example involves four teachers—Mrs. Patterson, Ms. Chang, Mr. Jefferson, and Mrs. Weinberg—and their educational objectives for a unit on *Macbeth.* Each has a different perspective on what students should learn during the unit. Of course, all four teachers have multiple educational objectives, but the example highlights how these teachers focus on objectives that reflect different types of knowledge.

Mrs. Patterson believes that her students should know the names of the characters in the play and the readily apparent relationships among them (e.g., Macbeth and MacDuff were enemies). Students should know the details of the plot, and they should know which characters said what, even to the point that they can recite certain important passages from memory. Because Mrs. Patterson focuses on the specific details and elements of *Macbeth,* in the language of the Taxonomy Table she seems to be concerned with *Factual knowledge.*

Ms. Chang believes that *Macbeth* enables students to learn about important concepts such as ambition, tragic hero, and irony. She also is interested in having her students know how these ideas are related to one another. For example, what role does ambition play in the development of a tragic hero? Ms. Chang believes that a focus on these ideas and their relationships makes *Macbeth* come alive to her students by allowing them to make connections between the actual play and these different concepts that can be applied to understanding the human condition. In terms of the Taxonomy Table, she is concerned with *Conceptual knowledge.*

Mr. Jefferson believes that *Macbeth* is but one of many plays that could be included in the English literature curriculum. His goal is to use *Macbeth* as a vehicle for teaching students how to think about plays in general. Toward this end, he has developed a general approach that he wants students to use as they read a play. The approach begins by having the class discuss the plot, then examine the relationships among the characters, then discern the messages being conveyed by the playwright, and finally consider the way the play was written and its cultural context. Given that these four general steps make up a procedure that can be applied to all plays, not just *Macbeth,* Mr. Jefferson seems to be focused on applying *Procedural knowledge,* in the language of the Taxonomy Table.

Like Mr. Jefferson, Mrs. Weinberg sees *Macbeth* as one of many plays that students will encounter in high school as well as beyond. She also wants her students to learn a set of general procedures or "tools" they can use to study, understand, analyze, and appreciate other plays. However, Mrs. Weinberg is also concerned that students do not just apply or use these tools in a rote or mechanical fashion. She wants her students to "think about what they are doing as they do it," to be self-reflective and metacognitive about how they are using these tools. For example, she wants them to note any problems they have in using the procedures (e.g., confusing plot with character development) and learn from these problems. Finally, she hopes that students will learn something about themselves, perhaps their own ambitions or their own strengths and weaknesses, by identifying with the characters in the play. In the language of the Taxonomy Table, Mrs. Weinberg is concerned with *Metacognitive knowledge.*

In all four examples the content of the play is the same. However, the four teachers use this content in different ways to focus on varied objectives that emphasize different types of knowledge. All subject matters are composed of specific content, but how this content is structured by teachers in terms of their objectives and instructional activities results in different types of knowledge being emphasized in the unit. Accordingly, how teachers set their educational objectives, organize their instruction to meet these objectives, and even assess student learning of the objectives results in different outcomes, even when the content is ostensibly the same.

Different Types of Knowledge

The problem of how to characterize knowledge and how individuals represent knowledge is a classic and enduring question in philosophy and psychology. It is well beyond the scope of this chapter to survey all the different philosophical positions and psychological theories and models of knowledge. Our general perspective is informed by current perspectives in cognitive science and cognitive psychology on knowledge representation. We do not adhere to a simple behaviorist view that knowledge is best represented as an accumulation of associations between stimuli and responses (although some surely is) or merely a quantitative increase in bits of information (a hallmark of the empiricist tradition—see Case, 1998; Keil, 1998). Rather, our perspective reflects the idea that knowledge is organized and structured by the learner in line with a rationalist-constructivist tradition. Reflecting recent cognitive and developmental psychological research (e.g., Case, 1998), however, we also do not adhere to the idea that knowledge is organized in "stages" or in system-wide logical structures as in traditional developmental stage models of thinking (e.g., Piagetian models).

Based on cognitive science research on the development of expertise, expert thinking, and problem solving, our perspective is that knowledge is domain specific and contextualized. Our understanding of knowledge should reflect this domain specificity and the role that social experiences and context play in the construction and development of knowledge (Bereiter and Scardamalia, 1998; Bransford, Brown, and Cocking, 1999; Case, 1998; Keil, 1998; Mandler, 1998; Wellman and Gelman, 1998).

There are many different types of knowledge and seemingly even more terms used to describe them. In alphabetical order, some of the terms are: conceptual knowledge, conditional knowledge, content knowledge, declarative knowledge, disciplinary knowledge, discourse knowledge, domain knowledge, episodic knowledge, explicit knowledge, factual knowledge, metacognitive knowledge, prior knowledge, procedural knowledge, semantic knowledge, situational knowledge, sociocultural knowledge, strategic knowledge, and tacit knowledge (see, for example, Alexander, Schallert, and Hare, 1991; deJong and Ferguson-Hessler, 1996; Dochy and Alexander, 1995; Ryle, 1949).

Some of the different terms signify important differences among the varieties of knowledge, whereas others are apparently just different labels for the same knowledge category. Later in this chapter we point out that the distinction between "important differences" and "different labels" is central to the different types and subtypes of knowledge in the revised Taxonomy. Given the many different terms and the lack of agreement about the many aspects of the knowledge dimension, it is a difficult task to develop a taxonomy of knowledge that captures the complexity and comprehensiveness of our knowledge base while being relatively simple, practical, and easy to use, as well as maintaining some parsimony in the number of categories. In considering these multiple constraints, we arrived at our four general types of knowledge: (1) *Factual Knowledge*, (2) *Conceptual Knowledge*, (3) *Procedural Knowledge*, and (4) *Metacognitive Knowledge*.

In the next major section of this chapter we define all four types of knowledge along with their associated subtypes. First, however, we give our reasons for including both factual and conceptual knowledge and for including metacognitive knowledge.

A Distinction Between Factual and Conceptual Knowledge

In cognitive psychology, declarative knowledge is usually defined in terms of "knowing that": *knowing that* Bogota is the capital of Colombia, or *knowing that* a square is a two-dimensional figure with four perpendicular sides of equal length. This knowledge can be (1) specific content elements such as terms and facts or (2) more general concepts, principles, models, or theories (Alexander, Schallert, and Hare, 1991; Anderson, 1983; deJong and Ferguson-Hessler, 1996; Dochy and Alexander, 1995). In the revised Taxonomy, we wanted to distinguish knowledge of discrete, isolated content elements (i.e., terms and facts) from knowledge of larger, more organized bodies of knowledge (i.e., concepts, principles, models, or theories).

This differentiation parallels a general distinction in cognitive psychology between the knowledge of "bits of information" and more general "mental models," "schemas," or "theories" (implicit or explicit) that individuals may use to help them organize a body of information in an interconnected, nonarbitrary, and systematic manner. Accordingly, we have reserved the term *Factual Knowledge* for the knowledge of discrete, isolated "bits of information" and the term *Conceptual Knowledge* for more complex, organized knowledge forms. We think this is an important distinction for teachers and other educators to make.

Moreover, research has shown that many students do not make the important connections between and among the facts they learn in classrooms and the larger system of ideas reflected in an expert's knowledge of a discipline. Although developing expertise in an academic discipline and disciplinary ways of thinking is certainly an important goal of education, students often do not even learn to transfer or apply the facts and ideas they learn in classrooms to understanding their experiences in the everyday world. This is often labeled the problem of "inert" knowledge; that is, students often seem to acquire a great deal of factual knowledge, but they do not understand it at a deeper level or integrate or systematically organize it in disciplinary or useful ways (Bereiter and Scardamalia, 1998; Bransford, Brown, and Cocking, 1999).

One of the hallmarks of experts is that not only do they know a lot about their discipline, but also their knowledge is organized and reflects a deep understanding of the subject matter. In combination, *Conceptual knowledge* and deep understanding can help individuals as they attempt to transfer what they have learned to new situations, thereby overcoming some of the problems of inert knowledge (Bransford, Brown, and Cocking, 1999).

Accordingly, on both empirical and practical grounds, we distinguish between *Factual knowledge* and *Conceptual knowledge*. The distinction may not be appropriate in terms of formal psychological models of knowledge representation (e.g., propositional network models or connectionist models), but we do think it has meaning for classroom instruction and assessment. Educational objectives can focus both the teacher and students on acquiring small bits and pieces of knowledge without concern for how they "fit" within a larger disciplinary or more systematic perspective. By separating *Factual knowledge* from *Conceptual knowledge*, we highlight the need for educators to teach for deep understanding of *Conceptual knowledge*, not just for remembering isolated and small bits of *Factual knowledge*.

A Rationale for Metacognitive Knowledge

Our inclusion of *Metacognitive knowledge* reflects recent research on how students' **knowledge** about their own cognition and **control** of their own cognition play an important role in learning (Bransford, Brown, and Cocking, 1999; Sternberg, 1985; Zimmerman and Schunk, 1998). Although behaviorist psychology models generally excluded ideas such as consciousness, awareness, self-reflection, self-regulation, and thinking about and controlling one's own thinking and learning, current cognitive and social constructivist models of learning emphasize the importance of these activities. Because these activities focus on cognition itself, the prefix *meta* is added to reflect the idea that metacognition is about or "above" or "transcends" cognition. Social constructivist models also stress self-reflective activity as an important aspect of learning. In this case, both cognitive and social constructivist models agree about the importance of facilitating students' thinking about their own thinking. Accordingly, we have added this new category to the Taxonomy to reflect current research and theory on the importance of metacognitive knowledge in learning.

The term *metacognition* has been used in many different ways, but an important general distinction concerns two aspects of metacognition: (1) **knowledge about cognition** and (2) **control, monitoring, and regulation of cognitive processes.** The latter is also called metacognitive control and regulation as well as more generally, self-regulation (Boekaerts, Pintrich, and Zeidner, 2000; Bransford, Brown, and Cocking, 1999; Brown, Bransford, Ferrara, and Campione, 1983; Pintrich, Wolters, and Baxter, in press; Zimmerman and Schunk, 1998). This basic distinction between metacognitive knowledge and metacognitive control or self-regulation parallels the two dimensions in our Taxonomy Table. Accordingly, we have limited *Metacognitive knowledge* to knowledge about cognition. The aspect of metacognition that involves metacognitive control and self-regulation reflects different types of cognitive processes and therefore fits into the cognitive process dimension, which is discussed in Chapter 5.

Metacognitive knowledge includes knowledge of general strategies that may be used for different tasks, the conditions under which these strategies may be used, the extent to which the strategies are effective, and self-knowledge (Bransford, Brown, and Cocking, 1999; Flavell, 1979; Pintrich, Wolters, and Baxter, in press; Schneider and Pressley, 1997). For example, learners can know about different strategies for reading a chapter in a textbook and also about strategies to monitor and check their comprehension as they read. Learners also activate relevant knowledge about their own strengths and weaknesses on the reading assignment as well as their motivation for completing the assignment. For example, students may realize that they already know a fair amount about the topic of the chapter in the textbook and that they are interested in the topic. This *Metacognitive knowledge* could lead them to change their approach to the task by adjusting their speed or using an entirely different approach.

Learners also can activate the relevant situational, conditional, or cultural knowledge for solving a problem in a certain context (e.g., in this classroom, on this type of test, in this type of situation, in this subculture). For example, they may know that the teacher uses only multiple-choice tests. Furthermore, they know that multiple-choice tests require only recognition of the correct answers, not actual recall of the information as in essay tests. This *Metacognitive knowledge* might influence how they prepare for the test.

During the meetings that led to the preparation of this revised Taxonomy, we discussed frequently and in great detail both the inclusion and proper placement of *Metacognitive knowledge*. Our inclusion of *Metacognitive knowledge* is predicated on our belief that it is extremely important in understanding and facilitating learning, a belief that is consistent with the basic precepts of cognitive psychology and supported by empirical research (Bransford, Brown, and Cocking, 1999). Just as the original Taxonomy raised the possibility of teaching for "higher-order" objectives, our revised framework points to the possibility of teaching for *Metacognitive knowledge* as well as self-regulation.

In terms of proper placement, we debated several issues. Should *Metacognitive knowledge* be a separate dimension, thus producing a three-dimensional figure? Should the focus of *Metacognitive knowledge* be on metacognitive processes and self-regulation rather than knowledge and, if so, wouldn't it be better placed along the Cognitive Process dimension of the Taxonomy Table? Doesn't *Metacognitive knowledge* overlap with *Factual, Conceptual*, and *Procedural knowledge* and, if so, isn't it redundant? These are legitimate questions we grappled with for a long time.

We chose to place *Metacognitive knowledge* as a fourth knowledge category for two primary reasons. First, metacognitive control and self-regulation require the use of the cognitive processes included on the other dimension of the Taxonomy Table. Metacognitive control and self-regulation involve processes such as *Remember, Understand, Apply, Analyze, Evaluate*, and *Create*. Thus, adding metacognitive control and self-regulation processes to the cognitive process dimension was seen as redundant. Second, *Factual, Conceptual*, and *Procedural knowledge* as conceived in the original Taxonomy pertain to subject matter content. In contrast, *Metacognitive knowledge* is knowledge of cognition and about oneself in relation to various subject matters, either individually or collectively (e.g., all sciences, academic subjects in general).

Of course, *Metacognitive knowledge* does not have the same status as the other three types of knowledge. We noted earlier that these types of knowledge were developed through consensus within a scientific or disciplinary community. This is clearly not the case with *self-knowledge* (Dc), which is based on an individual's own self-awareness and knowledge base. *Strategic knowledge* (Da) and *knowledge about cognitive tasks* (Db) have been developed within different communities. For example, cognitive psychology has developed a wealth of information on the usefulness of different cognitive strategies for memory, learning, thinking, and problem solving. When students come to know and understand metacognitive knowledge about strategies that is based on scientific research, they may be better prepared than when they rely on their own idiosyncratic strategies for learning.

Categories of the Knowledge Dimension

Four types of knowledge are listed in Table 4.1. The first three categories of our revised framework include all the knowledge categories from the original Taxonomy (see Appendix B). Some of the labels are different, however, and some of the original subtypes are collapsed into more general categories. Moreover, reflecting the prescient nature of the original *Handbook*, much of the text and many of the examples in the sections that follow are taken from the original *Handbook*. Finally, as we mentioned earlier, the fourth category, *Metacognitive knowledge*, and its subtypes are all new.

A. Factual Knowledge

Factual knowledge encompasses the basic elements that experts use in communicating about their academic discipline, understanding it, and organizing it systematically. These elements are usually serviceable to people who work in the discipline in the very form in which they are presented; they need little or no alteration from one use or application to another. *Factual knowledge* contains the basic elements students must know if they are to be acquainted with the discipline or to solve any of the problems in it. The elements are usually symbols associated with some concrete referents, or "strings of symbols" that convey important information. For the most part, *Factual knowledge* exists at a relatively low level of abstraction.

Because there is a tremendous wealth of these basic elements, it is almost inconceivable that a student could learn all of them relevant to a particular subject matter. As our knowledge increases in the social sciences, sciences, and humanities, even experts in these fields have difficulty keeping up with all the new elements. Consequently, some selection for educational purposes is almost always required. For classification purposes, *Factual knowledge* may be distinguished from *Conceptual knowledge* by virtue of its very specificity; that is, *Factual knowledge* can be isolated as elements or bits of information that are believed to have some value in and of themselves. The two subtypes of *Factual knowledge* are *knowledge of terminology* (Aa) and *knowledge of specific details and elements* (Ab).

Aa. Knowledge of Terminology

Knowledge of terminology includes knowledge of specific verbal and nonverbal labels and symbols (e.g., words, numerals, signs, pictures). Each subject matter contains a large number of labels and symbols, both verbal and nonverbal, that have particular referents. They are the basic language of the discipline—the shorthand used by experts to express what they know. In any attempt by experts to communicate with others about phenomena within their discipline, they find it necessary to use the special labels and symbols they have devised. In many cases it is impossible for experts to discuss problems in their discipline without making use of essential terms. Quite literally, they are unable to even think about many of the phenomena in the discipline unless they use these labels and symbols.

4.1 The Knowledge Dimension

Major Types and Subtypes	Examples
A. Factual knowledge—The basic elements students must know to be acquainted with a discipline or solve problems in it	
Aa. Knowledge of terminology	Technical vocabulary, musical symbols
Ab. Knowledge of specific details and elements	Major natural resources, reliable sources of information
B. Conceptual knowledge—The interrelationships among the basic elements within a larger structure that enable them to function together	
Ba. Knowledge of classifications and categories	Periods of geological time, forms of business ownership
Bb. Knowledge of principles and generalizations	Pythagorean theorem, law of supply and demand
Bc. Knowledge of theories, models, and structures	Theory of evolution, structure of Congress
C. Procedural knowledge—How to do something, methods of inquiry, and criteria for using skills, algorithms, techniques, and methods	
Ca. Knowledge of subject-specific skills and algorithms	Skills used in painting with watercolors, whole-number division algorithm
Cb. Knowledge of subject-specific techniques and methods	Interviewing techniques, scientific method
Cc. Knowledge of criteria for determining when to use appropriate procedures	Criteria used to determine when to apply a procedure involving Newton's second law, criteria used to judge the feasibility of using a particular method to estimate business costs
D. Metacognitive knowledge—Knowledge of cognition in general as well as awareness and knowledge of one's own cognition	
Da. Strategic knowledge	Knowledge of outlining as a means of capturing the structure of a unit of subject matter in a text-book, knowledge of the use of heuristics
Db. Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge	Knowledge of the types of tests particular teachers administer, knowledge of the cognitive demands of different tasks
Dc. Self-knowledge	Knowledge that critiquing essays is a personal strength, whereas writing essays is a personal weakness; awareness of one's own knowledge level

The novice learner must be cognizant of these labels and symbols and learn the generally accepted referents that are attached to them. As the expert must communicate with these terms, so must those learning the discipline have a knowledge of the terms and their referents as they attempt to comprehend or think about the phenomena of the discipline.

Here, to a greater extent than in any other category of knowledge, experts find their own labels and symbols so useful and precise that they are likely to want the learner to know more than the learner really needs to know or can learn. This may be especially true in the sciences, where attempts are made to use labels and symbols with great precision. Scientists find it difficult to express ideas or discuss particular phenomena with the use of other symbols or with "popular" or "folk knowledge" terms more familiar to a lay population.

Examples of Knowledge of Terminology

- Knowledge of the alphabet
- Knowledge of scientific terms (e.g., labels for parts of a cell, names for subatomic particles)
- Knowledge of the vocabulary of painting
- Knowledge of important accounting terms
- Knowledge of the standard representational symbols on maps and charts
- Knowledge of the symbols used to indicate the correct pronunciation of words

Ab. Knowledge of Specific Details and Elements

Knowledge of specific details and elements refers to knowledge of events, locations, people, dates, sources of information, and the like. It may include very precise and specific information, such as the exact date of an event or the exact magnitude of a phenomenon. It may also include approximate information, such as a time period in which an event occurred or the general order of magnitude of a phenomenon. Specific facts are those that can be isolated as separate, discrete elements in contrast to those that can be known only in a larger context.

Every subject matter contains some events, locations, people, dates, and other details that experts know and believe to represent important knowledge about the field. Such specific facts are basic information that experts use in describing their field and in thinking about specific problems or topics in the field. These facts can be distinguished from terminology, in that terminology generally represents the conventions or agreements within a field (i.e., a common language), whereas facts represent findings arrived at by means other than consensual agreements made for purposes of communication. Subtype Ab also includes knowledge about particular books, writings, and other sources of information on specific topics and problems. Thus, knowledge of a specific fact and knowledge of the sources of the fact are classified in this subtype.

Again, the tremendous number of specific facts forces educators (e.g., curriculum specialists, textbook authors, teachers) to make choices about what is basic and what is of secondary importance or of importance primarily to the expert. Educators must also consider the level of precision with which different facts must be known. Frequently educators may be content to have a student learn only the approximate magnitude of the phenomenon rather than its precise quantity or to learn an approximate time period rather than the precise date or time of a specific event. Educators have considerable difficulty determining whether many of the specific facts are such that students should learn them as part of an educational unit or course, or they can be left to be acquired whenever they really need them.

Examples of Knowledge of Specific Details and Elements

- Knowledge of major facts about particular cultures and societies
- Knowledge of practical facts important to health, citizenship, and other human needs and concerns
- Knowledge of the more significant names, places, and events in the news
- Knowledge of the reputation of a given author for presenting and interpreting facts on governmental problems
- Knowledge of major products and exports of countries
- Knowledge of reliable sources of information for wise purchasing

B. Conceptual Knowledge

Conceptual knowledge includes knowledge of categories and classifications and the relationships between and among them—more complex, organized knowledge forms. *Conceptual knowledge* includes schemas, mental models, or implicit or explicit theories in different cognitive psychological models. These schemas, models, and theories represent the knowledge an individual has about how a particular subject matter is organized and structured, how the different parts or bits of information are interconnected and interrelated in a more systematic manner, and how these parts function together. For example, a mental model for why the seasons occur may include ideas about the earth, the sun, the rotation of the earth around the sun, and the tilt of the earth toward the sun at different times during the year. These are not just simple, isolated facts about the earth and sun but rather ideas about the relationships between them and how they are linked to the seasonal changes. This type of conceptual knowledge might be one aspect of what is termed "disciplinary knowledge," or the way experts in the discipline think about a phenomenon—in this case the scientific explanation for the occurrence of the seasons.

Conceptual knowledge includes three subtypes: *knowledge of classifications and categories* (Ba), *knowledge of principles and generalizations* (Bb), and *knowledge of theories, models, and structures* (Bc). Classifications and categories form the basis for principles and generalizations. These, in turn, form the basis for theories, models, and structures. The three subtypes should capture a great deal of the knowledge that is generated within all the different disciplines.

BA. KNOWLEDGE OF CLASSIFICATIONS AND CATEGORIES

Subtype Ba includes the specific categories, classes, divisions, and arrangements that are used in different subject matters. As a subject matter develops, individuals who work on it find it advantageous to develop classifications and categories that they can use to structure and systematize the phenomena. This type of knowledge is somewhat more general and often more abstract than the knowledge of terminology and specific facts. Each subject matter has a set of categories that are used to discover new elements as well as to deal with them once they are discovered. Classifications and categories differ from terminology and facts in that they form the connecting links between and among specific elements.

When one is writing or analyzing a story, for example, the major categories include plot, character, and setting. Note that plot **as a category** is substantially different from the plot **of this story**. When the concern is plot as a category, the key question is What makes a plot a plot? The category "plot" is defined by what all specific plots have in common. In contrast, when the concern is the plot of a particular story, the key question is What is the plot of this story?—*knowledge of specific details and elements* (Ab).

Sometimes it is difficult to distinguish *knowledge of classifications and categories* (Ba) from *Factual knowledge* (A). To complicate matters further, basic classifications and categories can be placed into larger, more comprehensive classifications and categories. In mathematics, for example, whole numbers, integers, and fractions can be placed into the category rational numbers. Each larger category moves us away from the concrete specifics and into the realm of the abstract.

For the purposes of our Taxonomy, several characteristics are useful in distinguishing the subtypes of knowledge. Classifications and categories are largely the result of agreement and convenience, whereas knowledge of specific details stems more directly from observation, experimentation, and discovery. *Knowledge of classifications and categories* is commonly a reflection of how experts in the field think and attack problems, whereas knowledge of which specific details become important is derived from the results of such thought and problem solving.

Knowledge of classifications and categories is an important aspect of developing expertise in an academic discipline. Proper classification of information and experience into appropriate categories is a classic sign of learning and development. Moreover, recent cognitive research on conceptual change and understanding suggests that student learning can be constrained by misclassification of information into inappropriate categories. For example, Chi and her colleagues (see Chi, 1992; Chi, Slotta, and deLeeuw, 1994; Slotta, Chi, and Joram, 1995) suggest that students may have difficulty understanding basic science concepts such as heat, light, force, and electricity when they classify these concepts as material substances rather than as processes. Once concepts are classified as substances or objects, students invoke a whole range of characteristics and properties of "objects." As a result, students try to apply these object-like characteristics to what are better described in scientific terms as processes. The naive categorization of these concepts as substances does not match the more scientifically accurate categorization of them as processes.

The categorization of heat, light, force, and electricity as substances becomes the basis for an implicit theory of how these processes are supposed to operate and leads to systematic misconceptions about the nature of the processes. This implicit theory, in turn, makes it difficult for students to develop the appropriate scientific understanding. Accordingly, learning the appropriate classification and category system can reflect a "conceptual change" and result in a more appropriate understanding of the concepts than just learning their definitions (as would be the case in the *Factual knowledge* category).

For several reasons, it seems likely that students will have greater difficulty learning *knowledge of classifications and categories* than *Factual knowledge*. First, many of the classifications and categories students encounter represent relatively arbitrary and even artificial forms of knowledge that are meaningful only to experts who recognize their value as tools and techniques in their work. Second, students may be able to operate in their daily life without knowing the appropriate subject matter classifications and categories to the level of precision expected by experts in the field. Third, *knowledge of classifications and categories* requires that students make connections among specific content elements (i.e., terminology and facts). Finally, as classifications and categories are combined to form larger classifications and categories, learning becomes more abstract. Nevertheless, the student is expected to know these classifications and categories and to know when they are appropriate or useful in dealing with subject matter content. As the student begins to work with a subject matter within an academic discipline and learns how to use the tools, the value of these classifications and categories becomes apparent.

EXAMPLES OF KNOWLEDGE OF CLASSIFICATIONS AND CATEGORIES

- Knowledge of the variety of types of literature
- Knowledge of the various forms of business ownership
- Knowledge of the parts of sentences (e.g., nouns, verbs, adjectives)
- Knowledge of different kinds of psychological problems
- Knowledge of the different periods of geologic time

Bb. Knowledge of Principles and Generalizations

As mentioned earlier, principles and generalizations are composed of classifications and categories. Principles and generalizations tend to dominate an academic discipline and are used to study phenomena or solve problems in the discipline. One of the hallmarks of a subject matter expert is the ability to recognize meaningful patterns (e.g., generalizations) and activate the relevant knowledge of these patterns with little cognitive effort (Bransford, Brown, and Cocking, 1999).

Subtype Bb includes knowledge of particular abstractions that summarize observations of phenomena. These abstractions have the greatest value in describing, predicting, explaining, or determining the most appropriate and relevant action or direction to be taken. Principles and generalizations bring together large numbers of specific facts and events, describe the processes and interrelationships among these specific details (thus forming classifications and categories), and, furthermore, describe the processes and interrelationships among the classifications and categories. In this way, they enable the expert to begin to organize the whole in a parsimonious and coherent manner.

Principles and generalizations tend to be broad ideas that may be difficult for students to understand because students may not be thoroughly acquainted with the phenomena they are intended to summarize and organize. If students do get to know the principles and generalizations, however, they have a means for relating and organizing a great deal of subject matter. As a result, they should have more insight into the subject matter as well as better memory of it.

Examples of Knowledge of Principles and Generalizations

- Knowledge of major generalizations about particular cultures
- Knowledge of the fundamental laws of physics
- Knowledge of the principles of chemistry that are relevant to life processes and health
- Knowledge of the implications of American foreign trade policies for the international economy and international good will
- Knowledge of the major principles involved in learning
- Knowledge of the principles of federalism
- Knowledge of the principles that govern rudimentary arithmetic operations (e.g., the commutative principle, the associative principle)

Bc. Knowledge of Theories, Models, and Structures

Subtype Bc includes knowledge of principles and generalizations together with their interrelationships that present a clear, rounded, and systemic view of a complex phenomenon, problem, or subject matter. These are the most abstract formulations. They can show the interrelationships and organization of a great range of specific details, classifications and categories, and principles and generalizations. This subtype, Bc, differs from Bb in its emphasis on a set of principles and generalizations related in some way to form a theory, model, or structure. The principles and generalizations in subtype Bb do not need to be related in any meaningful way.

Subtype Bc includes knowledge of the different paradigms, epistemologies, theories, and models that different disciplines use to describe, understand, explain, and predict phenomena. Disciplines have different paradigms and epistemologies for structuring inquiry, and students should come to know these different ways of conceptualizing and organizing subject matter and areas of research within the subject matter. In biology, for example, knowledge of the theory of evolution and how to think in evolutionary terms to explain different biological phenomena is an important aspect of this subtype of *Conceptual knowledge*. Similarly, behavioral, cognitive, and social constructivist theories in psychology make different epistemological assumptions and reflect different perspectives on human behavior. An expert in a discipline knows not only the different disciplinary theories, models, and structures but also their relative strengths and weaknesses and can think "within" one of them as well as "outside" any of them.

Examples of Knowledge of Theories, Models, and Structures

- Knowledge of the interrelationships among chemical principles as the basis for chemical theories
- Knowledge of the overall structure of Congress (i.e., organization, functions)
- Knowledge of the basic structural organization of the local city government
- Knowledge of a relatively complete formulation of the theory of evolution
- Knowledge of the theory of plate tectonics
- Knowledge of genetic models (e.g., DNA)

C. Procedural Knowledge

Procedural knowledge is the "knowledge of how" to do something. The "something" might range from completing fairly routine exercises to solving novel problems. *Procedural knowledge* often takes the form of a series or sequence of steps to be followed. It includes knowledge of skills, algorithms, techniques, and methods, collectively known as procedures (Alexander, Schallert, and Hare, 1991; Anderson, 1983; deJong and Ferguson-Hessler, 1996; Dochy and Alexander, 1995). *Procedural knowledge* also includes knowledge of the criteria used to determine when to use various procedures. In fact, as Bransford, Brown, and Cocking (1999) noted, not only do experts have a great deal of knowledge about their subject matter, but their knowledge is "conditionalized" so that they know when and where to use it.

Whereas *Factual knowledge* and *Conceptual knowledge* represent the "what" of knowledge, procedural knowledge concerns the "how." In other words, *Procedural knowledge* reflects knowledge of different "processes," whereas *Factual* *knowledge* and *Conceptual knowledge* deal with what might be termed "products." It is important to note that *Procedural knowledge* represents only the knowledge of these procedures; their actual use is discussed in Chapter 5.

In contrast to *Metacognitive knowledge* (which includes knowledge of more general strategies that cut across subject matters or academic disciplines), *Procedural knowledge* is specific or germane to particular subject matters or academic disciplines. Accordingly, we reserve the term *Procedural knowledge* for the knowledge of skills, algorithms, techniques, and methods that are subject specific or discipline specific. In mathematics, for example, there are algorithms for performing long division, solving quadratic equations, and establishing the congruence of triangles. In science, there are general methods for designing and performing experiments. In social studies, there are procedures for reading maps, estimating the age of physical artifacts, and collecting historical data. In language arts, there are procedures for spelling words in English and for generating grammatically correct sentences. Because of the subject-specific nature of these procedures, knowledge of them also reflects specific disciplinary knowledge or specific disciplinary ways of thinking in contrast to general strategies for problem solving that can be applied across many disciplines.

CA. Knowledge of Subject-Specific Skills and Algorithms

As we mentioned, *Procedural knowledge* can be expressed as a series or sequence of steps, collectively known as a procedure. Sometimes the steps are followed in a fixed order; at other times decisions must be made about which step to perform next. Similarly, sometimes the end result is fixed (e.g., there is a single prespecified answer); in other cases it is not. Although the process may be either fixed or more open, the end result is generally considered fixed in this subtype of knowledge. A common example is knowledge of algorithms used with mathematics exercises. The procedure for multiplying fractions in arithmetic, when applied, generally results in a fixed answer (barring computational mistakes, of course).

Although the concern here is with *Procedural knowledge*, the result of using *Procedural knowledge* is often *Factual knowledge* or *Conceptual knowledge*. For example, the algorithm for the addition of whole numbers that we use to add 2 and 2 is *Procedural knowledge*; the answer 4 is simply *Factual knowledge*. Once again, the emphasis here is on the student's knowledge of the procedure rather than on his or her ability to use it.

Examples of Knowledge of Subject-Specific Skills and Algorithms

- Knowledge of the skills used in painting with watercolors
- Knowledge of the skills used to determine word meaning based on structural analysis
- Knowledge of the various algorithms for solving quadratic equations
- Knowledge of the skills involved in performing the high jump

Cb. Knowledge of Subject-Specific Techniques and Methods

In contrast with specific skills and algorithms that usually end in a fixed result, some procedures do not lead to a single predetermined answer or solution. We can follow the general scientific method in a somewhat sequential manner to design a study, for example, but the resulting experimental design can vary greatly depending on a host of factors. In this subtype, Cb, of *Procedural knowledge*, then, the result is more open and not fixed, in contrast to subtype Ca, *Knowledge of skills and algorithms*.

Knowledge of subject-specific techniques and methods includes knowledge that is largely the result of consensus, agreement, or disciplinary norms rather than knowledge that is more directly an outcome of observation, experimentation, or discovery. This subtype of knowledge generally reflects how experts in the field or discipline think and attack problems rather than the results of such thought or problem solving. For example, knowledge of the general scientific method and how to apply it to different situations, including social situations and policy problems, reflects a "scientific" way of thinking. Another example is the "mathematization" of problems not originally presented as mathematics problems. For example, the simple problem of choosing a checkout line in a grocery store can be made into a mathematical problem that draws on mathematical knowledge and procedures (e.g., number of people in each line, number of items per person).

Examples of Knowledge of Subject-Specific Techniques and Methods

- Knowledge of research methods relevant to the social sciences
- Knowledge of the techniques used by scientists in seeking solutions to problems
- Knowledge of the methods for evaluating health concepts
- Knowledge of various methods of literary criticism

Cc. Knowledge of Criteria for Determining When to Use Appropriate Procedures

In addition to knowing subject-specific procedures, students are expected to know *when* to use them, which often involves knowing the ways they have been used in the past. Such knowledge is nearly always of a historical or encyclopedic type. Though simpler and perhaps less functional than the ability to actually use the procedures, knowledge of when to use appropriate procedures is an important prelude to their proper use. Thus, before engaging in an inquiry, students may be expected to know the methods and techniques that have been used in similar inquiries. At a later stage in the inquiry, they may be expected to show relationships between the methods and techniques they actually employed and the methods employed by others.

Here again is a systematization that is used by subject matter experts as they attack problems in their field. Experts know when and where to apply their knowledge. They have criteria that help them make decisions about when and where to use different types of subject-specific procedural knowledge; that is, their knowledge is "conditionalized," in that they know the conditions under which the procedures are to be applied (Chi, Feltovich, and Glaser, 1981). For example, in solving a physics problem, an expert can recognize the type of physics problem and apply the appropriate procedure (e.g., a problem that involves Newton's second law, $F = ma$). Students therefore may be expected to make use of the criteria as well as have knowledge of them.

The ways in which the criteria are used in actual problem situations is discussed in Chapter 5. Here, we refer only to *knowledge of criteria for determining when to use appropriate procedures.* The criteria vary markedly from subject matter to subject matter. Initially, they are likely to appear complex and abstract to students; they acquire meaning as they are related to concrete situations and problems.

EXAMPLES OF KNOWLEDGE OF CRITERIA FOR DETERMINING WHEN TO USE APPROPRIATE PROCEDURES

- Knowledge of the criteria for determining which of several types of essays to write (e.g., expository, persuasive)
- Knowledge of the criteria for determining which method to use in solving algebraic equations
- Knowledge of the criteria for determining which statistical procedure to use with data collected in a particular experiment
- Knowledge of the criteria for determining which technique to apply to create a desired effect in a particular watercolor painting

D. METACOGNITIVE KNOWLEDGE

Metacognitive knowledge is knowledge about cognition in general as well as awareness of and knowledge about one's own cognition. One of the hallmarks of theory and research on learning since the publication of the original *Handbook* is the emphasis on making students more aware of and responsible for their own knowledge and thought. This change cuts across different theoretical approaches to learning and development from neo-Piagetian models, to cognitive and information processing models, to Vygotskian and cultural or situated learning models. Regardless of their theoretical perspective, researchers generally agree that with development students will become more aware of their own thinking as well as more knowledgeable about cognition in general, and as they act on this awareness they will tend to learn better (Bransford, Brown, and Cocking, 1999). The labels for this general developmental trend vary from theory to theory but include metacognitive knowledge, metacognitive awareness, self-awareness, self-reflection, and self-regulation.

As we mentioned earlier, an important distinction in the field is between **knowledge of cognition** and the **monitoring, control, and regulation of cognition** (e.g., Bransford, Brown, and Cocking, 1999; Brown, Bransford, Ferrara, and Campione, 1983; Flavell, 1979; Paris and Winograd, 1990; Pintrich, Wolters, and Baxter, in press; Schneider and Pressley, 1997; Zimmerman and Schunk, 1998). Recognizing this distinction, in this chapter we describe only students' knowledge of various aspects of cognition, not the actual monitoring, control, and regulation of their cognition. In the way that the other types of knowledge described in this chapter are acted upon in some way by the cognitive processes described in Chapter 5, the same is true of *Metacognitive knowledge*.

In Flavell's (1979) classic article on metacognition, he suggested that metacognition included knowledge of strategy, task, and person variables. We have represented this general framework in our categories by including students' knowledge of general strategies for learning and thinking (*strategic knowledge*) and their knowledge of cognitive tasks as well as when and why to use these different strategies (*knowledge about cognitive tasks*). Finally, we include knowledge about the self (the person variable) in relation to both cognitive and motivational components of performance (*self-knowledge*).

Da. Strategic Knowledge

Strategic knowledge is knowledge of the general strategies for learning, thinking, and problem solving. The strategies in this subtype can be used across many different tasks and subject matters, rather than being most useful for one particular type of task in one specific subject area (e.g., solving a quadratic equation or applying Ohm's law).

This subtype, Da, includes knowledge of the variety of strategies that students might use to memorize material, extract meaning from text, or comprehend what they hear in classrooms or read in books and other course materials. The large number of different learning strategies can be grouped into three general categories: rehearsal, elaboration, and organizational (Weinstein and Mayer, 1986). Rehearsal strategies involve repeating words or terms to be recalled over and over to oneself; they are generally not the most effective strategies for deeper levels of learning and comprehension. In contrast, elaboration strategies include the use of various mnemonics for memory tasks as well as techniques such as summarizing, paraphrasing, and selecting the main idea from texts. Elaboration strategies foster deeper processing of the material to be learned and result in better comprehension and learning than do rehearsal strategies. Organizational strategies include various forms of outlining, drawing "cognitive maps" or concept mapping, and note taking; students transform the material from one form to another. Organizational strategies usually result in better comprehension and learning than do rehearsal strategies.

In addition to these general learning strategies, students can have knowledge of various metacognitive strategies that are useful in planning, monitoring, and regulating their cognition. Students can eventually use these strategies to plan their cognition (e.g., set subgoals), monitor their cognition (e.g., ask themselves questions as they read a piece of text, check their answer to a math problem), and regulate their cognition (e.g., re-read something they don't understand, go back and "repair" their calculating mistake in a math problem).

Again, in this category we refer to students' knowledge of these various strategies, not their actual use.

Finally, this subtype, Da, includes general strategies for problem solving and thinking (Baron, 1994; Nickerson, Perkins, and Smith, 1985; Sternberg, 1985). These strategies represent the various general heuristics students can use to solve problems, particularly ill-defined problems that have no definitive solution method. Examples of heuristics are means-ends analysis and working backward from the desired goal state. In addition to problem-solving strategies, there are general strategies for deductive and inductive thinking, including evaluating the validity of different logical statements, avoiding circularity in arguments, making appropriate inferences from different sources of data, and drawing on appropriate samples to make inferences (i.e., avoiding the availability heuristic—making decisions from convenient instead of representative symbols).

Examples of Strategic Knowledge

- Knowledge that rehearsal of information is one way to retain the information
- Knowledge of various mnemonic strategies for memory (e.g., the use of acronyms such as Roy G Biv for the colors of the spectrum.)
- Knowledge of various elaboration strategies such as paraphrasing and summarizing
- Knowledge of various organizational strategies such as outlining or diagramming
- Knowledge of planning strategies such as setting goals for reading
- Knowledge of comprehension-monitoring strategies such as self-testing or self-questioning
- Knowledge of means-ends analysis as a heuristic for solving an ill-defined problem
- Knowledge of the availability heuristic and the problems of failing to sample in an unbiased manner

Db. Knowledge About Cognitive Tasks, Including Contextual and Conditional Knowledge

In addition to knowledge about various strategies, individuals accumulate knowledge about cognitive tasks. In his traditional division of *Metacognitive knowledge*, Flavell (1979) included knowledge that different cognitive tasks can be more or less difficult, may make differential demands on the cognitive system, and may require different cognitive strategies. For example, a recall task is more difficult than a recognition task. The recall task requires the person to search memory actively and retrieve the relevant information, whereas the recognition task requires only that the person discriminate among alternatives and select the correct or most appropriate answer.

As students develop knowledge of different learning and thinking strategies, this knowledge reflects both what general strategies to use and how to use them. As with *Procedural knowledge*, however, this knowledge may not be sufficient for expertise in learning. Students also need to develop the conditional knowledge for these general cognitive strategies; in other words, they need to develop some knowledge about the when and why of using these strategies appropriately (Paris, Lipson, and Wixson, 1983). All these different strategies may not be appropriate for all situations, and the learner must develop some knowledge of the different conditions and tasks for which the different strategies are most appropriate. Conditional knowledge refers to knowledge of the situations in which students may use *Metacognitive knowledge*. In contrast, *Procedural knowledge* refers to knowledge of the situations in which students may use subject-specific skills, algorithms, techniques, and methods.

If one thinks of strategies as cognitive "tools" that help students construct understanding, then different cognitive tasks require different tools, just as a carpenter uses different tools for performing all the tasks that go into building a house. Of course, one tool, such as a hammer, can be used in many different ways for different tasks, but this is not necessarily the most adaptive use of a hammer, particularly if other tools are better suited to some of the tasks. In the same way, certain general learning and thinking strategies are better suited to different tasks. For example, if one confronts a novel problem that is ill defined, then general problem-solving heuristics may be useful. In contrast, if one confronts a physics problem about the second law of thermodynamics, then more specific *Procedural knowledge* is more useful and adaptive. An important aspect of learning about strategies is the conditional knowledge of when and why to use them appropriately.

Another important aspect of conditional knowledge is the local situational and general social, conventional, and cultural norms for using different strategies. For example, a teacher may encourage the use of a certain strategy for monitoring reading comprehension. A student who knows that strategy is better able to meet the demands of this teacher's classroom. In the same manner, different cultures and subcultures may have norms for the use of different strategies and ways of thinking about problems. Again, knowing these norms can help students adapt to the demands of the culture in terms of solving the problem. For example, the strategies used in a classroom learning situation may not be the most appropriate ones to use in a work setting. Knowledge of the different situations and the cultural norms regarding the use of different strategies within those situations is an important aspect of *Metacognitive knowledge.*

Examples of Knowledge About Cognitive Tasks, Including Contextual and Conditional Knowledge

- Knowledge that recall tasks (i.e., short-answer items) generally make more demands on the individual's memory system than recognition tasks (i.e., multiple-choice items)
- Knowledge that a primary source book may be more difficult to understand than a general textbook or popular book

- Knowledge that a simple memorization task (e.g., remembering a phone number) may require only rehearsal
- Knowledge that elaboration strategies like summarizing and paraphrasing can result in deeper levels of comprehension
- Knowledge that general problem-solving heuristics may be most useful when the individual lacks relevant subject- or task-specific knowledge or in the absence of specific *Procedural knowledge*
- Knowledge of the local and general social, conventional, and cultural norms for how, when, and why to use different strategies

Dc. SELF-KNOWLEDGE

Along with knowledge of different strategies and cognitive tasks, Flavell (1979) proposed that *self-knowledge* was an important component of metacognition. In his model self-knowledge includes knowledge of one's strengths and weaknesses in relation to cognition and learning. For example, students who know they generally do better on multiple-choice tests than on essay tests have some self-knowledge about their test-taking skills. This knowledge may be useful to students as they study for the two different types of tests. In addition, one hallmark of experts is that they know when they do not know something and they then have some general strategies for finding the needed and appropriate information. Self-awareness of the breadth and depth of one's own knowledge base is an important aspect of self-knowledge. Finally, students need to be aware of the different types of general strategies they are likely to rely on in different situations. An awareness that one tends to overrely on a particular strategy, when there may be other more adaptive strategies for the task, could lead to a change in strategy use.

In addition to knowledge of one's general cognition, individuals have beliefs about their motivation. Motivation is a complicated and confusing area, with many models and theories available. Although motivational beliefs are usually not considered in cognitive models, a fairly substantial body of literature is emerging that shows important links between students' motivational beliefs and their cognition and learning (Snow, Corno, and Jackson, 1996; Pintrich and Schrauben, 1992; Pintrich and Schunk, 1996).

A consensus has emerged, however, around general social cognitive models of motivation that propose three sets of motivational beliefs (Pintrich and Schunk, 1996). Because these beliefs are social cognitive in nature, they fit into a taxonomy of knowledge. The first set consists of self-efficacy beliefs, that is, students' judgments of their capability to accomplish a specific task. The second set includes beliefs about the goals or reasons students have for pursuing a specific task (e.g., learning vs. getting a good grade). The third set contains value and interest beliefs, which represent students' perceptions of their personal interest (liking) for a task as well as their judgments of how important and useful the task is to them. Just as students need to develop self-knowledge and awareness about their own knowledge and cognition, they also need to develop self-knowledge and awareness about their own motivation. Again, awareness of these different motivational beliefs may enable learners to monitor and regulate their behavior in learning situations in a more adaptive manner.

Self-knowledge is an important aspect of *Metacognitive knowledge*, but the accuracy of *self-knowledge* seems to be most crucial for learning. We are not advocating that teachers try to boost students' "self-esteem" (a completely different construct from *self-knowledge*) by providing students with positive but false, inaccurate, and misleading feedback about their academic strengths and weaknesses. It is much more important for students to have accurate perceptions and judgments of their knowledge base and expertise than to have inflated and inaccurate *self-knowledge* (Pintrich and Schunk, 1996). If students are not aware they do not know some aspect of *Factual knowledge* or *Conceptual knowledge* or that they don't know how to do something (*Procedural knowledge*), it is unlikely they will make any effort to learn the new material. A hallmark of experts is that they know what they know and what they do not know, and they do not have inflated or false impressions of their actual knowledge and abilities. Accordingly, we emphasize the need for teachers to help students make accurate assessments of their *self-knowledge* and not attempt to inflate students' academic self-esteem.

Examples of Self-Knowledge

- Knowledge that one is knowledgeable in some areas but not in others
- Knowledge that one tends to rely on one type of "cognitive tool" (strategy) in certain situations
- Knowledge of one's capabilities to perform a particular task that are accurate, not inflated (e.g., overconfident)
- Knowledge of one's goals for performing a task
- Knowledge of one's personal interest in a task
- Knowledge of one's judgments about the relative utility value of a task

Assessing Objectives Involving Metacognitive Knowledge

The assessment of objectives for *Factual knowledge*, *Conceptual knowledge*, and *Procedural knowledge* is discussed in the next chapter because all objectives are some combination of the Knowledge and Cognitive Process dimensions. Accordingly, it makes no sense to discuss assessment of the knowledge categories without also considering how the knowledge is to be used with the different cognitive processes. Because *Metacognitive knowledge* is not discussed in much detail in the next chapter, however, a word about the assessment of *Metacognitive knowledge* is warranted here.

The assessment of objectives that relate to *Metacognitive knowledge* is unique because the objectives require a different perspective on what constitutes a "correct" answer. Unless the verb in the objective is associated with the cognitive process *Create*, most assessment tasks for objectives that relate to *Factual knowledge*, *Conceptual knowledge*, and *Procedural knowledge* have a "correct" answer. Moreover, this answer is the same for all students. For example, for an objective that involves *remembering factual knowledge,* the date on which Lincoln delivered the Gettysburg Address is the same for all students. For objectives that involve *Metacognitive knowledge,* in contrast, there may be important individual differences and perspectives on the "correct" answer. Further, each of the three subtypes of *Metacognitive knowledge* may require a different perspective on the "correct" answer.

For the first subtype, *strategic knowledge,* some knowledge about general strategies may be "correct." For example, if students are asked to simply recall some information about general strategies for memory (e.g., the use of acronyms), then there is in fact a correct answer. On the other hand, if students are asked to apply this knowledge to a new situation, then there may be many possible ways for them to use acronyms to help them remember the important information.

The other two subtypes of *Metacognitive knowledge* provide even more possibilities for individual differences to emerge in assessment. The subtype pertaining to cognitive tasks does include some knowledge that calls for a correct answer. For example, it is a truism that recognition tasks are easier than recall tasks, so a question about this relationship does have a correct answer. On the other hand, there are many different conditions, situations, contexts, and cultures that change the way general cognitive strategies can be applied. It is difficult to specify a correct answer to an assessment task without some knowledge of these different conditions and contexts.

Finally, assessing *self-knowledge* presents even more possibilities for individual differences. Within this subtype it is assumed that individual students vary in their knowledge and motivation. Moreover, how does one determine "correct" answers for self-knowledge? Self-knowledge may even be faulty (e.g., a student believes that he does best on tests if he eats pepperoni pizza the night before), and there should be occasions to correct these faulty and superstitious beliefs. Perhaps the best way of assessing self-knowledge, however, is by helping students become more aware and conscious of their own beliefs, helping them determine the feasibility of these beliefs in light of what currently is known about learning, and helping them learn how to monitor and evaluate these beliefs.

It is difficult to assess *Metacognitive knowledge* using simple paper-and-pencil measures (Pintrich, Wolter, and Baxter, in press). Consequently, objectives that relate to *Metacognitive knowledge* may be best assessed in the context of classroom activities and discussions of various strategies. Certainly, courses designed to teach students general strategies for learning and thinking (e.g., classes on learning strategies, thinking skills, study skills) engage students in learning about all three aspects of *Metacognitive knowledge*. Students can learn about general strategies as well as how other students use strategies. They then can compare their own strategies with those used by other students. Moreover, class discussions in any course, not just strategy courses, that focus on the issues of learning and thinking can help students become aware of their own *Metacognitive knowledge*. As teachers listen to students talk about their strategies in these discussions, have conversations with students individually, or review student journals about their own learning, teachers may gain some understanding of their students' *Metacognitive knowledge*. We have much to learn about the best ways to assess *Metacognitive knowledge*, but given its importance in learning, it seems timely to continue our efforts in this area.

CONCLUSION

In this chapter we identified and described four types of knowledge: *Factual, Conceptual, Procedural,* and *Metacognitive. Factual knowledge* and *Conceptual knowledge* are most similar in that they involve the knowledge of "what," although *Conceptual knowledge* is a deeper, more organized, integrated, and systemic knowledge than just knowledge of terminology and isolated facts. *Procedural knowledge* is the knowledge of "how" to do something. These three categories were all represented in the original Taxonomy. Reflecting recent cognitive science and cognitive psychological research on the importance of metacognition, we have added a fourth category: *Metacognitive knowledge*. In simplest terms, *Metacognitive knowledge* is knowledge about cognition.

Although the importance of differentiating among these four types of knowledge may be apparent after reading this chapter, the next chapter reinforces this view. In Chapter 5 we show how different types of knowledge tend to be associated with certain types of cognitive processes. The differentiation of these knowledge types is further explicated in the discussion of the vignettes and their analysis in Chapters 8–13.

CHAPTER 5

The Cognitive Process Dimension

In Chapter 4 we described each of the four types of knowledge in detail. Although much of schooling focuses on *Factual knowledge,* we suggested that this limited focus can be expanded by placing greater emphasis on a broader range of knowledge types, including *Conceptual knowledge, Procedural knowledge,* and *Metacognitive knowledge.* Similarly, in this chapter we suggest that although instruction and assessment commonly emphasize one kind of cognitive processing—*Remembering*—schooling can be expanded to include a broader range of cognitive processes. In fact, the predominant use of the original framework has been in the analysis of curricula and examinations to demonstrate their overemphasis on remembering and their lack of emphasis on the more complex process categories (Anderson and Sosniak, 1994). The purpose of this chapter is to describe the full range of processes in more detail.

Two of the most important educational goals are to promote retention and to promote transfer (which, when it occurs, indicates meaningful learning). Retention is the ability to remember material at some later time in much the same way as it was presented during instruction. Transfer is the ability to use what was learned to solve new problems, to answer new questions, or to facilitate learning new subject matter (Mayer and Wittrock, 1996). In short, retention requires that students **remember** what they have learned, whereas transfer requires students not only to remember but also to **make sense of** and **be able to use** what they have learned (Bransford, Brown, and Cocking, 1999; Detterman and Sternberg, 1993; McKeough, Lupart, and Marini, 1995; Mayer, 1995; Phye, 1997). Stated somewhat differently, retention focuses on the **past**, whereas transfer emphasizes the **future**. After students read a textbook lesson on Ohm's law, for example, a retention test might ask them to write the formula for Ohm's law. In contrast, a transfer test might ask students to rearrange an electrical circuit to maximize the rate of electron flow or to use Ohm's law to explain a complex electric circuit.

Although educational objectives for promoting retention are fairly easy to construct, educators may have more difficulty in formulating, teaching, and assessing objectives aimed at promoting transfer (Baxter, Elder, and Glaser, 1996; Phye, 1997). Our revised framework is intended to help broaden the typical set of educational objectives to include those aimed at promoting transfer. We begin this chapter by introducing retention and transfer. Next, we describe our six cognitive process categories (one that emphasizes retention and five that, although they may facilitate retention, emphasize transfer). We end the chapter with an example of how this discussion can be applied to teaching, learning, and assessing a lesson on Ohm's law.

A Tale of Three Learning Outcomes

As an introduction, we briefly consider three learning scenarios. The first exemplifies no learning (that is, no intended learning), the second rote learning, and the third meaningful learning.

No Learning

Amy reads a chapter on electrical circuits in her science textbook. She skims the material, sure that the test will be a breeze. When she is asked to recall part of the lesson (as a retention test), she is able to remember very few of the key terms and facts. For example, she cannot list the major components in an electrical circuit even though they were described in the chapter. When she is asked to use the information to solve problems (as part of a transfer test), she cannot. For example, she cannot answer an essay question that asks her to diagnose a problem in an electrical circuit. In this worst-case scenario, Amy neither possesses nor is able to use the relevant knowledge. Amy has neither sufficiently attended to nor encoded the material during learning. The resulting outcome can be characterized as essentially **no learning**.

Rote Learning

Becky reads the same chapter on electrical circuits. She reads carefully, making sure she reads every word. She goes over the material and memorizes the key facts. When she is asked to recall the material, she can remember almost all of the important terms and facts in the lesson. Unlike Amy, she is able to list the major components in an electrical circuit. When she is asked to use the information to solve problems, however, she cannot. Like Amy, she cannot answer the essay question about the diagnosis of a problem in an electrical circuit. In this scenario, Becky possesses relevant knowledge but cannot use that knowledge to solve problems. She cannot transfer this knowledge to a new situation. Becky has attended to relevant information, but she has not understood it and therefore cannot use it. The resulting learning outcome can be called **rote learning**.

Meaningful Learning

Carla reads the same textbook chapter on electrical circuits. She reads carefully, trying to make sense out of it. When she is asked to recall the material, she, like Becky, can remember almost all of the important terms and facts in the lesson. Furthermore, when she is asked to use the information to solve problems, she generates many possible solutions. In this scenario, not only does Carla possess relevant knowledge, but she also can use that knowledge to solve problems and to understand new concepts. She can transfer her knowledge to new problems and new learning situations. Carla has attended to relevant information and has understood it. The resulting learning outcome can be called **meaningful learning**.

Meaningful learning provides students with the knowledge and cognitive processes they need for successful problem solving. Problem solving occurs when a student devises a way of achieving a goal that he or she has never previously achieved, that is, of figuring out how to change a situation from its given state into a goal state (Duncker, 1945; Mayer, 1992). Two major components in problem solving are problem representation—in which a student builds a mental representation of the problem—and problem solution—in which a student devises and carries out a plan for solving the problem (Mayer, 1992). Consistent with recent research (Gick and Holyoak, 1980, 1983; Vosniadou and Ortony, 1989), the authors of the original *Handbook* recognized that students often solve problems by analogy. That is, they reformulate the problem in a more familiar form, recognize that it is similar to a familiar problem type, abstract the solution method for that familiar problem type, and then apply the method to the to-be-solved problem.

Meaningful Learning as Constructing Knowledge Frameworks

A focus on meaningful learning is consistent with the view of learning as knowledge construction, in which students seek to make sense of their experiences. In constructivist learning, as mentioned on page 38, students engage in active cognitive processing, such as paying attention to relevant incoming information, mentally organizing incoming information into a coherent representation, and mentally integrating incoming information with existing knowledge (Mayer, 1999). In contrast, a focus on rote learning is consistent with the view of learning as knowledge acquisition, in which students seek to add new information to their memories (Mayer, 1999).

Constructivist learning (i.e., meaningful learning) is recognized as an important educational goal. It requires that instruction go beyond the simple presentation of factual knowledge and that assessment tasks require more of students than simply recall or recognition of factual knowledge (Bransford, Brown, and Cocking, 1999; Lambert and McCombs, 1998; Marshall, 1996; Steffe and Gale, 1995). The cognitive processes summarized in this chapter provide a means of describing the range of students' cognitive activities in constructivist learning; that is, these processes are ways in which students can actively engage in the process of constructing meaning.

Cognitive Processes for Retention and Transfer

If we were interested mainly in teaching and assessing the degree to which students learned some subject matter content and retained it over some period of time, we would focus primarily on one class of cognitive processes—namely, those associated with *Remember*. In contrast, if we wish to expand our focus by examining ways to foster and assess meaningful learning, we need to examine processes that go beyond remembering.

What cognitive processes are used for retention and transfer? As we discussed, our revised framework includes six categories of processes—one most closely related to retention (*Remember*) and the other five increasingly related to transfer (*Understand, Apply, Analyze, Evaluate,* and *Create*). Based on a review of the illustrative objectives listed in the original *Handbook* and an examination of other classification systems (e.g., DeLandsheere, 1977; Metfessel, Michael, and Kirsner, 1969; Mosenthal, 1998; Royer, Ciscero, and Carlo, 1993; Sternberg, 1998), we have selected 19 cognitive processes that fit within these six categories. Table 5.1 provides a brief definition and example of each cognitive process, lists their alternative names, and indicates the category to which it belongs. These 19 specific cognitive processes are intended to be mutually exclusive; together they delineate the breadth and boundaries of the six categories.

CATEGORIES OF THE COGNITIVE PROCESS DIMENSION

In the discussion that follows, we define the cognitive processes within each of the six categories in detail, making comparisons with other cognitive processes, where appropriate. We offer sample educational objectives and assessments in various subject areas as well as alternative versions of assessment tasks. Each illustrative objective in the following material should be read as though preceded by the phrase "The student is able to . . ." or "The student learns to. . . ."

1. REMEMBER

When the objective of instruction is to promote retention of the presented material in much the same form as it was taught, the relevant process category is *Remember.* Remembering involves retrieving relevant knowledge from long-term memory. The two associated cognitive processes are *recognizing* and *recalling*. The relevant knowledge may be *Factual, Conceptual, Procedural,* or *Metacognitive,* or some combination of these.

To assess student learning in the simplest process category, the student is given a recognition or recall task under conditions very similar to those in which he or she learned the material. Little, if any, extension beyond those conditions is expected. If, for example, a student learned the English equivalents of 20 Spanish words, then a test of remembering could involve requesting the student to match the Spanish words in one list with their English equivalents in a second list (i.e., *recognize*) or to write the corresponding English word next to each of the Spanish words presented in the list (i.e., *recall*).

Remembering knowledge is essential for meaningful learning and problem solving as that knowledge is used in more complex tasks. For example, knowledge of the correct spelling of common English words appropriate to a given grade level is necessary if the student is to master writing an essay. Where teachers concentrate solely on rote learning, teaching and assessing focus solely on remembering elements or fragments of knowledge, often in isolation from their context. When teachers focus on meaningful learning, however, re-

5.1 THE COGNITIVE PROCESS DIMENSION

CATEGORIES & COGNITIVE PROCESSES	ALTERNATIVE NAMES	DEFINITIONS AND EXAMPLES
1. REMEMBER—Retrieve relevant knowledge from long-term memory		
1.1 RECOGNIZING	Identifying	Locating knowledge in long-term memory that is consistent with presented material (e.g., Recognize the dates of important events in U.S. history)
1.2 RECALLING	Retrieving	Retrieving relevant knowledge from long-term memory (e.g., Recall the dates of important events in U.S. history)
2. UNDERSTAND—Construct meaning from instructional messages, including oral, written, and graphic communication		
2.1 INTERPRETING	Clarifying, paraphrasing, representing, translating	Changing from one form of representation (e.g., numerical) to another (e.g., verbal) (e.g., Paraphrase important speeches and documents)
2.2 EXEMPLIFYING	Illustrating, instantiating	Finding a specific example or illustration of a concept or principle (e.g., Give examples of various artistic painting styles)
2.3 CLASSIFYING	Categorizing, subsuming	Determining that something belongs to a category (e.g., concept or principle) (e.g., Classify observed or described cases of mental disorders)
2.4 SUMMARIZING	Abstracting, generalizing	Abstracting a general theme or major point(s) (e.g., Write a short summary of the events portrayed on a videotape)
2.5 INFERRING	Concluding, extrapolating, interpolating, predicting	Drawing a logical conclusion from presented information (e.g., In learning a foreign language, infer grammatical principles from examples)
2.6 COMPARING	Contrasting, mapping, matching	Detecting correspondences between two ideas, objects, and the like (e.g., Compare historical events to contemporary situations)
2.7 EXPLAINING	Constructing models	Constructing a cause-and-effect model of a system (e.g., Explain the causes of important 18th-century events in France)
3. APPLY—Carry out or use a procedure in a given situation		
3.1 EXECUTING	Carrying out	Applying a procedure to a familiar task (e.g., Divide one whole number by another whole number, both with multiple digits)
3.2 IMPLEMENTING	Using	Applying a procedure to an unfamiliar task (e.g., Use Newton's Second Law in situations in which it is appropriate)

5.1 THE COGNITIVE PROCESS DIMENSION (CONTINUED)

CATEGORIES & COGNITIVE PROCESSES	ALTERNATIVE NAMES	DEFINITIONS AND EXAMPLES
4. ANALYZE—Break material into its constituent parts and determine how the parts relate to one another and to an overall structure or purpose		
4.1 DIFFERENTIATING	Discriminating, distinguishing, focusing, selecting	Distinguishing relevant from irrelevant parts or important from unimportant parts of presented material (e.g., Distinguish between relevant and irrelevant numbers in a mathematical word problem)
4.2 ORGANIZING	Finding coherence, intergrating, outlining, parsing, structuring	Determining how elements fit or function within a structure (e.g., Structure evidence in a historical description into evidence for and against a particular historical explanation)
4.3 ATTRIBUTING	Deconstructing	Determine a point of view, bias, values, or intent underlying presented material (e.g., Determine the point of view of the author of an essay in terms of his or her political perspective)
5. EVALUATE—Make judgments based on criteria and standards		
5.1 CHECKING	Coordinating, detecting, monitoring, testing	Detecting inconsistencies or fallacies within a process or product; determining whether a process or product has internal consistency; detecting the effectiveness of a procedure as it is being implemented (e.g., Determine if a scientist's conclusions follow from observed data)
5.2 CRITIQUING	Judging	Detecting inconsistencies between a product and external criteria, determining whether a product has external consistency; detecting the appropriateness of a procedure for a given problem (e.g., Judge which of two methods is the best way to solve a given problem)
6. CREATE—Put elements together to form a coherent or functional whole; reorganize elements into a new pattern or structure		
6.1 GENERATING	Hypothesizing	Coming up with alternative hypotheses based on criteria (e.g., Generate hypotheses to account for an observed phenomenon)
6.2 PLANNING	Designing	Devising a procedure for accomplishing some task (e.g., Plan a research paper on a given historical topic)
6.3 PRODUCING	Constructing	Inventing a product (e.g., Build habitats for a specific purpose)

membering knowledge is integrated within the larger task of constructing new knowledge or solving new problems.

1.1 Recognizing

Recognizing involves retrieving relevant knowledge from long-term memory in order to compare it with presented information. In *recognizing,* the student searches long-term memory for a piece of information that is identical or extremely similar to the presented information (as represented in working memory). When presented with new information, the student determines whether that information corresponds to previously learned knowledge, searching for a match. An alternative term for *recognizing* is identifying.

Sample Objectives and Corresponding Assessments In social studies, an objective could be for students to recognize the correct dates of important events in U.S. history. A corresponding test item is: "True or false: The Declaration of Independence was adopted on July 4, 1776." In literature, an objective could be to recognize authors of British literary works. A corresponding assessment is a matching test that contains a list of ten authors (including Charles Dickens) and a list of slightly more than ten novels (including *David Copperfield*). In mathematics, an objective could be to recognize the numbers of sides in basic geometric shapes. A corresponding assessment is a multiple-choice test with items such as the following: "How many sides does a pentagon have? (a) four, (b) five, (c) six, (d) seven."

Assessment Formats As illustrated in the preceding paragraph, three main methods of presenting a recognition task for the purpose of assessment are verification, matching, and forced choice. In verification tasks, the student is given some information and must choose whether or not it is correct. The true-false format is the most common example. In matching, two lists are presented, and the student must choose how each item in one list corresponds to an item in the other list. In forced choice tasks, the student is given a prompt along with several possible answers and must choose which answer is the correct or "best answer." Multiple-choice is the most common format.

1.2 Recalling

Recalling involves retrieving relevant knowledge from long-term memory when given a prompt to do so. The prompt is often a question. In *recalling,* a student searches long-term memory for a piece of information and brings that piece of information to working memory where it can be processed. An alternative term for *recalling* is retrieving.

Sample Objectives and Corresponding Assessments In *recalling,* a student remembers previously learned information when given a prompt. In social studies, an objective could be to recall the major exports of various South American countries. A corresponding test item is "What is the major export of Bolivia?" In literature, an objective could be to recall the poets who wrote various poems. A corresponding test question is "Who wrote *The Charge of the Light Brigade*?" In mathematics, an objective could be to recall the whole-number multiplication facts. A corresponding test item asks students to multiply 7 × 8 (or "7 × 8 = ?").

ASSESSMENT FORMATS Assessment tasks for *recalling* can vary in the number and quality of cues that students are provided. With low cueing, the student is not given any hints or related information (such as "What is a meter?"). With high cueing, the student is given several hints (such as "In the metric system, a meter is a measure of ________________.").

Assessment tasks for *recalling* can also vary in the amount of embedding, or the extent to which the items are placed within a larger meaningful context. With low embedding, the recall task is presented as a single, isolated event, as in the preceding examples. With high embedding, the recall task is included within the context of a larger problem, such as asking a student to recall the formula for the area of a circle when solving a word problem that requires that formula.

2. UNDERSTAND

As we indicated, when the primary goal of instruction is to promote retention, the focus is on objectives that emphasize *Remember*. When the goal of instruction is to promote transfer, however, the focus shifts to the other five cognitive processes, *Understand* through *Create*. Of these, arguably the largest category of transfer-based educational objectives emphasized in schools and colleges is *Understand*. Students are said to *Understand* when they are able to construct meaning from instructional messages, including oral, written, and graphic communications, however they are presented to students: during lectures, in books, or on computer monitors. Examples of potential instructional messages include an in-class physics demonstration, a geological formation seen on a field trip, a computer simulation of a trip through an art museum, and a musical work played by an orchestra, as well as numerous verbal, pictorial, and symbolic representations on paper.

Students understand when they build connections between the "new" knowledge to be gained and their prior knowledge. More specifically, the incoming knowledge is integrated with existing schemas and cognitive frameworks. Since concepts are the building blocks for these schemas and frameworks, *Conceptual knowledge* provides a basis for understanding. Cognitive processes in the category of *Understand* include *interpreting, exemplifying, classifying, summarizing, inferring, comparing,* and *explaining*.

2.1 INTERPRETING

Interpreting occurs when a student is able to convert information from one representational form to another. *Interpreting* may involve converting words to words (e.g., paraphrasing), pictures to words, words to pictures, numbers to words, words to numbers, musical notes to tones, and the like.

Alternative terms are translating, paraphrasing, representing, and clarifying.

Sample Objectives and Corresponding Assessments In *interpreting*, when given information in one form of representation, a student is able to change it into another form. In social studies, for example, an objective could be to learn to paraphrase important speeches and documents from the Civil War period in U.S. history. A corresponding assessment asks a student to paraphrase a famous speech, such as Lincoln's Gettysburg Address. In science, an objective could be to learn to draw pictorial representations of various natural phenomena. A corresponding assessment item asks a student to draw a series of diagrams illustrating photosynthesis. In mathematics, a sample objective could be to learn to translate number sentences expressed in words into algebraic equations expressed in symbols. A corresponding assessment item asks a student to write an equation (using B for the number of boys and G for the number of girls) that corresponds to the statement "There are twice as many boys as girls in this class."

Assessment Formats Appropriate test item formats include both constructed response (i.e., supply an answer) and selected response (i.e., choose an answer). Information is presented in one form, and students are asked either to construct or to select the same information in a different form. For example, a constructed response task is: "Write an equation that corresponds to the following statement, using T for total cost and P for number of pounds. The total cost of mailing a package is \$2.00 for the first pound plus \$1.50 for each additional pound." A selection version of this task is: "Which equation corresponds to the following statement, where T stands for total cost and P for number of pounds? The total cost of mailing a package is \$2.00 for the first pound plus \$1.50 for each additional pound. (a) $T = \$3.50 + P$, (b) $T = \$2.00 + \$1.50(P)$, (c) $T = \$2.00 + \$1.50(P - 1)$."

To increase the probability that *interpreting* rather than *remembering* is being assessed, the information included in the assessment task must be new. "New" here means that students did not encounter it during instruction. Unless this rule is observed, we cannot ensure that *interpreting* rather than *remembering* is being assessed. If the assessment task is identical to a task or example used during instruction, we are probably assessing *remembering*, despite our efforts to the contrary.

Although we will not repeat this point from here on, it applies to each of the process categories and cognitive processes beyond *Remember*. **If assessment tasks are to tap higher-order cognitive processes, they must require that students cannot answer them correctly by relying on memory alone.**

2.2 Exemplifying

Exemplifying occurs when a student gives a specific example or instance of a general concept or principle. *Exemplifying* involves identifying the defining features of the general concept or principle (e.g., an isosceles triangle must have two equal sides) and using these features to select or construct a specific instance (e.g., being able to select which of three presented triangles is an isosceles triangle). Alternative terms are illustrating and instantiating.

Sample Objectives and Corresponding Assessments In *exemplifying*, a student is given a concept or principle and must select or produce a specific example or instance of it that was not encountered during instruction. In art history, an objective could be to learn to give examples of various artistic painting styles. A corresponding assessment asks a student to select which of four paintings represents the impressionist style. In science, a sample objective could be to be able to give examples of various kinds of chemical compounds. A corresponding assessment task asks the student to locate an inorganic compound on a field trip and tell why it is inorganic (i.e., specify the defining features). In literature, an objective could be to learn to exemplify various play genres. The assessment may give the students brief sketches of four plays (only one of which is a romantic comedy) and ask the student to name the play that is a romantic comedy.

Assessment Formats *Exemplifying* tasks can involve the constructed response format—in which the student must create an example—or the selected response format—in which the student must select an example from a given set. The science example, "Locate an inorganic compound and tell why it is inorganic," requires a constructed response. In contrast, the item "Which of these is an inorganic compound? (a) iron, (b) protein, (c) blood, (d) leaf mold" requires a selected response.

2.3 Classifying

Classifying occurs when a student recognizes that something (e.g., a particular instance or example) belongs to a certain category (e.g., concept or principle). *Classifying* involves detecting relevant features or patterns that "fit" both the specific instance and the concept or principle. *Classifying* is a complementary process to *exemplifying*. Whereas *exemplifying* begins with a general concept or principle and requires the student to find a specific instance or example, *classifying* begins with a specific instance or example and requires the student to find a general concept or principle. Alternative terms for *classifying* are categorizing and subsuming.

Sample Objectives and Corresponding Assessments In social studies, an objective could be to learn to classify observed or described cases of mental disorders. A corresponding assessment item asks a student to observe a video of the behavior of a person with mental illness and then indicate the mental disorder that is displayed. In the natural sciences, an objective could be to learn to categorize the species of various prehistoric animals. An assessment gives a student some pictures of prehistoric animals with instructions to group them with others of the same species. In mathematics, an objective could be to be able to determine the categories to which numbers belong. An assessment task gives an example and asks a student to circle all numbers in a list from the same category.

Assessment Formats In constructed response tasks, a student is given an instance and must produce its related concept or principle. In selected response tasks, a student is given an instance and must select its concept or principle from a list. In a sorting task, a student is given a set of instances and must determine which ones belong in a specified category and which ones do not, or must place each instance into one of multiple categories.

2.4. Summarizing

Summarizing occurs when a student suggests a single statement that represents presented information or abstracts a general theme. *Summarizing* involves constructing a representation of the information, such as the meaning of a scene in a play, and abstracting a summary from it, such as determining a theme or main points. Alternative terms are generalizing and abstracting.

Sample Objectives and Corresponding Assessments In *summarizing*, when given information, a student provides a summary or abstracts a general theme. A sample objective in history could be to learn to write short summaries of events portrayed pictorially. A corresponding assessment item asks a student to watch a videotape on the French Revolution and then write a short summary. Similarly, a sample objective in the natural sciences could be to learn to summarize the major contributions of famous scientists after reading several of their writings. A corresponding assessment item asks a student to read selected writings about Charles Darwin and summarize the major points. In computer science, an objective could be to learn to summarize the purposes of various subroutines in a program. An assessment item presents a program and asks a student to write a sentence describing the subgoal that each section of the program accomplishes within the overall program.

Assessment Formats Assessment tasks can be presented in constructed response or selection formats, involving either themes or summaries. Generally speaking, themes are more abstract than summaries. For example, in a constructed response task, the student may be asked to read an untitled passage on the California Gold Rush and then write an appropriate title. In a selection task, a student may be asked to read a passage on the California Gold Rush and then select the most appropriate title from a list of four possible titles or rank the titles in order of their "fit" to the point of the passage.

2.5 Inferring

Inferring involves finding a pattern within a series of examples or instances. *Inferring* occurs when a student is able to abstract a concept or principle that accounts for a set of examples or instances by encoding the relevant features of each instance and, most important, by noting relationships among them. For example, when given a series of numbers such as 1, 2, 3, 5, 8, 13, 21, a student is able to focus on the numerical value of each digit rather than on irrelevant features such as the shape of each digit or whether each digit is odd or even. He or she then is able to distinguish the pattern in the series of numbers (i.e., after the first two numbers, each is the sum of the preceding two numbers).

The process of *inferring* involves making comparisons among instances within the context of the entire set. For example, to determine what number will come next in the series above, a student must identify the pattern. A related process is using the pattern to create a new instance (e.g., the next number on the series is 34, the sum of 13 and 21). This is an example of *executing*, which is a cognitive process associated with *Apply*. *Inferring* and *executing* are often used together on cognitive tasks.

Finally, *inferring* is different from *attributing* (a cognitive process associated with *Analyze*). As we discuss later in this chapter, *attributing* focuses solely on the pragmatic issue of determining the author's point of view or intention, whereas *inferring* focuses on the issue of inducing a pattern based on presented information. Another way of differentiating between these two is that *attributing* is broadly applicable to situations in which one must "read between the lines," especially when one is seeking to determine an author's point of view. *Inferring*, on the other hand, occurs in a context that supplies an expectation of what is to be inferred. Alternative terms for *inferring* are extrapolating, interpolating, predicting, and concluding.

Sample Objectives and Corresponding Assessments In *inferring*, when given a set or series of examples or instances, a student finds a concept or principle that accounts for them. For example, in learning Spanish as a second language, a sample objective could be to be able to infer grammatical principles from examples. For assessment, a student is given the article-noun pairs "la casa, el muchacho, la señorita, el pero" and asked to formulate a principle for when to use "la" and when to use "el." In mathematics, an objective could be to learn to infer the relationship expressed as an equation that represents several observations of values for two variables. An assessment item asks a student to describe the relationship as an equation involving x and y for situations in which if x is 1, then y is 0; if x is 2, then y is 3; and if x is 3, then y is 8.

Assessment Formats Three common tasks that require *inferring* (often along with *implementing*) are completion tasks, analogy tasks, and oddity tasks. In completion tasks, a student is given a series of items and must determine what will come next, as in the number series example above. In analogy tasks, a student is given an analogy of the form A is to B as C is to D, such as "nation" is to "president" as "state" is to ______________. The student's task is to produce or select a term that fits in the blank and completes the analogy (such as "governor"). In an oddity task, a student is given three or more items and must determine which does not belong. For example, a student may be given three physics problems, two involving one principle and another involving a different principle. To focus solely on the inferring process, the question in each assessment task could be to state the underlying concept or principle the student is using to arrive at the correct answer.

2.6 COMPARING

Comparing involves detecting similarities and differences between two or more objects, events, ideas, problems, or situations, such as determining how a well-known event (e.g., a recent political scandal) is like a less familiar event (e.g., a historical political scandal). *Comparing* includes finding one-to-one correspondences between elements and patterns in one object, event, or idea and those in another object, event, or idea. When used in conjunction with *inferring* (e.g., first, abstracting a rule from the more familiar situation) and *implementing* (e.g., second, applying the rule to the less familiar situation), *comparing* can contribute to reasoning by analogy. Alternative terms are contrasting, matching, and mapping.

SAMPLE OBJECTIVES AND CORRESPONDING ASSESSMENTS In *comparing*, when given new information, a student detects correspondences with more familiar knowledge. For example, in social studies, an objective could be to understand historical events by comparing them to familiar situations. A corresponding assessment question is "How is the American Revolution like a family fight or an argument between friends?" In the natural sciences, a sample objective could be to learn to compare an electrical circuit to a more familiar system. In assessment, we ask "How is an electrical circuit like water flowing through a pipe?"

Comparing may also involve determining correspondences between two or more presented objects, events, or ideas. In mathematics, a sample objective could be to learn to compare structurally similar word problems. A corresponding assessment question asks a student to tell how a certain mixture problem is like a certain work problem.

ASSESSMENT FORMATS A major technique for assessing the cognitive process of *comparing* is mapping. In mapping, a student must show how each part of one object, idea, problem, or situation corresponds to (or maps onto) each part of another. For example, a student could be asked to detail how the battery, wire, and resistor in an electrical circuit are like the pump, pipes, and pipe constructions in a water flow system, respectively.

2.7 EXPLAINING

Explaining occurs when a student is able to construct and use a cause-and-effect model of a system. The model may be derived from a formal theory (as is often the case in the natural sciences) or may be grounded in research or experience (as is often the case in the social sciences and humanities). A complete explanation involves constructing a cause-and-effect model, including each major part in a system or each major event in the chain, and using the model to determine how a change in one part of the system or one "link" in the chain affects a change in another part. An alternative term for *explaining* is constructing a model.

SAMPLE OBJECTIVES AND CORRESPONDING ASSESSMENTS In *explaining*, when given a description of a system, a student develops and uses a cause-and-effect model of the system. For example, in social studies, an objective could be to explain the causes of important eighteenth-century historical events. As an assessment, after reading and discussing a unit on the American Revolution, students are asked to construct a cause-and-effect chain of events that best explains why the war occurred. In the natural sciences, an objective could be to explain how basic physics laws work. Corresponding assessments ask students who have studied Ohm's law to explain what happens to the rate of the current when a second battery is added to a circuit, or ask students who have viewed a video on lightning storms to explain how differences in temperature affect the formation of lightning.

ASSESSMENT FORMATS Several tasks can be aimed at assessing a student's ability to explain, including reasoning, troubleshooting, redesigning, and predicting. In reasoning tasks, a student is asked to offer a reason for a given event. For example, "Why does air enter a bicycle tire pump when you pull up on the handle?" In this case, an answer such as "It is forced in because the air pressure is less inside the pump than outside" involves finding a principle that accounts for a given event.

In troubleshooting, a student is asked to diagnose what could have gone wrong in a malfunctioning system. For example, "Suppose you pull up and press down on the handle of a bicycle tire pump several times but no air comes out. What's wrong?" In this case, the student must find an explanation for a symptom, such as "There is a hole in the cylinder" or "A valve is stuck in the open position."

In redesigning, a student is asked to change the system to accomplish some goal. For example, "How could you improve a bicycle tire pump so that it would be more efficient?" To answer this question, a student must imagine altering one or more of the components in the system, such as "Put lubricant between the piston and the cylinder."

In predicting, a student is asked how a change in one part of a system will effect a change in another part of the system. For example, "What would happen if you increased the diameter of the cylinder in a bicycle tire pump?" This question requires that the student "operate" the mental model of the pump to see that the amount of air moving through the pump could be increased by increasing the diameter of the cylinder.

3. Apply

Apply involves using procedures to perform exercises or solve problems. Thus, *Apply* is closely linked with *Procedural knowledge*. An exercise is a task for which the student already knows the proper procedure to use, so the student has developed a fairly routinized approach to it. A problem is a task for which the student initially does not know what procedure to use, so the student must locate a procedure to solve the problem. The *Apply* category consists of two cognitive processes: *executing*—when the task is an exercise (familiar)—and *implementing*—when the task is a problem (unfamiliar).

When the task is a familiar exercise, students generally know what *Procedural knowledge* to use. When given an exercise (or set of exercises), students typically perform the procedure with little thought. For example, an algebra student confronted with the 50th exercise involving quadratic equations might simply "plug in the numbers and turn the crank."

When the task is an unfamiliar problem, however, students must determine what knowledge they will use. If the task appears to call for *Procedural knowledge* and no available procedure fits the problem situation exactly, then modifications in selected *Procedural knowledge* may be necessary. In contrast to *executing*, then, *implementing* requires some degree of understanding of the problem as well as of the solution procedure. In the case of *implementing*, then, to *understand conceptual knowledge* is a prerequisite to being able to *apply procedural knowledge.*

3.1 Executing

In *executing*, a student routinely carries out a procedure when confronted with a familiar task (i.e., exercise). The familiarity of the situation often provides sufficient clues to guide the choice of the appropriate procedure to use. *Executing* is more frequently associated with the use of skills and algorithms than with techniques and methods (see our discussion of *Procedural knowledge* on pages 52–53). Skills and algorithms have two qualities that make them particularly amenable to *executing*. First, they consist of a sequence of steps that are generally followed *in a fixed order*. Second, when the steps are performed correctly, the end result is a predetermined answer. An alternative term for *executing* is carrying out.

Sample Objectives and Corresponding Assessments In *executing*, a student is faced with a familiar task and knows what to do in order to complete it. The student simply carries out a known procedure to perform the task. For example, a sample objective in elementary level mathematics could be for students to learn to divide one whole number by another, both with multiple digits. The instructions to "divide" signify the division algorithm, which is the necessary *Procedural knowledge*. To assess the objective, a student is given a worksheet that has 15 whole-number division exercises (e.g., 784/15) and is asked to find the quotients. In the natural sciences, a sample objective could be to learn to compute the value of variables using scientific formulas. To assess the objective, a student is given the formula Density = Mass/Volume and must answer the question "What is the density of a material with a mass of 18 pounds and a volume of 9 cubic inches?"

ASSESSMENT FORMATS In *executing*, a student is given a familiar task that can be performed using a well-known procedure. For example, an execution task is "Solve for x: $x^2 + 2x - 3 = 0$ using the technique of completing the square." Students may be asked to supply the answer or, where appropriate, select from among a set of possible answers. Furthermore, because the emphasis is on the procedure as well as the answer, students may be required not only to find the answer but also to show their work.

3.2 IMPLEMENTING

Implementing occurs when a student selects and uses a procedure to perform an unfamiliar task. Because selection is required, students must possess an understanding of the type of problem encountered as well as the range of procedures that are available. Thus, *implementing* is used in conjunction with other cognitive process categories, such as *Understand* and *Create*.

Because the student is faced with an unfamiliar problem, he or she does not immediately know which of the available procedures to use. Furthermore, no single procedure may be a "perfect fit" for the problem; some modification in the procedure may be needed. *Implementing* is more frequently associated with the use of techniques and methods than with skills and algorithms (see the discussion of *Procedural knowledge* on pages 52–53). Techniques and methods have two qualities that make them particularly amenable to *implementing*. First, the procedure may be more like a "flow chart" than a fixed sequence; that is, the procedure may have "decision points" built into it (e.g., after completing Step 3, should I do Step 4A or Step 4B?). Second, there often is no single, fixed answer that is expected when the procedure is applied correctly.

The notion of no single, fixed answer is especially applicable to objectives that call for *applying conceptual knowledge* such as theories, models, and structures (subtype Cc), where no procedure has been developed for the application. Consider an objective such as "The student shall be able to apply a social psychological theory of crowd behavior to crowd control." Social psychological theory is *Conceptual* not *Procedural knowledge*. This is clearly an *Apply* objective, however, and there is no procedure for making the application. Given that the theory would very clearly structure and guide the student in the application, this objective is just barely on the *Apply* side of *Create*, but *Apply* it is. So it would be classified as *implementing*.

To see why it fits, think of the *Apply* category as structured along a continuum. It starts with the narrow, highly structured *execute*, in which the known *Procedural knowledge* is applied almost routinely. It continues through the broad, increasingly unstructured *implement*, in which, at the beginning, the procedure must be selected to fit a new situation. In the middle of the category, the procedure may have to be modified to *implement* it. At the far end of *implementing*, where there is no set *Procedural knowledge* to modify, a procedure must be manufactured out of *Conceptual knowledge* using theories, models, or structures as a guide. So, although *Apply* is closely linked to *Procedural knowledge*, and this linkage carries through most of the category of *Apply*, there are some instances in *implementing* to which one applies *Conceptual knowledge* as well. An alternative term for *implementing* is using.

SAMPLE OBJECTIVES AND CORRESPONDING ASSESSMENTS In mathematics, a sample objective could be to learn to solve a variety of personal finance problems. A corresponding assessment is to present students with a problem in which they must choose the most economical financing package for a new car. In the natural sciences, a sample objective could be to learn to use the most effective, efficient, and affordable method of conducting a research study to address a specific research question. A corresponding assessment is to give students a research question and have them propose a research study that meets specified criteria of effectiveness, efficiency, and affordability. Notice that in both of these assessment tasks, the student must not only apply a procedure (i.e., engage in *implementing*) but also rely on conceptual understanding of the problem, the procedure, or both.

ASSESSMENT FORMATS In *implementing*, a student is given an unfamiliar problem that must be solved. Thus, most assessment formats begin with specification of the problem. Students are asked to determine the procedure needed to solve the problem, solve the problem using the selected procedure (making modifications as necessary), or usually both.

4. ANALYZE

Analyze involves breaking material into its constituent parts and determining how the parts are related to one another and to an overall structure. This process category includes the cognitive processes of *differentiating*, *organizing*, and *attributing*. Objectives classified as *Analyze* include learning to determine the relevant or important pieces of a message (*differentiating*), the ways in which the pieces of a message are organized (*organizing*), and the underlying purpose of the message (*attributing*). Although learning to *Analyze* may be viewed as an end in itself, it is probably more defensible educationally to consider analysis as an extension of *Understanding* or as a prelude to *Evaluating* or *Creating*.

Improving students' skills in analyzing educational communications is a goal in many fields of study. Teachers of science, social studies, the humanities, and the arts frequently give "learning to analyze" as one of their important objectives. They may, for example, wish to develop in their students the ability to:

- distinguish fact from opinion (or reality from fantasy);
- connect conclusions with supporting statements;

- distinguish relevant from extraneous material;
- determine how ideas are related to one another;
- ascertain the unstated assumptions involved in what is said;
- distinguish dominant from subordinate ideas or themes in poetry or music; and
- find evidence in support of the author's purposes.

The process categories of *Understand, Analyze,* and *Evaluate* are interrelated and often used iteratively in performing cognitive tasks. At the same time, however, it is important to maintain them as separate process categories. A person who understands a communication may not be able to analyze it well. Similarly, someone who is skillful in analyzing a communication may evaluate it poorly.

4.1 DIFFERENTIATING

Differentiating involves distinguishing the parts of a whole structure in terms of their relevance or importance. *Differentiating* occurs when a student discriminates relevant from irrelevant information, or important from unimportant information, and then attends to the relevant or important information. *Differentiating* is different from the cognitive processes associated with *Understand* because it involves structural organization and, in particular, determining how the parts fit into the overall structure or whole. More specifically, *differentiating* differs from *comparing* in using the larger context to determine what is relevant or important and what is not. For instance, in *differentiating* apples and oranges in the context of fruit, internal seeds are relevant, but color and shape are irrelevant. In *comparing*, all of these aspects (i.e., seeds, color, and shape) are relevant. Alternative terms for *differentiating* are discriminating, selecting, distinguishing, and focusing.

SAMPLE OBJECTIVES AND CORRESPONDING ASSESSMENTS In the social sciences, an objective could be to learn to determine the major points in research reports. A corresponding assessment item requires a student to circle the main points in an archeological report about an ancient Mayan city (such as when the city began and when it ended, the population of the city over the course of its existence, the geographic location of the city, the physical buildings in the city, its economic and cultural function, the social organization of the city, why the city was built and why it was deserted).

Similarly, in the natural sciences, an objective could be to select the main steps in a written description of how something works. A corresponding assessment item asks a student to read a chapter in a book that describes lightning formation and then to divide the process into major steps (including moist air rising to form a cloud, creation of updrafts and downdrafts inside the cloud, separation of charges within the cloud, movement of a stepped leader downward from cloud to ground, and creation of a return stroke from ground to cloud).

Finally, in mathematics, an objective could be to distinguish between relevant and irrelevant numbers in a word problem. An assessment item requires a student to circle the relevant numbers and cross out the irrelevant numbers in a word problem.

Assessment Formats *Differentiating* can be assessed with constructed response or selection tasks. In a constructed response task, a student is given some material and is asked to indicate which parts are most important or relevant, as in this example: "Write the numbers that are needed to solve this problem: Pencils come in packages that contain 12 each and cost $2.00 each. John has $5.00 and wishes to buy 24 pencils. How many packages does he need to buy?" In a selection task, a student is given some material and is asked to choose which parts are most important or relevant, as in this example: "Which numbers are needed to solve this problem? Pencils come in packages that contain 12 each and cost $2.00 each. John has $5.00 and wishes to buy 24 pencils. How many packages does he need to buy? (a) 12, $2.00, $5.00, 24; (b) 12, $2.00, $5.00; (c) 12, $2.00, 24; (d) 12, 24."

4.2 Organizing

Organizing involves identifying the elements of a communication or situation and recognizing how they fit together into a coherent structure. In *organizing*, a student builds systematic and coherent connections among pieces of presented information. *Organizing* usually occurs in conjunction with *differentiating*. The student first identifies the relevant or important elements and then determines the overall structure within which the elements fit. *Organizing* can also occur in conjunction with *attributing*, in which the focus is on determining the author's intention or point of view. Alternative terms for *organizing* are structuring, integrating, finding coherence, outlining, and parsing.

Sample Objectives and Corresponding Assessments In *organizing*, when given a description of a situation or problem, a student is able to identify the systematic, coherent relationships among relevant elements. A sample objective in social studies could be to learn to structure a historical description into evidence for and against a particular explanation. A corresponding assessment item asks a student to write an outline that shows which facts in a passage on American history support and which facts do not support the conclusion that the American Civil War was caused by differences in the rural and urban composition of the North and South. A sample objective in the natural sciences could be to learn to analyze research reports in terms of four sections: hypothesis, method, data, and conclusion. As an assessment, students are asked to produce an outline of a presented research report. In mathematics, a sample objective could be to learn to outline textbook lessons. A corresponding assessment task asks a student to read a textbook lesson on basic statistics and then generate a matrix that includes each statistic's name, formula, and the conditions under which it is used.

Assessment Formats *Organizing* involves imposing a structure on material (such as an outline, table, matrix, or hierarchical diagram). Thus, assessment can be based on constructed response or selection tasks. In a constructed response task, a student may be asked to produce a written outline of a passage. In a selection task, a student may be asked to select which of four alternative graphic hierarchies best corresponds to the organization of a presented passage.

4.3 Attributing

Attributing occurs when a student is able to ascertain the point of view, biases, values, or intention underlying communications. *Attributing* involves a process of deconstruction, in which a student determines the intentions of the author of the presented material. In contrast to *interpreting*, in which the student seeks to *Understand* the meaning of the presented material, *attributing* involves an extension beyond basic understanding to infer the intention or point of view underlying the presented material. For example, in reading a passage on the battle of Atlanta in the American Civil War, a student needs to determine whether the author takes the perspective of the North or the South.
An alternative term is deconstructing.

Sample Objectives and Corresponding Assessments In *attributing*, when given information, a student is able to determine the underlying point of view or intention of the author. For example, in literature, an objective could be to learn to determine the motives for a series of actions by characters in a story. A corresponding assessment task for the students having read Shakespeare's *Macbeth* is to ask what motive(s) Shakespeare attributed to Macbeth for the murder of King Duncan. In social studies, a sample objective could be to learn to determine the point of view of the author of an essay on a controversial topic in terms of his or her theoretical perspective. A corresponding assessment task asks a student whether a report on Amazon rain forests was written from a pro-environment or pro-business point of view. This objective is also applicable to the natural sciences. A corresponding assessment task asks a student to determine whether a behaviorist or a cognitive psychologist wrote an essay about human learning.

Assessment Formats *Attributing* can be assessed by presenting some written or oral material and then asking a student to construct or select a description of the author's or speaker's point of view, intentions, and the like. For example, a constructed response task is "What is the author's purpose in writing the essay you read on the Amazon rain forests?" A selection version of this task is "The author's purpose in writing the essay you read is to: (a) provide factual information about Amazon rain forests, (b) alert the reader to the need to protect rain forests, (c) demonstrate the economic advantages of developing rain forests, or (d) describe the consequences to humans if rain forests are developed." Alternatively, students might be asked to indicate whether the author of the essay would (a) strongly agree, (b) agree, (c) neither agree nor disagree, (d) disagree, or (e) strongly disagree with several statements. Statements like "The rainforest is a unique type of ecological system" would follow.

5. EVALUATE

Evaluate is defined as making judgments based on criteria and standards. The criteria most often used are quality, effectiveness, efficiency, and consistency. They may be determined by the student or by others. The standards may be either quantitative (i.e., Is this a sufficient amount?) or qualitative (i.e., Is this good enough?). The standards are applied to the criteria (e.g., Is this process sufficiently effective? Is this product of sufficient quality?). The category *Evaluate* includes the cognitive processes of *checking* (judgments about the internal consistency) and *critiquing* (judgments based on external criteria).

It must be emphasized that not all judgments are evaluative. For example, students make judgments about whether a specific example fits within a category. They make judgments about the appropriateness of a particular procedure for a specified problem. They make judgments about whether two objects are similar or different. Most of the cognitive processes, in fact, require some form of judgment. What most clearly differentiates *Evaluate* as defined here from other judgments made by students is the use of standards of performance with clearly defined criteria. Is this machine working as efficiently as it should be? Is this method the best way to achieve the goal? Is this approach more cost effective than other approaches? Such questions are addressed by people engaged in *Evaluating*.

5.1 CHECKING

Checking involves testing for internal inconsistencies or fallacies in an operation or a product. For example, *checking* occurs when a student tests whether or not a conclusion follows from its premises, whether data support or disconfirm a hypothesis, or whether presented material contains parts that contradict one another. When combined with *planning* (a cognitive process in the category *Create*) and *implementing* (a cognitive process in the category *Apply*), checking involves determining how well the plan is working. Alternative terms for *checking* are testing, detecting, monitoring, and coordinating.

SAMPLE OBJECTIVES AND CORRESPONDING ASSESSMENTS In *checking,* students look for internal inconsistencies. A sample objective in the social sciences could be to learn to detect inconsistencies in persuasive messages. A corresponding assessment task asks students to watch a television advertisement for a political candidate and point out any logical flaws in the persuasive message. A sample objective in the sciences could be to learn to determine whether a scientist's conclusion follows from the observed data. An assessment task asks a student to read a report of a chemistry experiment and determine whether or not the conclusion follows from the results of the experiment.

Assessment Formats *Checking* tasks can involve operations or products given to the students or ones created by the students themselves. *Checking* can also take place within the context of carrying out a solution to a problem or performing a task, where one is concerned with the consistency of the actual implementation (e.g., Is this where I should be in light of what I've done so far?).

5.2 Critiquing

Critiquing involves judging a product or operation based on externally imposed criteria and standards. In *critiquing*, a student notes the positive and negative features of a product and makes a judgment based at least partly on those features. *Critiquing* lies at the core of what has been called critical thinking. An example of *critiquing* is judging the merits of a particular solution to the problem of acid rain in terms of its likely effectiveness and its associated costs (e.g., requiring all power plants throughout the country to restrict their smokestack emissions to certain limits). An alternative term is judging.

Sample Objectives and Corresponding Assessments In *critiquing,* students judge the merits of a product or operation based on specified or student-determined criteria and standards. In the social sciences, an objective could be to learn to evaluate a proposed solution (such as "eliminate all grading") to a social problem (such as "how to improve K–12 education") in terms of its likely effectiveness. In the natural sciences, an objective could be to learn to evaluate the reasonableness of a hypothesis (such as the hypothesis that strawberries are growing to extraordinary size because of the unusual alignment of the stars). Finally, in mathematics, an objective could be to learn to judge which of two alternative methods is a more effective and efficient way of solving given problems (such as judging whether it is better to find all prime factors of 60 or to produce an algebraic equation to solve the problem "What are the possible ways you could multiply two whole numbers to get 60?").

Assessment Formats A student may be asked to critique his or her own hypotheses or creations or those generated by someone else. The critique could be based on positive, negative, or both kinds of criteria and yield both positive and negative consequences. For example, in *critiquing* a school district's proposal for year-round schools, a student would generate positive consequences, such as the elimination of learning loss over summer vacation, and negative consequences, such as disruption of family vacations.

6. Create

Create involves putting elements together to form a coherent or functional whole. Objectives classified as *Create* have students make a new product by mentally reorganizing some elements or parts into a pattern or structure not clearly present before. The processes involved in *Create* are generally coordinated with the student's previous learning experiences. Although *Create* requires creative thinking on the part of the student, this is not completely free creative expression unconstrained by the demands of the learning task or situation.

To some persons, creativity is the production of unusual products, often as a result of some special skill. *Create,* as used here, however, although it includes objectives that call for unique production, also refers to objectives calling for production that all students can and will do. If nothing else, in meeting these objectives, many students will create in the sense of producing their own synthesis of information or materials to form a new whole, as in writing, painting, sculpting, building, and so on.

Although many objectives in the *Create* category emphasize originality (or uniqueness), educators must define what is original or unique. Can the term *unique* be used to describe the work of an individual student (e.g., "This is unique for Adam Jones") or is it reserved for use with a group of students (e.g., "This is unique for a fifth-grader")? It is important to note, however, that many objectives in the *Create* category do not rely on originality or uniqueness. The teachers' intent with these objectives is that students should be able to synthesize material into a whole. This synthesis is often required in papers in which the student is expected to assemble previously taught material into an organized presentation.

Although the process categories of *Understand, Apply,* and *Analyze* may involve detecting relationships among presented elements, *Create* is different because it also involves the construction of an original product. Unlike *Create,* the other categories involve working with a given set of elements that are part of a given whole; that is, they are part of a larger structure the student is trying to understand. In *Create,* on the other hand, the student must draw upon elements from many sources and put them together into a novel structure or pattern relative to his or her own prior knowledge. *Create* results in a new product, that is, something that can be observed and that is more than the student's beginning materials. A task that requires *Create* is likely to require aspects of each of the earlier cognitive process categories to some extent, but not necessarily in the order in which they are listed in the Taxonomy Table.

We recognize that composition (including writing) often, but not always, requires the cognitive processes associated with *Create.* For example, *Create* is not involved in writing that represents the remembering of ideas or the interpretation of materials. We also recognize that deep understanding that goes beyond basic understanding can require the cognitive processes associated with *Create.* To the extent that deep understanding is an act of construction or insight, the cognitive processes of *Create* are involved.

The creative process can be broken into three phases: problem representation, in which a student attempts to understand the task and generate possible solutions; solution planning, in which a student examines the possibilities and devises a workable plan; and solution execution, in which a student successfully carries out the plan. Thus, the creative process can be thought of as starting with a divergent phase in which a variety of possible solutions are considered as the student attempts to understand the task (*generating*). This is followed by a convergent phase, in which the student devises a solution method and turns it into a plan of action (*planning*). Finally, the plan is executed as the student constructs the solution (*producing*). It is not surprising, then, that *Create* is associated with three cognitive processes: *generating, planning,* and *producing*.

6.1 GENERATING

Generating involves representing the problem and arriving at alternatives or hypotheses that meet certain criteria. Often the way a problem is initially represented suggests possible solutions; however, redefining or coming up with a new representation of the problem may suggest different solutions. When *generating* transcends the boundaries or constraints of prior knowledge and existing theories, it involves divergent thinking and forms the core of what can be called creative thinking.

Generating is used in a restricted sense here. *Understand* also requires generative processes, which we have included in *translating, exemplifying, summarizing, inferring, classifying, comparing,* and *explaining*. However, the goal of *Understand* is most often convergent (that is, to arrive at a single meaning). In contrast, the goal of *generating* within *Create* is divergent (that is, to arrive at various possibilities). An alternative term for *generating* is hypothesizing.

SAMPLE OBJECTIVE AND CORRESPONDING ASSESSMENT In *generating*, a student is given a description of a problem and must produce alternative solutions. For example, in the social sciences, an objective could be to learn to generate multiple useful solutions for social problems. A corresponding assessment item is: "Suggest as many ways as you can to assure that everyone has adequate medical insurance." To assess student responses, the teacher should construct a set of criteria that are shared with the students. These might include the number of alternatives, the reasonableness of the various alternatives, the practicality of the various alternatives, and so on. In the natural sciences, an objective could be to learn to generate hypotheses to explain observed phenomena. A corresponding assessment task asks students to write as many hypotheses as they can to explain strawberries growing to extraordinary size. Again, the teacher should establish clearly defined criteria for judging the quality of the responses and give them to the students. Finally, an objective from the field of mathematics could be to be able to generate alternative methods for achieving a particular result. A corresponding assessment item is: "What alternative methods could you use to find what whole numbers yield 60 when multiplied together?" For each of these assessments, explicit, publicly shared scoring criteria are needed.

ASSESSMENT FORMATS Assessing *generating* typically involves constructed response formats in which a student is asked to produce alternatives or hypotheses. Two traditional subtypes are consequences tasks and uses tasks. In a consequences task, a student must list all the possible consequences of a certain event, such as "What would happen if there was a flat income tax rather than a graduated income tax?" In a uses task, a student must list all possible uses for an object, such as "What are the possible uses for the World Wide Web?" It is almost impossible to use the multiple-choice format to assess *generating* processes.

6.2 Planning

Planning involves devising a solution method that meets a problem's criteria, that is, developing a plan for solving the problem. *Planning* stops short of carrying out the steps to create the actual solution for a given problem. In *planning,* a student may establish subgoals, or break a task into subtasks to be performed when solving the problem. Teachers often skip stating *planning* objectives, instead stating their objectives in terms of *producing,* the final stage of the creative process. When this happens, *planning* is either assumed or implicit in the *producing* objective. In this case, *planning* is likely to be carried out by the student covertly during the course of constructing a product (i.e., *producing*). An alternative term is designing.

Sample Objectives and Corresponding Assessments In *planning,* when given a problem statement, a student develops a solution method. In history, a sample objective could be to be able to plan research papers on given historical topics. An assessment task asks the student, prior to writing a research paper on the causes of the American Revolution, to submit an outline of the paper, including the steps he or she intends to follow to conduct the research. In the natural sciences, a sample objective could be to learn to design studies to test various hypotheses. An assessment task asks students to plan a way of determining which of three factors determines the rate of oscillation of a pendulum. In mathematics, an objective could be to be able to lay out the steps needed to solve geometry problems. An assessment task asks students to devise a plan for determining the volume of the frustrum of a pyramid (a task not previously considered in class). The plan may involve computing the volume of the large pyramid, then computing the volume of the small pyramid, and finally subtracting the smaller volume from the larger.

Assessment Formats *Planning* may be assessed by asking students to develop worked-out solutions, describe solution plans, or select solution plans for a given problem.

6.3 Producing

Producing involves carrying out a plan for solving a given problem that meets certain specifications. As we noted earlier, objectives within the category *Create* may or may not include originality or uniqueness as one of the specifications. So it is with *producing* objectives. *Producing* can require the coordination of the four types of knowledge described in Chapter 4. An alternative term is constructing.

Sample Objectives and Corresponding Assessments In *producing,* a student is given a functional description of a goal and must create a product that satisfies the description. It involves carrying out a solution plan for a given problem. Sample objectives involve producing novel and useful products that meet certain requirements. In history, an objective could be to learn to write papers pertaining to particular historical periods that meet specified standards of scholarship. An assessment task asks students to write a short story that takes place during the American Revolution. In science, an objective could be to learn to design habitats for certain species and certain purposes. A corresponding assessment task asks students to design the living quarters of a space station. In English literature, an objective could be to learn to design sets for plays. A corresponding assessment task asks students to design the set for a student production of *Driving Miss Daisy.* In all these examples, the specifications become the criteria for evaluating student performance relative to the objective. These specifications, then, should be included in a scoring rubric that is given to the students in advance of the assessment.

Assessment Formats A common task for assessing *producing* is a design task, in which students are asked to create a product that corresponds to certain specifications. For example, students may be asked to produce schematic plans for a new high school that include new ways for students to conveniently store their personal belongings.

Decontextualized and Contextualized Cognitive Processes

We have examined each cognitive process in isolation (i.e., as decontextualized processes). In the next section we examine the processes within the context of a particular educational objective (i.e., as contextualized processes). In this way, we are reuniting cognitive processes with knowledge. Unlike decontextualized processes (e.g., planning), contextualized processes occur within a specific academic context (e.g., planning the composition of a literary essay, planning to solve an arithmetic word problem, or planning to perform a scientific experiment).

Although it may be easier to focus on decontextualized cognitive processes, two findings from research in cognitive science point to the important role of context in learning and thinking (Bransford, Brown, and Cocking, 1999; Mayer, 1992; Smith, 1991). First, research suggests that the nature of the cognitive process depends on the subject matter to which it is applied (Bruer, 1993; Mayer, 1999; Pressley and Woloshyn, 1995). For example, learning to plan solutions to mathematics problems is different from learning to plan the composition of literary essays. Consequently, experience in planning in mathematics does not necessarily help a student learn to plan essay compositions. Second, research on authentic assessment suggests that the nature of a process depends on the authenticity of the task to which it is applied (Baker, O'Neil, and Linn, 1993; Hambleton, 1996). For example, learning to generate writing plans (without actually writing an essay) is different from learning to generate plans within the context of actually producing an essay.

Although we have described the cognitive processes individually, they are likely to be used in coordination with one another to facilitate meaningful school learning. Most authentic academic tasks require the coordinated use of several cognitive processes as well as several types of knowledge. For example, to solve a mathematical word problem, a student may engage in:

- *interpreting* (to understand each sentence in the problem);
- *recalling* (to retrieve the relevant *Factual knowledge* needed to solve the problem);
- *organizing* (to build a coherent representation of the key information in the problem, that is, *Conceptual knowledge*);
- *planning* (to devise a solution plan); and
- *producing* (to carry out the plan, that is, *Procedural knowledge*) (Mayer, 1992).

Similarly, to write an essay, a student may engage in:

- *recalling* (to retrieve relevant information that may be included in the essay);
- *planning* (to decide what to include in the essay, determine what to say, and how to say it);
- *producing* (to create a written product); and
- *critiquing* (to make sure the written essay "makes sense") (Levy and Ransdell, 1996).

AN EXAMPLE OF EDUCATIONAL OBJECTIVES IN CONTEXT

In simplest terms, our revised framework is intended to help teachers teach, learners learn, and assessors assess. Suppose, for example, that a teacher has a very general objective for her students: She wants them to learn about Ohm's law. She devises an instructional unit accordingly. Because of the vagueness of the objective, this unit potentially includes all four types of knowledge: *Factual, Conceptual, Procedural,* and *Metacognitive.* An example of *Factual knowledge* is that current is measured in amps, voltage in volts, and resistance in ohms. An example of *Procedural knowledge* is the steps involved in using the formula for Ohm's law (voltage = current × resistance) to compute a numerical value.

Although these two types of knowledge are the most obvious to include in this unit, a deeper understanding of Ohm's law requires the other two types of knowledge: *Conceptual* and *Metacognitive.* An example of *Conceptual knowledge* is the structure and workings of an electrical circuit that consists of batteries, wires, and a light bulb. An electrical circuit is a conceptual system in which there are causal relations among the elements (e.g., if more batteries are added in serial, the voltage increases, which causes an increase in the flow of electrons in the wires as measured by an increase in current). As an example of *Metacognitive knowledge,* the teacher may intend students to know when to use mnemonic strategies for memorizing the name of the law, the formula, and similar relevant items. She also may want them to establish their own goals for learning Ohm's law and its applications.

Remembering What Was Learned

A restricted set of objectives for the unit on Ohm's law could focus solely on promoting retention. Objectives for promoting retention are based primarily on the cognitive process category *Remember*, which includes *recalling* and *recognizing factual, procedural, conceptual,* and *metacognitive knowledge.* For example, an objective for *recalling factual knowledge* is that students will be able to *recall* what the letters stand for in the formula for Ohm's law. An objective for *recalling procedural knowledge* is that students will be able to *recall* the steps involved in applying Ohm's law.

Although these are the obvious kinds of retention-type objectives to include in the unit, it is also possible to develop retention-type objectives that involve *Conceptual* and *Metacognitive knowledge*. For *Conceptual knowledge*, an objective is that students will be able to draw, from memory, a picture of an electrical circuit. Because this objective focuses on *recalling*, each student's drawing is evaluated in terms of how closely it corresponds to a picture presented in the textbook or previously on the chalkboard. Students may answer questions about *Conceptual* and *Metacognitive knowledge* in a rote manner, relying exclusively on previously presented material. When the overall purpose of the unit is to promote transfer of learning, *Remember* objectives need to be supplemented with objectives that involve more complex cognitive processes.

Finally, an objective pertaining to *recalling metacognitive knowledge* is that students remember "When stuck in a hole, stop digging." In other words, when their first approach to solving a problem or arriving at an answer is not succeeding, they remember to stop and assess other possible approaches. Again, with the emphasis on *Remember*, students may be queried about whether, when their first approach to a problem bogged down, they remembered the slogan. If student answers are being graded, students will give the response they know the teacher desires (i.e., "Of course, I did"), so this assessment task works only where students realize its purpose is to help them improve their learning.

Making Sense of and Using What Was Learned

When the concern of the teacher turns to promoting transfer, he or she needs to consider the full range of cognitive process categories. Consider the myriad of possibilities inherent in the following list:

- An objective for *interpreting factual knowledge*: "Students should be able to define key terms (e.g., *resistance*) in their own words."
- An objective for *explaining conceptual knowledge*: "Students should be able to explain what happens to the rate of current in an electrical circuit when changes are made in the system (e.g., two batteries that were connected in serial are reconnected in parallel)."
- An objective for *executing procedural knowledge*: "The student will be able to use Ohm's law to compute the voltage when given the current (in amperes) and the resistance (in ohms)."
- An objective for *differentiating conceptual knowledge*: "The student will be able to determine which information in word problems involving Ohm's

law (e.g., wattage of light bulb, thickness of wire, voltage of battery) is needed to determine the resistance."

- An objective for *checking procedural knowledge*: "The student will be able to determine whether a worked-out solution to a problem involving Ohm's law is likely to be effective in solving it."
- An objective for *critiquing metacognitive knowledge*: "The student will be able to choose a plan for solving problems involving Ohm's law that is most consistent with his or her current level of understanding."
- An objective for *generating conceptual knowledge*: "The student will be able to generate alternative ways of increasing the brightness of the light in a circuit without changing the battery."

We can summarize the entire set of objectives in this instructional unit on Ohm's law using the Taxonomy Table (see Table 5.2). The Xs indicate objectives that are included in this unit based on the examples we gave. Not all cells are filled; thus, not all possible combinations of cognitive process and knowledge are included in the unit. Nonetheless, it is clear that the unit includes a variety of objectives that go beyond *remember factual knowledge*. Our focus on objectives in instructional units suggests that the most effective way of teaching and assessing educational objectives may be to embed them within a few basic contexts (such as an instructional unit) rather than to focus on each in isolation. We return to this theme later.

CONCLUSION

A major goal of this chapter is to examine how teaching and assessing can be broadened beyond an exclusive focus on the cognitive process *Remember*. We described 19 specific cognitive processes associated with six process categories. Two of these cognitive processes are associated with *Remember*; 17 are associated with the process categories beyond it: *Understand, Apply, Analyze, Evaluate,* and *Create*.

Our analysis has implications for both teaching and assessing. On the teaching side, two of the cognitive processes help to promote retention of learning, whereas 17 of them help to foster transfer of learning. Thus, when the goal of instruction is to promote transfer, objectives should include the cognitive processes associated with *Understand, Apply, Analyze, Evaluate,* and *Create*. The descriptions in this chapter are intended to help educators generate a broader range of educational objectives that are likely to result in both retention and transfer.

On the assessment side, our analysis of cognitive processes is intended to help educators (including test designers) broaden their assessments of learning. When the goal of instruction is to promote transfer, assessment tasks should tap cognitive processes that go beyond remembering. Although assessment tasks that tap *recalling* and *recognizing* have a place in assessment, these tasks can (and often should) be supplemented with those that tap the full range of cognitive processes required for transfer of learning.

5.2 Completed Taxonomy Table for Hypothetical Ohm's Law Unit

The Knowledge Dimension	The Cognitive Process Dimension					
	1. Remember	2. Understand	3. Apply	4. Analyze	5. Evaluate	6. Create
A. Factual knowledge	X	X				
B. Conceptual knowledge	X	X		X		X
C. Procedural knowledge	X		X		X	
D. Meta-cognitive knowledge	X				X	

SECTION III

The Taxonomy in Use

CHAPTER 6

Using the Taxonomy Table

In this major section we demonstrate how educators can use the Taxonomy Table to help teachers and other educators in at least three ways. First, it can help them gain a more complete understanding of their objectives (both those they choose for themselves and those that are provided by others); that is, the table can help educators answer what we refer to as the "learning question" (see page 6). Second, from this understanding, teachers can use the table to make better decisions about how to teach and assess their students in terms of the objectives; that is, the table can help educators answer the "instruction question" and the "assessment question" (see pages 7–8). Third, it can help them determine how well the objectives, assessments, and instructional activities fit together in a meaningful and useful way; that is, the table can help educators answer the "alignment question" (see page 10). In this initial chapter we address these questions in the context of an example that involves the teaching of science to illustrate how using the Taxonomy Table can help educators.

Using the Taxonomy Table in Analyzing Your Own Work

Before we revisit the Taxonomy Table and explore how it can be helpful, we have an important word for teachers who are planning to use the framework to guide the development of curriculum units: Your use of the framework will be less complex than what is presented in this and the following chapters because we are analyzing units prepared by others. This requires us to take the stance of an observer attributing intended meaning to objectives, instructional activities, and assessments. The result appears complicated because we make hypotheses about what was meant and then we have to check them against other evidence for confirmation.

As an example, we interrupt the narrative of Chapter 8, the first vignette, with analyses that make trial inferences about what Ms. Nagengast, the teacher, meant by certain actions so that we can relate them to the Taxonomy. If Ms. Nagengast had done the analysis herself, the vignette would have looked quite different and been much simpler. It would also have been less instructive about the Taxonomy framework, however (which is why we didn't present it that way). The trial inferences illustrate the distinctions among categories and show how the various categories are used.

If she were doing the analysis herself, Ms. Nagengast would have an internal idea of what she is seeking to teach. Then the framework would become a reference to use as she develops the unit. As part of the unit development process, she would reflect on her actions and decisions by answering questions such as those that follow.

"In stating my objective, do the words I use describe what I intend?" A teacher may use the word "explain" when she does not mean "to construct a causal model" (our definition). Rather, she might mean interpret or summarize. Although all three of these cognitive processes are in the category *Understand*, the choice of one over the other has different implications for instruction and assessment. Using the Taxonomy's terms can add precision.

"Is the objective that can be inferred from my instructional activities consistent with my statement of the objective?" When both objectives and instructional activities are translated into the Taxonomy framework, do they point to the same types of knowledge and the same cognitive processes? Several factors can guide a teacher's choice of instructional activities. Are students interested in them? Do they enjoy them? Are they likely to engage in them? Do I have the resources I need to support them (e.g., the equipment needed for a laboratory experiment)? If activities are selected mainly on these criteria, their link with the stated objective may become eroded. Thus, inferring objectives from instructional activities and relating them to the intended objective are the means to ensure that instructional activities are "on target."

"Are my assessments valid?" When one classifies the assessments in the Taxonomy framework, do they align with the stated objectives? At the very least, validity means that the assessment used by the teacher provides him or her with information about how well the students achieved (or are achieving) the objective. Inferences about objectives based on assessments can come from two sources. The first is the actual assessment tasks (e.g., test items, project directions). This source is sufficient when select-type formats with correct answers are used (e.g., multiple choice, matching). The second source is the criteria used to score or evaluate student performance on the assessment tasks (e.g., scoring keys, rating scales, scoring rubrics). This source becomes necessary when extended-response formats are used (e.g., essays, research reports). The question here is whether inferences based on the assessments lead back to the stated objectives.

Using the Taxonomy Table in Analyzing the Work of Others

When anyone uses the framework to analyze the work of others, they encounter the same complexities we faced in our vignette analyses. Teachers may be handed objectives (e.g., state or local standards) or assessments prepared by others (e.g., statewide or standardized tests). They may be asked to analyze another teacher's units or conduct observations in fellow teachers' classrooms. These analyses all require attributions of intent, which are difficult when objectives lack important words or phrases or when peripheral words or phrases are misleading. Even the key words and phrases do not always mean what they seem to mean. In addition, words (i.e., the statement of the objective) and actions (i.e., the instructional activities and assessments related to the objective) may be inconsistent. For all these reasons, placing an objective in the Taxonomy Table requires that one determine the intentions of the teacher [or author(s) in the case of materials prepared by others] in relation to the meaning of the objective, the purpose of the instructional activities, and the aim of the assessments.

On page 34, we stated that the use of multiple sources of information is likely to result in the most valid and defensible classification of objectives. In the next section we begin to explore why this is so.

The Taxonomy Table Revisited

The two-dimensional Taxonomy Table, shown earlier as Table 3.1, is reproduced on the inside front cover of this book. Tables 4.1 and 5.1, which summarize the knowledge and cognitive process dimensions, are printed on the front and back covers, respectively and on the next page. We encourage you to refer to these tables while reading the remainder of this chapter.

The Learning Question

Let us begin with a seemingly straightforward objective: "Students should learn to use laws of electricity and magnetism (such as Lenz' law and Ohm's law) to solve problems." To place this objective in the Taxonomy Table, we must examine the verb and noun phrase in relation to the categories of the table. Specifically, we must relate the verb, "use," to one of the six major cognitive process categories and the noun phrase, "laws of electricity and magnetism," to one of the four types of knowledge. The verb is fairly easy: "use" is an alternative name for *implement* (see inside back cover), which is associated with the category *Apply*. With respect to the noun, laws are principles or generalizations, and knowledge of principles and generalizations is *Conceptual knowledge*. If our analysis is correct, then, this objective should be placed in the cell of the Taxonomy Table that corresponds to the intersection of *Apply* and *Conceptual knowledge* (cell B3; see Table 6.1. Note in Table 6.1 that the four types of knowledge form the rows labeled A through D, and the six processes form the columns labeled 1 through 6. A cell can thus be designated by a letter and a number to indicate its intersection of a row and a column). Now we have answered the "learning question." We want students to learn to *apply conceptual knowledge*.

In this analysis we relied on knowledge subtypes (e.g., *knowledge of principles and generalizations*) and specific cognitive processes (e.g., *implementing*) rather than on the four major types of knowledge and the six cognitive process categories. Based on our collective experience, we believe subtypes and specific processes provide the best clues to the proper placement of objectives in the Taxonomy Table. Note also that we based our decisions on assumptions we

6.1 Placement of the Objective in the Taxonomy Table

The Knowledge Dimension	The Cognitive Process Dimension					
	1. Remember	2. Understand	3. Apply	4. Analyze	5. Evaluate	6. Create
A. Factual knowledge						
B. Conceptual knowledge			Objective			
C. Procedural knowledge						
D. Meta-cognitive knowledge						

Key.
Objective = the objective, "Students should learn to use laws of electricity and magnetism (such as Lenz' law and Ohm's law) to solve problems."

made about the teacher's intention. For example, our inference that we are dealing with *implementing* rather than *executing* is supported not only by the inclusion of the verb "use" but also by the phrase "in problems" in the statement of the objective. Because problems are unfamiliar (rather than familiar) tasks (see page 77), *implementing* seems more appropriate than *executing* (see inside back cover).

THE INSTRUCTION QUESTION

Although the objective can be classified in one cell (see Table 6.1), when we consider different instructional activities a teacher may use, we see a much more complex and differentiated picture. For example, in general, if students are to implement scientific laws, they might (1) determine the type of problem they are confronting, (2) select a law that will likely solve that type of problem, and (3) use a procedure in which the law is embedded to solve the problem. As we described on pages 78–79, then, *implementing* involves both *Conceptual knowledge* (i.e., knowledge of the type or category of problem) and *Procedural knowledge* (i.e., knowledge of the steps to follow to solve the problem). Instructional activities might help students develop both types of knowledge.

Note the verbs used in the decomposition of this single objective: "determine," "select," and "use." From Table 5.1, inside back cover, we see that determining that something belongs to a category is the definition of *classifying (Understand)*, selecting is an alternative term for *differentiating (Analyze)*, and using is an alternative term for *implementing (Apply)*. The instructional activities should help students engage in *classifying* and *differentiating* as well as *implementing*.

Because students may make errors in *classifying*, *differentiating*, and *implementing*, it also seems reasonable to emphasize *Metacognitive knowledge* during instruction. For example, students might be taught strategies for monitoring their decisions and choices to see whether they "make sense." "How do I know this problem is a certain type?" "If it is, how do I know which laws to use?" In addition to being able to *recall* these strategies, students may be taught to *implement* them.

Finally, it may be advisable to focus some of the instructional activities on so-called higher-order cognitive processes. Because *implementation* often involves making choices along the way, students should be taught to check as they go and critique the final result or solution. Both *checking* and *critiquing* fall in the *Evaluate* category.

The answer to the "instruction question," then, is far more complicated that it would appear to be at first blush. Instructional activities might provide opportunities for students to develop at least three types of knowledge (*Conceptual*, *Procedural*, and *Metacognitive*) and engage in at least six cognitive processes (*recalling*, *classifying*, *differentiating*, *implementing*, *checking*, and *critiquing*) associated with five process categories (*Remember*, *Understand*, *Apply*, *Analyze*, and *Evaluate*). An analysis of the instructional activities in terms of the Taxonomy Table, then, results in many more cells being included (see Table 6.2).

6.2 Placement of the Objective and Instructional Activities in the Taxonomy Table

The Knowledge Dimension	The Cognitive Process Dimension					
	1. Remember	2. Understand	3. Apply	4. Analyze	5. Evaluate	6. Create
A. Factual knowledge						
B. Conceptual knowledge		*Activity 1*	**Objective**	*Activity 2*	*Activity 7*	
C. Procedural knowledge			*Activity 3*		*Activity 6*	
D. Meta-cognitive knowledge	*Activity 4*		*Activity 5*			

Key.
Objective = the objective, "Students should learn to use laws of electricity and magnetism (such as Lenz' law and Ohm's law) to solve problems."
Activity 1 = activities intended to help students classify types of problems
Activity 2 = activities intended to help students select appropriate laws
Activity 3 = activities intended to help students implement proper procedures
Activity 4 = activities intended to help students recall metacognitive strategies
Activity 5 = activities intended to help students implement metacognitive strategies
Activity 6 = activities intended to help students check their implementation of the procedure
Activity 7 = activities intended to help students critique the correctness of their solution

An examination of the relationship of the single cell that contains the objective (B3) to the seven cells that contain the instructional activities (B2, B4, B5, C3, C5, D1, and D3) produces an interesting result; namely, none of the instructional activities pertains directly to the objective. The reason for this is clear from our definition of *Apply* (see inside back cover). *Apply* means to carry out or use a procedure in a given situation. In other words, *Apply* requires *Procedural knowledge*. Therefore, if laws of electricity and magnetism (*Conceptual knowledge*) are to be applied, they must be embedded within a procedure (*Procedural knowledge*). The procedure typically "unpacks" the laws in a way that facilitates their application (e.g., first, calculate or estimate the electromotive force in volts; second, calculate or estimate the current in amperes; third, divide the electromotive force by the current to yield the resistance). Earlier consideration of the relationship between *Apply* and *Procedural knowledge* might have suggested that we initially classify the objective as *apply procedural knowledge* (C3) instead of *apply conceptual knowledge* (B3).

THE ASSESSMENT QUESTION

Suppose a teacher has spent several days of instruction on this objective and wants to know how well her students are learning. She has a number of decisions to make, including these three important ones: Does she focus her assessment only on the cell that contains the objective, or does she assess the effectiveness of the various instructional activities as well? Does she integrate assessment with her instruction (i.e., formative assessment), or does she conduct a more independent assessment for the purpose of assigning grades (i.e., summative assessment)? How does she know that her assessment tasks require the students to engage in *implementing* rather than *executing* (or some other cognitive process)?

FOCUSED VERSUS DISTRIBUTED ASSESSMENT Our initial analysis, based solely on the statement of the objective, suggests that the teacher focus her assessment on the extent to which students have learned to *apply conceptual knowledge* (cell B3). In contrast, our more detailed analysis, based on relevant and appropriate instructional activities, suggests the teacher assess the wide variety of cells related to attaining the primary objective (B2, B4, B5, C3, C5, D1, and D3). The trade-off seems to be breadth versus depth. On the one hand, the focused assessment permits the teacher to probe the depths of student learning relative to a single objective. A variety of different problems related to this objective can be included on a single assessment. On the other hand, a more distributed assessment permits the teacher to examine broadly the processes involved in the attainment of the target objective. The broader testing not only assesses the primary objective in the context of related knowledge and cognitive processes, but also may permit a diagnosis of the student's underlying difficulties where, for example, a contributing aspect of *Procedural knowledge* is not adequately learned.

FORMATIVE VERSUS SUMMATIVE ASSESSMENT Formative assessment is concerned with gathering information about learning as learning is taking place, so that "in-flight" instructional modifications may be made to improve the quality or amount of learning. In contrast, summative assessment is concerned with gathering information about learning after the learning should have occurred, usually for the purpose of assigning grades to students. Thus, formative assessment is used primarily to improve student learning; summative assessment is used primarily to assign grades. Class work and homework are often used in formative assessment; more formal tests are used as a means of summative assessment.

ASSESSING IMPLEMENTING VERSUS EXECUTING Because *implementing* and *executing* are both associated with *Apply*, it is important to distinguish between them if the results of the assessment are to be valid. If assessment tasks do not include unfamiliar tasks and/or do not require students to select relevant and appropriate *Procedural knowledge*, then it is more likely that *executing* rather than *implementing* is being assessed. As we mentioned in the discussion of *interpreting* (see page 71), using assessment tasks that are new to the student is a primary method of ensuring that students respond to the assessments at the most complex cognitive process called for in the objective.

ASSESSMENT AND THE TAXONOMY TABLE Continuing with our example, let us suppose that the teacher decides she is as concerned about students using the correct procedure as she is about their getting the right answer. The teacher sees the assessment as formative in nature. She gives her students ten electrical and mechanical problems and asks them to solve each problem, showing their work.

As we did for the objective and the instructional activities, we can examine the assessment in terms of the Taxonomy Table. In this case, we would focus on the assigned point values. For each of the ten problems, score points are given for "selecting a correct procedure." The teacher's scoring rubric requires that students are able to classify the problem correctly *(understanding conceptual knowledge*, one point), select the appropriate law (*analyzing conceptual knowledge*, one point), and select a procedure that follows from the law and is likely to solve the problem (*analyzing procedural knowledge*, one point). Since she considers the procedure and the result to be equally important, having given three points for selecting the correct procedure for solving each problem, she gives three points for arriving at the correct solution to the problem (i.e., *implementing procedural knowledge*). Once again, the results of our analysis can be summarized in terms of the Taxonomy Table (see Table 6.3).

THE ALIGNMENT QUESTION

Since the entries in Tables 6.1 and 6.2 are reproduced in Table 6.3, we can address the alignment question by focusing on Table 6.3. Specifically, one can examine the cells that contain the objective, the instructional activities, the assessments, and various combinations of these. Cells that contain an objective, one or more instructional activities, and some aspect of assessment indicate a high degree of alignment. In contrast, cells that contain only the objective or only an instructional

6.3 Placement of the Objective, Instructional Activities, and Assessment in the Taxonomy Table

The Knowledge Dimension	The Cognitive Process Dimension					
	1. Remember	2. Understand	3. Apply	4. Analyze	5. Evaluate	6. Create
A. Factual knowledge						
B. Conceptual knowledge		*Activity 1* Test 1A	**Objective**	*Activity 2* Test 1B	*Activity 7*	
C. Procedural knowledge			*Activity 3* Test 2	[Objective as Refocused—See Page 104] Test 1C	*Activity 6*	
D. Meta-cognitive knowledge	*Activity 4*		*Activity 5*			

Key
Objective = the objective, "Students should learn to use laws of electricity and magnetism (such as Lenz' law and Ohm's law) to solve problems."
Activity 1 = activities intended to help students classify types of problems
Activity 2 = activities intended to help students select appropriate laws
Activity 3 = activities intended to help students implement proper procedures
Activity 4 = activities intended to help students recall metacognitive strategies
Activity 5 = activities intended to help students implement metacognitive strategies
Activity 6 = activities intended to help students check their implementation of the procedure
Activity 7 = activities intended to help students critique the correctness of their solution
Test 1A, Test 1B, Test 1C = cells associated with the procedural aspect of each problem, Test 2 = cell associated with the correct "answer"

activity or only some aspect of assessment indicate weak alignment. This interpretation, however, requires that a basic assumption be made. Because the completed table represents our inferences, we must assume that we made reasonably valid inferences on the statement of objective, our analysis of the instructional activities, and our examination of the assessment. This assumption enables us to differentiate misclassification from misalignment.

If we assume correct classification from these three sources (i.e., the statement of objective, the instructional activities, and the assessment), then Table 6.3 presents evidence of both alignment and misalignment. For example, cell C3 (*apply procedural knowledge*) includes both an instructional activity and a score point on the assessment. If the objective were properly classified, in line with our earlier discussion, this would increase the alignment. Similar alignment appears in cells B2 and B4, which also contain an instructional activity and a score point on the assessment.

At the same time, looking at Table 6.3, we see misalignment, which appears to stem from three sources.

- Having a "disconnect" between the verb and noun in the statement of the objective. "Use," being an alternative term for *implement*, is associated with the category *Apply* (see the inside back cover). *Procedural knowledge* is typically associated with *Apply*. We approached the analysis of the noun phrase "laws of electricity and magnetism" with this in mind. Thus, rather than focusing on knowledge of "laws" as *Conceptual knowledge* (which it is), we should focus on procedures for using the laws to solve problems—*Procedural knowledge*. In light of this "re-focus" on the procedures instead of the laws, the objective should be classified in cell C3 (*apply procedural knowledge*), rather than in cell B3 (*apply conceptual knowledge*). That classification gives the strongest possible alignment in cell C3: The objective, instructional activity, and assessment would all be present there.
- Including instructional activities that are not assessed and thus provide no information for the diagnosis of learning problems. Examples in Table 6.3 include ACT4 (remembering they should check their progress as they work on each problem), ACT6 (determining whether their progress is satisfactory), ACT5 (making modifications based on their "progress checks," if needed), and ACT7 (checking the accuracy of their final solution). All four relate to the process of reviewing work "in progress." Simply asking students whether they had done the reviews would reinforce the importance of doing so. Furthermore, individually querying those students who reported reviewing but still arrived at the wrong solution might help them find mistakes in their own work and how they typically attack such problems.
- Awarding points (cell C4) based on the problem-solving process that either was not emphasized during the instructional activities or, if it was, was not linked with any stated objective.

Based on the analysis using the Taxonomy Table, the teacher can make changes in the statement of the objective, the instructional activities, or the assessment tasks or evaluation criteria to increase the overall alignment.

PROBLEMS IN CLASSIFYING OBJECTIVES

Because the classification of objectives, whether the objectives are stated, implicit in instructional activities, or deduced from assessments, requires that inferences be made, there are many instances in which the classification is not easy. The editors of the original *Handbook* noted problems inherent in the classification of objectives. We pose these problems as questions:

- Am I working at the level of specificity at which the Taxonomy Table is most useful?
- Have I made correct assumptions about students' prior learning?
- Does the objective as stated describe an intended learning result, not activities or behaviors that are "means to an end"?

THE LEVEL OF SPECIFICITY PROBLEM

As we discussed on page 15, educational objectives can be written at three levels of specificity. They can be general program goals to be achieved over a year or a number of years, objectives for a particular course or unit within a course, or objectives for a particular lesson within a unit (Krathwohl, 1964; Krathwohl and Payne, 1971). The Taxonomy is designed to be most useful in planning instruction and assessment at the course or unit level. As we demonstrate in the vignette analyses, however, the Taxonomy has implications for learning activities and assessment tasks at the daily lesson level as well.

A useful test of the specificity of an objective is to ask whether, after having read it, you can visualize the performance of a student who has achieved it. "What would a student have to do to demonstrate that he or she has learned what I intended him or her to learn?" If you envision a variety of different performances, you probably ought to ask, "What performance is the most representative of the achievement of this objective?" Discerning this central performance narrows broad objectives down to the more specific ones that are needed to use the Taxonomy Table.

Consider, for example, this global objective: "The student should learn to be a good citizen in a democracy." What pictures come to mind when you try to visualize the actions of a student who has mastered this global objective? Probably lots of things: Voting? Protection of minority viewpoints? Acceptance of majority rule? Each of these suggests a more specific objective that, in combination, could help the student move toward the broad citizenship goal. An example might be: "The student will learn a variety of strategies for resolving group conflicts (e.g., voting, mediation)." The somewhat more specific objectives are the most appropriate for use with the Taxonomy Table.

THE PRIOR LEARNING PROBLEM

To classify an objective correctly, one must make assumptions about students' prior learning. This is most obvious when a student experiences an instructional activity or assessment task that he or she has encountered before. In such cases, an activity or task that is intended to evoke a more complex cognitive process (e.g., *Analyze*) will not do so because the student has only to *Remember* the prior experience. If we intend students to learn to *Analyze*, we must do what we can to ensure that instructional activities and assessments evoke the complex processes intended.

In the same vein, an objective may fall into different cognitive process categories with increasing grade levels. What is a more complex objective in the early grades may become a less complex objective in later grades. For example, a mathematics objective in grade 3 that requires *differentiating* in order to painstakingly sort out what is needed to solve a particular problem type may require in grade 4 *implementing* because the identification of that problem type has become routine. By grade 5, this same objective may require *executing* because problem solution is almost automatic, and by grade 6, the objective may require simple *recalling* because all the common problem types likely to be used in instruction and assessment have already been encountered.

Thus, to reach agreement about the classification of objectives, teachers must have some knowledge or make an assumption about the students' prior learning. This is probably the single most common and most difficult problem to overcome when trying to classify an objective in the abstract without reference to any specific group and/or grade level or when using the Taxonomy Table with no information provided about students' prior learning.

Differentiating Objectives from Activities

In working with the Taxonomy Table, one sometimes finds (as those of us who worked on this project often did) that it is easy to slip into the mode of trying to categorize learning activities rather than intended learning outcomes. To test the framework, one of us would suggest a verb—for instance, "estimating"—and ask where it belongs. Initially, we found that estimating was difficult to categorize. When we paired it with knowledge so that it became an objective, however, classifying became much easier. Consider the following: "Students should learn to estimate the product of two large numbers." This objective reduces to students learning a three-step procedure: (1) rounding to the nearest power of ten, (2) multiplying the remaining one-digit, non zero numbers, and (3) adding the correct number of zeros. In this context, estimating means *executing* an estimation procedure, or *applying procedural knowledge*.

Sometimes one of us would suggest a silly activity like "doodling" and ask where it would fit. Not only is "doodling" unlikely to appear in an educational objective, but if it were to appear, it once again would have to be in a knowledge context to be classifiable. For example, "The student will learn that doodling helps him or her to relieve stress temporarily when working on difficult problems." This might be a strategy within *Metacognitive knowledge*. The phrase "learn that" suggests simple *recall* (i.e., "know that"). The objective, then, would take the form *remember metacognitive knowledge*. The point is that it makes sense to try to classify "doodling" when it is placed in a knowledge context; without that context, it makes no sense.

We have one final point in this regard: Many "verbs," particularly those associated with undesirable student behavior (e.g., disrupt, agitate), are not likely to be included in statements of educational objectives. Consequently, they are not usefully classified within our framework.

Some Helpful Hints

In light of the problems and based on our combined experience in the field, we offer four helpful hints that should increase your probability of classifying objectives correctly: (1) consider the verb-noun combination, (2) relate the knowledge type to the process, (3) make sure you have the right noun or noun phrase, and (4) rely on multiple sources.

Consider the Verb-Noun Combination

As we mentioned earlier, verbs by themselves can be misleading. Consider this objective: "Students should be able to identify various literary devices (e.g., similes, metaphors, hyperbole, personification, alliteration) used in novels." Clearly, the verb is "identify." In Table 5.1, inside back cover, identifying is an alternative term for *recognizing*, which is in the process category *Remember*. If we categorized this as a *Remember* objective, however, it would be inappropriate. A more complete reading of this objective suggests that the intention is for students to learn to identify examples of literary devices in novels. Finding examples is *exemplifying*, which is associated with the process category *Understand*. This inference is consistent with the fact that literary devices are concepts (that is, classes of things sharing common attributes). More likely, then, the objective has the form *understand conceptual knowledge*.

Relate Type of Knowledge to Process

For objectives that involve *Remember*, *Understand*, and *Apply*, there generally is a direct correspondence between process category and type of knowledge. We do intend, for example, students to recall facts (*remember factual knowledge*), interpret principles (*understand conceptual knowledge*), and execute algorithms (*apply procedural knowledge*).

When *Analyze*, *Evaluate*, and *Create* are involved, however, the correspondence between process category and type of knowledge is less predictable. Consider, for example, *evaluate conceptual knowledge*. We typically do not intend students to learn to *critique* (*Evaluate*) a set of criteria (*Conceptual knowledge*). Rather, we intend them to learn to *critique* **something** <u>based on</u> or <u>in terms of</u> the criteria. The something might be a hypothesis advanced by a scientist or a solution to a problem proposed by a legislator. The criteria on which the evaluation is based may include reasonableness and cost effectiveness, respectively. Thus, *evaluate conceptual knowledge* becomes in essence *evaluate* [based on] *conceptual knowledge* or *evaluate* [in terms of] *conceptual knowledge*.

Now consider *Create*. Again, we intend for students to learn to *create* something—poems, novel solutions to a problem, research reports. Students typically are expected to rely on more than one type of knowledge during the creative process. Suppose, for example, we intend for students to learn to write original research reports about famous Americans in history based on themes and supporting details derived from materials about them. We could classify this objective as *Create* (write original research reports) *Conceptual knowledge* (themes) and *Factual knowledge* (supporting details). This classification would be not only confusing but also likely incorrect. We do not necessarily intend for students to *create conceptual* and *factual knowledge*. However, we do intend them to *create* [original research reports based on] *conceptual* and *factual knowledge*. As in the preceding case of *Evaluate*, students are to *Create* something based on some knowledge. With *Create*, students may well use all the knowledge at their disposal (*Factual*, *Conceptual*, *Procedural*, and *Metacognitive*).

The point here is simple but important. When objectives involve the three most complex cognitive processes, knowledge provides the basis for the cognitive processes and often multiple types of knowledge are required. This idea is exemplified in several of the vignettes.

Make Sure You Have the Right Noun

As we worked with various drafts of the Taxonomy Table, we encountered statements of objectives in which the nouns and noun phrases did not help us determine the appropriate type of knowledge. In general, the verbs in these objectives indicated more complex cognitive process categories (i.e., *Analyze*, *Evaluate*, and *Create*). Consider the following examples:

- Students should learn to outline textbook lessons.
- Students should learn to critique proposed solutions to social problems.
- Students should learn to design sets for various plays.

In each case, the verb is easily identifiable and quite easily classified. Outlining is an alternative term for *organizing* [*Analyze*], *critiquing* is associated with *Evaluate*, and constructing is an alternative term for *producing* [*Create*]. The noun phrases in these cases are "textbook lessons," "proposed solutions to social problems," and "sets for various plays." What is missing from these statements, and what must be made explicit before the objectives can be classified correctly, is the knowledge that students need to organize lessons (e.g., the organizing principles), critique proposed solutions (e.g., the evaluation criteria), or plan sets (e.g., the design parameters).

Now consider a second set of objectives:

- Students should learn to analyze in a work of art the relationship of the materials used to the rendition of color.
- Students should learn to evaluate commercials seen on television or read in newspapers/magazines from the standpoint of a set of principles pertaining to "appeals."

- Students should learn to design habitats for certain species so their survival is ensured.

Like the objectives in the first set, these three objectives are concerned with *Analyze, Evaluate,* and *Create,* respectively. Unlike the objectives in the first set, however, the knowledge needed is contained in the objectives (as underlined). In the first objective, students need knowledge of the relationship of the materials used to the rendition of color. In the second objective, students need knowledge of the set of principles pertaining to "appeals." Finally, in the third objective, students need sufficient knowledge of a particular species so they can design a habitat to ensure their survival. The point here is that not all nouns and noun phrases provide useful clues to the proper classification of the objective in terms of the knowledge component. Particularly for objectives that focus on developing more complex cognitive processes, the clues pertaining to knowledge may be found in:

- the definition or description of the cognitive process itself (see, for example, our discussion of *differentiating* on pages 80–81); and/or
- the evaluation criteria or scoring rules used with the assessment.

If clues are not given in either of these sources, then there is a need to further clarify, or spell out, the knowledge in the statement of the objective.

Rely on Multiple Sources

As we began to analyze the vignettes, we learned that our understanding of the objectives of the unit increased as we considered multiple sources: the statements of the objectives, the instructional activities, and the assessment tasks and evaluation criteria. This was particularly important in those cases in which one or more of the stated objectives was a bit vague or more global than those we could classify easily. The value of multiple sources will be seen in the vignettes. Before we move to the individual vignettes, however, we explore in the next chapter how the vignettes were put together, what they "look like," and how they were analyzed.

CHAPTER 7

Introduction to the Vignettes

Based in large measure on our collective experiences in working with the original *Handbook,* we believe that a framework such as the Taxonomy Table requires numerous illustrations and a great deal of discussion before it can be adequately understood and ultimately used in classroom settings. To this end, we have developed six vignettes (see Table 7.1).

In combination, the vignettes were selected to ground the propositions advanced in the earlier chapters and to illustrate the key concepts and elements in the Taxonomy Table. The purpose of this chapter is to characterize the vignettes in our collection, spell out their central components, and suggest ways in which the Taxonomy Table can be used to aid in understanding the complex nature of classroom instruction. With increased understanding may come opportunities to improve the quality of instruction provided in our classrooms.

CHARACTERIZATION OF THE VIGNETTES

It is instructive to begin with what the vignettes are **not**. First, they do not necessarily represent "best practice," excellent teaching, or models of instruction for others to adopt or emulate. Looking at the vignettes in such an evaluative light will likely undermine our purpose for including them in this volume. We urge readers to suspend their need to evaluate and instead see the vignettes as a collection of teaching episodes within larger curriculum units written by teachers.[1] The question for the reader is not whether the vignettes represent good or bad teaching. Rather, the question is how the Taxonomy Table can help the reader make sense of the objectives, instructional activities, and assessments described by the teachers with the intent of improving their own teaching and the students' learning.

[1] Chapter 12, the Volcanoes? Here? vignette, was taught by an experienced teacher, but the vignette was prepared by Dr. Michael Smith, who observed the teaching as part of a National Science Foundation study.

TABLE 7.1 Our Collection of Vignettes

CHAPTER NUMBER	TITLE	GRADE LEVEL(S)	SUBJECT AREA
8	Nutrition	5	Health
9	*Macbeth*	12	English literature
10	Addition Facts	2	Mathematics
11	Parliamentary Acts	5	History
12	Volcanoes? Here?	6–7	Science
13	Report Writing	4	Language arts

Second, these vignettes certainly do not represent all approaches to classroom instruction at all grade levels in all subject matters in all countries of the world. Stated somewhat differently, the collection is intended to be illustrative, not exhaustive. However, we believe that our analysis of the vignettes can enable readers to analyze their own and others' learning expectations, instruction, and assessment, and to consider alternative approaches to instruction and assessment that may be more appropriate and effective in light of what students are expected to learn.

Having discussed what the vignettes are not, we now turn to what they are. First, and perhaps most important, the vignettes are real. They represent curriculum units taught in American schools by practicing teachers. The initial drafts of these vignettes varied from being fairly brief to quite expansive—almost 20 pages. Because of space limitations, the longer vignettes were edited. Nonetheless, they all contain essential descriptions of curriculum units told in the language of the teachers who taught them.

Second, the vignettes represent high levels of verisimilitude. They capture some of the complexity, ambiguity, and problematic nature of classroom instruction. These qualities should add to the wonderment the reader brings to the descriptions and allow us to show the usefulness of the Taxonomy Table. Simple linear teaching over extremely short periods of time requires little in the way of analysis.

Third, we asked the teachers to describe curriculum units, rather than briefer one- or two-day lessons. Our rationale for this decision is presented in the next section.

THE CURRICULUM UNIT

A curriculum unit consists of one or more educational objectives that require approximately two to three weeks to achieve. If there is more than one educational objective, the objectives are related in some way, often in that they pertain to the same topic (e.g., Chapter 8, Nutrition; Chapter 9, *Macbeth;* Chapter 12, Volcanoes? Here?). Interdisciplinary units (e.g., a unit on airplanes involving history, science, mathematics, and literature) and integrative units (e.g., Chapter 11, Parliamentary Acts; Chapter 13, Report Writing) are also examples of curriculum units. Within a curriculum unit, there may be several instructional objectives, each associated with a lesson that lasts one, two, or perhaps three days. In other cases, no instructional objectives are stated (although they may be implied).

A focus on curriculum units offers four advantages over a focus on daily lessons. First, curriculum units provide the time needed for more integrated, holistic learning. Over time students can be helped to see relationships and connections among ideas, materials, activities, and topics; that is, the unit structure helps them see the forest as well as the trees.

Second, curriculum units provide more flexibility in the use of available time. If a teacher runs out of time on a particular day, the activity can be carried out the next day. The availability of "flexible time" in a curriculum unit is important because, as we shall see in the vignettes, activities do not always go as planned. In addition, some students may need more time to learn than other students. Curriculum units allow teachers to accommodate these classroom realities.

Third, curriculum units provide a context for interpreting daily objectives, activities, and assessments. For example, the importance of a lesson on writing declarative sentences is often better understood in the context of a unit on writing paragraphs. Similarly, understanding the concepts of ratios and proportions can be enhanced in the context of a unit on painting and sculpture.

Finally, the larger curriculum units provide sufficient time for instructional activities that allow for the development and assessment of student learning of more complex objectives. Objectives that involve *Analyze*, *Evaluate*, and *Create* typically require longer time periods for students to learn.

Central Components of the Vignette Descriptions

To provide a common structure, one that permits comparisons to be made across the vignettes, each vignette begins with a description of the classroom context and then is divided into three major components: (1) objectives, (2) instructional activities, and (3) assessment. For each component a series of questions was written to guide teachers in the preparation of the vignettes.

For the classroom context description and the objectives component, our questions included the following:

- What are the unit objectives and how were they determined?
- How does the unit fit into the larger scheme of things (e.g., statewide standards or testing program, district curriculum, prior and/or future units, age or grade level of students)?
- What materials (e.g., texts, software, maps, videos) and equipment (e.g., computers, television, laboratory equipment) were available to you and the students?

- How much time was allocated to the unit? On what basis did you decide on the temporal length of the unit?

For the instructional activities component, we asked teachers questions such as the following:

- How was the unit introduced to the students (e.g., Was an overview of the entire unit given? Was the need for or purpose of the unit discussed with the students?)?
- In what activities were students engaged during the unit? Why were these activities selected?
- What assignments were given to students? Why were specific assignments selected?
- How did you monitor the engagement and success of students in the activities and on the assignments?

Finally, for the assessment component, we asked teachers to consider questions such as these:

- How did you determine whether students were, in fact, learning? How did you assess what your students learned?
- Did you make use of rubrics, scoring keys or guides, criteria, and standards for judging the quality of student work? If so, what were they and how were they used?
- How did you inform students about how well they were doing (or did) on the unit?
- How were grading decisions made? What grading standards were used?

The teachers were told that the questions were guides, not requirements. Even a cursory examination of the vignettes will indicate that our prompts were used precisely in this way. Not all of our questions were relevant to all teachers, and teachers did not address those they believed to be irrelevant. Regardless of the questions considered, however, each teacher wrote a reasonably comprehensive account of each of the four central components. In all six vignettes, the components are presented and discussed in a fixed order: classroom context, objectives, instructional activities, and assessment.

We must emphasize that this order is not meant to convey a linear perspective on planning. We are well aware of the research suggesting that teachers often begin their planning with instructional activities, not with objectives or assessments. We assume that planning might begin with any of the three components: objectives, instructional activities, or assessment. Planning that is "objective-driven" begins with specifying instructional objectives. "Activity-driven" planning gives initial emphasis to the instructional activities. Finally, a teacher operating from a "test-driven" perspective starts with concerns for assessment. Regardless of the starting point, however, virtually all teachers are also concerned with the other two components as well as materials that are needed to support the activities and the amount of time that is available for the unit.

We anticipated that the description of instructional activities within the unit might take different forms. One was to convey a day-to-day chronology of events that took place in the classroom as the unit progressed. Another possibility was a little less sequential and more episodic, with descriptions of salient events related to key issues and concerns. Most teachers chose combinations of these approaches, focusing on salient events within a chronological time frame.

USING THE TAXONOMY TABLE TO ANALYZE THE VIGNETTES

We began our analysis by reading through the descriptions provided by the teachers, searching for clues that would enable us to make sense of these descriptions in the context of the Taxonomy Table. Consistent with the structure of our objectives (see Chapter 2), these clues came primarily from nouns and verbs. As we demonstrated in Chapter 6, we used Table 4.1 (see also the front inside cover) to make sense of the nouns we encountered and Table 5.1 (see also the back inside cover) to help us with the verbs.

The term *clues* in the preceding paragraph is used intentionally. We were never certain at any one time exactly where a specific descriptive element fit within the Taxonomy Table. Sometimes our initial placement became increasingly clear and more defensible the farther into the vignette we read. At other times later descriptions provided by the teacher contradicted our initial placement.

To understand our problem, consider the following example. One of the stated objectives in the Nutrition vignette (Chapter 8) is for students to "acquire knowledge of a classification scheme of appeals that describes the common targets commercial writers take into account in writing commercials." The verb "acquire" is nowhere to be found in our list of cognitive processes. However, the phrase "classification scheme" suggests *Conceptual Knowledge.* At this point, we assumed that "acquire" meant either *Remember* or *Understand,* and we made our initial classification of the objective in terms of the Taxonomy Table, namely, *remember* or *understand conceptual knowledge.*

With this initial placement in mind, we moved on to the description of the instructional activities. Early in the unit, Ms. Nagengast, the teacher, presented six "appeals" made by writers of commercials (i.e., ease, economy, health, love/admiration, fear, and comfort/pleasure) and students were expected to remember the **names** of the six appeals. Because the emphasis is on the names of the appeals rather than on their underlying **categories**, we classified the intent of this activity as *remember factual knowledge.* Note that this emphasis on *Factual knowledge* does not match our initial placement based on the stated objective. Shortly thereafter, however, students spent time with examples and nonexamples of each appeal and were asked to give examples to illustrate their understanding. The use of examples and nonexamples suggests two things: first, categories are being formed; second, students are engaged in *exemplifying.* Because knowledge of categories is *Conceptual knowledge* and *exemplifying* is associated with *Understand,* the inferred objective would be classified as *understand conceptual knowledge.* This inference is partially consistent with our initial placement (with a focus on *Understand* rather than *Remember*).

Finally, we moved on to assessment. Ms. Nagengast used two assessment tasks with this objective. In the first, she asked students to "identify a commercial, describe it, and then attribute to the commercial writers what appeal [i.e., the type or category of appeal] they were working with." In the second, she asked students to "develop a claim for a given product that would match the [type of] appeal she (the teacher) had advanced." To perform these assessment tasks well, students would need to do more than simply remember the names of the six types of appeals (i.e., *remember factual knowledge*). They would need to understand each type (i.e., category) of appeal in terms of its defining attributes or features so they could correctly place new examples in the proper category (task 1) or come up with new examples for a given category (task 2). In combination, then, the clues taken from the objectives, instructional activities, and assessments led us to believe that Ms. Nagengast's intention is for students to learn to *understand conceptual knowledge* (i.e., cell B2 of the Taxonomy Table).

In a similar way, we read each vignette component by component. In each component, we paid particular attention to those elements most likely to provide us with the necessary clues. These elements are summarized in Table 7.2.

In the objectives component, we focused on statements of general purpose, lists of included topics, and explicit objectives. In the Parliamentary Acts vignette (Chapter 11), for example, the teacher's general purpose is to "integrate students' persuasive writing with their knowledge of historical persons and events." The verb "integrate" and the noun phrases "persuasive writing" and "knowledge of historical persons and events" provided clues to the placement of intended student learning in the Taxonomy Table. Similarly, in the Volcanoes? Here? vignette (Chapter 12), the teacher indicates that the unit was predicated on the "dominant research paradigm in geology, the theory of plate tectonics." In combination with the unit title, this statement provides a clear topical emphasis for the unit—the role of plate tectonics in explaining volcanic activity. Topical emphases help us place objectives in the proper rows (i.e.,

TABLE 7.2 Elements Relevant to Taxonomic Analysis of the Vignettes

COMPONENT	ELEMENTS
Objectives	General purposes/aims
	Stated objectives
	Topics
Instructional activities	Teachers' comments
	Teachers' questions
	Student assignments
Assessment	Assessment tasks (e.g., test items, portfolio requirements)
	Scoring keys, guides, and rubrics
	Evaluation criteria and standards

types of knowledge) of the Taxonomy Table. Placement in the proper columns (i.e., kinds of cognitive processes), however, is virtually impossible when only a topical orientation is given.

In the instructional activities component, clues were provided by comments made by the teachers (particularly the way activities were introduced to the students or their descriptions of the activities), the questions teachers asked of students (and students of teachers), and the assignments students were given as part of or as a follow-up to the activity. In the Addition Facts vignette (Chapter 10), for example, the teacher tells her students that "if they learn one of the facts in a family (e.g., 3 + 5 = 8), they'll know the other (e.g., 5 + 3 = 8). Therefore, fact families make the job of memorizing easier because they have to remember only half of the facts." From the first statement we learn that the teacher is using categories (i.e., fact families) to reduce the amount of memorization that students need to do. Knowledge of the categories themselves is *Conceptual knowledge*. Unlike the Nutrition example, however, the categories are not intended to aid in understanding. Thus, the goal is **not** *understanding conceptual knowledge*. Rather, as the teacher makes clear in the second sentence, the categories are intended to reduce students' "memory load." The verb here is quite clearly "remember." The ultimate goal of this activity, then, is for students to memorize the addition facts (i.e., *remember factual knowledge*). As we read through the remainder of the vignette, our attention turned to the interesting relationship the teacher establishes between *Conceptual knowledge* and *Factual knowledge*, and between *Understand* and *Remember*.

In the *Macbeth* vignette (Chapter 9), clues came from the questions the teacher asks her students. As she leads the discussion of Act II, for example, she asks, "Why does Macbeth refuse to return to Duncan's room in order to plant the bloody dagger on the guards?" To answer this question, students must search for the underlying motive for a specific action (or, more specifically, inaction). That is, they must construct a mental model that explains the inaction in terms of one or more causes. Therefore, we would classify this question as explaining, which is associated with process category *Understand*.

Finally, in the assessment component, our clues came from the assessment tasks as well as the evaluation criteria (e.g., rating scales, scoring rubrics) used to judge the adequacy of student performances on the tasks. In the Parliamentary Acts vignette (Chapter 11), the teacher provides students with an "Evaluation Form" to use in evaluating their editorials, editorials that were to be written from the perspective of a historical figure. The form contains a set of evaluation criteria (e.g., the student has at least three reasons to support the character's point of view, at least one of which is not from the textbook or class discussion; the reasons are appropriate to the character and historically accurate). In combination, the criteria suggest a concern for both *Factual knowledge* (e.g., historical accuracy, reasons taken from the textbook or discussion) and *Conceptual knowledge* (e.g., appropriate to the character, at least one reason NOT taken from the textbook or discussion). When these criteria are examined within the context of the vignette as a whole, we would argue that students were expected to *remember factual knowledge* and *understand conceptual knowledge*.

Finally, in the Addition Facts vignette (Chapter 10), the ultimate assessment is a timed test of addition facts. The "timed" aspect of the assessment provided another clue that the teachers' concern is indeed memorization. Students who attempted to use the various memorization strategies included in the unit activities would be unable to complete the assessment in the time allotted. Thus, the primary unit objective is to recall the addition facts (i.e., *remember factual knowledge*), and all the activities are simply different ways of helping students attain that objective.

The Analytic Process: A Summary

After a great deal of discussion and much trial, error, and revision, we arrived at a four-step process for analyzing the vignettes. The first step was to identify and highlight the elements in the vignettes that lent themselves to analysis in terms of the Taxonomy Table. The entries in Table 7.2 proved useful in this regard. The second step required that we focus on the relevant nouns and verbs. Referring frequently to Table 4.1 (for the nouns) and Table 5.1 (for the verbs), we jotted down our "best guesses" about the type of knowledge and cognitive process underlying the objectives, instructional activities, and assessments described by the teacher. When possible and useful, we made a tentative placement of our "best guesses" in the Taxonomy Table at this point. In actuality, we completed three separate Taxonomy Tables: one for our analysis of the statement of objectives, one for our analysis of the instructional activities, and one for our analysis of the assessments. In the third step we re-read our entire set of notes and relevant portions of the vignette descriptions to see if we could make better guesses. In almost all cases we found this re-reading and re-examination very useful. We revised our notes and the Taxonomy Tables accordingly. Finally, we examined the consistency across the three tables, comparing the classifications of objectives, instructional activities, and assessments to determine whether they were in alignment. Having completed the analysis, we translated our notes into narrative form as they are contained in the vignette chapters.

It was during this final step that we began to come to grips with some of the major issues and concerns that confronted the teachers as they planned and implemented their units. These are discussed in Chapter 14. Not surprisingly, the issues and concerns we identified have troubled teachers for some time. We believe that serious consideration of these key issues and concerns along with serious and sustained attempts to deal with them holds great potential for the improvement of educational quality.

Organization and Structure of the Vignette Chapters

As we mentioned earlier, we use a common format for the vignettes to allow the reader to not only make sense of each vignette but also make comparisons across the vignettes.

The descriptive portions of each vignette, as prepared by the teachers themselves, are printed in the same font and size of type as this sentence and inset from the left margin as is this paragraph.

Periodically, you will encounter a commentary based on our analysis. All such commentaries are set off with headings printed in the same style of type as the rest of this book.

Following each major component (that is, objectives, instructional activities, and assessments), we summarize our analysis in terms of the Taxonomy Table. As we mentioned earlier, the end result is three completed Taxonomy Tables for each vignette. The first summarizes our analysis based on the objectives. The **objectives** are indicated in **bold type**. The second summarizes our analysis based on the instructional activities. The *activities* are given in *italics*. For ease of comparison, the **objectives** are carried over in **bold type** to this second table. The third table summarizes our analysis based on the assessments. The analysis based on the assessments is shown in regular type. Again, the **objectives (bold)** and the *instructional activities* (*italics*) are carried over.

We conclude our discussion of each vignette by examining it in terms of the four guiding questions: the learning question, the instruction question, the assessment question, and the alignment question. We also raise a few "closing questions" about the unit as designed and implemented by the teacher. The questions can be used as "starting points" for an open discussion of the unit as described in the vignette.

To get the reader started, we describe our analytic process in more detail in the first vignette (Chapter 8, Nutrition). The clues we use are shown in bold type. Specific relationships between these clues and our interpretation of them in terms of types of knowledge and/or specific cognitive processes are made explicit. In addition, connections between specific cognitive processes (e.g., *classify*) and process categories (e.g., *Understand*) are highlighted. Finally, we describe the reasoning behind our classifications when we believe such a description is necessary and appropriate.

In Chapter 5 we use the standard verb form to refer to process categories and gerunds to refer to specific cognitive processes. In the vignettes we deviate from this distinction from time to time only in order to adhere to basic rules of grammar. However, we continue to capitalize the first letter of each of the six process categories to differentiate them from the 19 specific cognitive processes, which are not capitalized. Both are italicized.

A Closing Comment

We close this chapter by reminding the reader of our purpose for including the vignettes. Although we hope they will enhance the credibility of our framework and approach, their primary purpose is to increase readers' understanding and thus to provide a means to analyze and ultimately improve the quality of education students receive.

CHAPTER 8

Nutrition Vignette

This vignette describes a two-week unit on commercials developed and taught by Ms. Nancy C. Nagengast. It is part of a larger nine-week unit on nutrition.

Most recently, I taught this unit to a second-grade class consisting of 13 boys and 13 girls. In general, the students were very distractible, but whenever they got "into" something, whether it had to do with school or not, they were motivated and enthusiastic. This unit, taught toward the end of the school year, capitalized on the study skills and cooperative learning dispositions the students had acquired during their year's experience.

The plan called for 30 minutes a day to be spent on the unit. On some days, when the children became engrossed in an activity, I extended the time allotted for this unit. On other days, when the assignment for the day had been completed after 30 minutes or so, we turned our attention away from commercials and nutrition until the next day.

PART 1: OBJECTIVES

Four objectives were established for the unit. Students were expected to:

1. **acquire knowledge** of a **classification scheme of "appeals"**[1] that describes the common targets that commercial writers take into account in writing commercials;
2. **check** the influences that commercials have **on their own "senses"** and **understand** how those influences work **on them**;
3. **evaluate** commercials seen on TV or read in newspapers/magazines **from the standpoint of a set of principles pertaining to "appeals";** and
4. **create** a commercial about a common food product that reflects **understandings of how commercials are designed to influence potential clients**.

[1]Attention is directed to clues used in the analysis of the appropriate Taxonomy classification by setting them in bold type. Intended to help readers get started on the analysis process, this convention appears in only this, the first of the vignettes.

Commentary

We begin our analysis of this vignette by looking for clues in the statements of objectives. In the first objective, the primary clue is the phrase "classification scheme of appeals." In terms of the knowledge dimension, knowledge of classification schemes is *Conceptual knowledge*. The verb phrase "acquire knowledge" is ambiguous in relation to the cognitive processes. It might refer to *Remember, Understand*, or one of the other process categories. At this point, we withhold judgment and seek additional information.

In the second objective, the primary clues come from the verbs: "check" and "understand." In Table 5.1 *checking* is one of the cognitive processes in the category *Evaluate*. On the surface, "understand" corresponds to the process category *Understand*. We are not sure at this point whether the teacher is using the term in the same way it is used in the Taxonomy Table, but our initial assumption is that she is. In terms of the knowledge dimension, the focus seems to be on the students' knowledge of themselves (i.e., the way in which students are influenced by commercials). This emphasis on self suggests *Metacognitive knowledge*.

In the third objective, the students are expected to evaluate the appeals made in commercials "from the standpoint of a set of principles." In the language of the Taxonomy Table, knowledge of principles is *Conceptual knowledge* (see Table 4.1). In terms of the objective, the principles become evaluation criteria. It is important to note that the "noun" in this objective is the principles, not the commercials; the commercials are merely the materials used to teach the objective. (The reader is encouraged to re-read our discussion of this important difference on pages 17–18.)

In the fourth objective, the emphasis is on creating commercials based on students' "understandings of how commercials are designed to influence potential clients." The verb is "create." As in the third objective, the noun is not the commercials; rather, it is "understandings of how commercials are designed," For the time being, we classify this as *Procedural knowledge*.

Now we can restate the four objectives in terms of the classifications of the Taxonomy Table. Students should learn to:

1. *remember* and *understand conceptual knowledge* (i.e., the classification scheme of appeals);
2. *evaluate* and *understand metacognitive knowledge* (i.e., how students are influenced by commercials);
3. *evaluate* [based on] *conceptual knowledge* (i.e., "appeals" principles); and
4. *create* [based on] *procedural knowledge* (i.e., knowledge of how commercials are designed).

We then place these objectives in the corresponding cells of the Taxonomy Table as shown in Table 8.1. Because two verbs are included in the first two objectives, Objectives 1 and 2 are placed in two cells of the table.

Part 2: Instructional Activities

After reviewing what we discussed about the **four food groups** and **nutritious food** earlier in the larger unit (see, for example, Attachment A at the end of

8.1 Analysis of the Nutrition Vignette in Terms of the Taxonomy Table Based on Stated Objectives

The Knowledge Dimension	The Cognitive Process Dimension					
	1. Remember	2. Understand	3. Apply	4. Analyze	5. Evaluate	6. Create
A. Factual knowledge						
B. Conceptual knowledge	Objective 1	Objective 1			Objective 3	
C. Procedural knowledge						Objective 4
D. Meta-cognitive knowledge		Objective 2			Objective 2	

Key
Objective 1 = Acquire knowledge of a classification scheme of "appeals."
Objective 2 = Check the influences commercials have on students' "senses."
Objective 3 = Evaluate commercials from the standpoint of a set of principles.
Objective 4 = Create a commercial that reflects understandings of how commercials are designed to influence people.

the chapter), I mentioned foods seen on television. I suggested that some commercials aim at the idea of economy (i.e., trying to convince people that buying the product will save money), while others focus on ease (e.g., trying to convince people that buying the product will save time and effort over alternatives). I then summarized by stating that these were **examples of appeals** that commercials make to the television viewer/potential consumer.

COMMENTARY

Once again we look for clues in the teacher's description of her instruction activities (see **bold** type). The teacher is presenting a variety of *Factual knowledge* related to the first objective. In addition, the exercises in Attachment A focus on *Factual knowledge* (e.g., locate and circle the fat grams, locate and circle the calories). The activity either (1) is preparatory to the first objective or (2) suggests that *Factual knowledge* is an important component of the first objective. We opt for the first choice because the teacher immediately begins to discuss each specific food in terms of one (or more) category of appeals.

Six such appeals were presented. In addition to **ease and economy, the others were health, fear, love/admiration, and comfort/pleasure**. Over the next few days, students spent time with **examples and nonexamples** of each appeal and gave examples to illustrate their **understanding**.

COMMENTARY

At this point the teacher completes the shift to *Conceptual knowledge*. The clue to this shift is the use of examples and nonexamples (a recognized approach to teaching *Conceptual knowledge*). Apparently Ms. Nagengast intends her students to acquire a classification system that includes six types of appeals. These activities, in addition to her use of the word "understanding," clarify the meaning of the first objective. The emphasis is on *understanding conceptual knowledge*.

To assess how well students had acquired the concepts in this scheme, I asked them to **describe a commercial** and then to **attribute to the commercial writers the appeal** they were making to the audience. Alternatively, I **gave students an appeal** as a prompt and asked them to **develop a claim** for a given product **that would match that appeal**.

COMMENTARY

These tasks also contribute to our understanding of the first objective. The first task is a form of *classifying* (placing specific commercials into the proper appeals category). The alternative task is a form of *exemplifying* (giving an example of a commercial for a specific type of appeal). Although both of these cognitive processes fall into the same category *Understand* (see inside the back cover), they are not identical.

One phrase used by the teacher requires additional consideration: "attribute to the commercial writers." This phrase suggests that students are not to classify the commercials based on the appeal-effect the commercial has on them; rather, they are to classify commercials on the basis of the appeal **intended by** the developer of the commercial. As we show in Table 5.1, *attributing* is a cognitive process associated with the category *Analyze*, which is a more complex category than *Understand*.

Some students were imaginative and fluent in matching commercials with appeals. Others had difficulty, and often the appeal they identified as the target of the ad writer was, at least from my point of view, decidedly off target.

COMMENTARY

Is there an explanation for this "learning problem"? Ms. Nagengast is discussing the instructional activities related to the first objective. But students may have the second objective in their minds as well, which would make them aware of the effect of the appeals on themselves. Consistent with her first objective, Ms. Nagengast is asking about the intended appeal of the writer. The students, however, realizing that the unit is also about the second objective, may miss this distinction. Therefore, those operating from an analytic (attributional) framework will more likely produce "proper" classifications. In contrast, students who respond in terms of their own understanding (its effect on them) can be expected to produce fewer correct classifications.

From these exercises, I was able to determine which students had and had not mastered the concept of appeal as it applied to nutritional commercials. To be successful, students not only had to **recall the names of all six appeals** but also had to **understand the concept of appeals well enough to classify commercials appropriately**.

COMMENTARY

Ms. Nagengast is making an important distinction here. Students may be able to remember the name of the class to which the appeal was assigned (*Factual knowledge*), but they may not be able to classify examples of appeals correctly (*Conceptual knowledge*). Ms. Nagengast is concerned with both types of knowledge. Thus, the activities related to Objective 1 focus on both *Remember* and *Understand* and on both *Factual* and *Conceptual knowledge* (see Table 8.2).

My second objective was for students to examine the impact that commercials have **on their own decisions**. Students were asked to respond to the impact that various "hooks" had **on their own thinking**. A first step was to get students to examine the phrases they associated with various products (see Attachment B) and then to reflect on the impact those commercials had **on their feelings**.

8.2 Analysis of the Nutrition Vignette in Terms of the Taxonomy Table Based on Instructional Activities

The Knowledge Dimension	The Cognitive Process Dimension					
	1. Remember	2. Understand	3. Apply	4. Analyze	5. Evaluate	6. Create
A. Factual knowledge	*Activities during teaching of Objective 1*					
B. Conceptual knowledge	**Objective 1**	**Objective 1** *Activities during teaching of Objective 1*		*Activities during teaching of Objective 1*	**Objective 3** *Activities during teaching of Objective 3*	*Activities during teaching of Objective 4*
C. Procedural knowledge			*Activities during teaching of Objective 4*			**Objective 4**
D. Meta-cognitive knowledge		**Objective 2** *Activities during teaching of Objective 2*		*Activities during teaching of Objective 2*	**Objective 2**	

Key
Objective 1 = Acquire knowledge of a classification scheme of "appeals."
Objective 2 = Check the influences commercials have on students' "senses."
Objective 3 = Evaluate commercials from the standpoint of a set of principles.
Objective 4 = Create a commercial that reflects understandings of how commercials are designed to influence people.

COMMENTARY

Consistent with the stated intent of Objective 2, these activities focus on the impact of the commercials on the students themselves. The initial "matching exercise" (Attachment B) is an attempt to determine the students' *Factual knowledge* about commercials. The questions asked by the teacher appear to be intended to stimulate *Metacognitive knowledge.*

In class discussion, students were asked questions such as "**What did you think** when you heard this commercial?" and "What was the commercial **writer expecting you to think** when the ad said that Michael Jordan uses the product?" The comments, questions, and observations shared in this discussion served as the evidence bearing on my second objective.

COMMENTARY

The first question reinforces our belief that Objective 2 emphasizes *understanding metacognitive knowledge* (i.e., to understand the impact that commercials have on the students). The second question asks for more than *Understanding.* Students are expected to examine the commercial from the point of view of the writer/designer of the commercial (i.e., attribute). This question reinforces our belief that the teacher wants students to *Analyze* commercials by making attributions about the motives of their writers/designers. This also is consistent with our commentary on the activities related to the first objective.

Once the students had mastered the idea of the appeals and discussed the effects of those appeals on themselves, I played three or four commercials on the VCR, asking students, working in groups, to evaluate how well the commercials "worked." Specifically, students were to **judge how well the commercial made the appeal and how convincing and compelling** it was. **Students generated criteria for "being convincing"** through a teacher-pupil planning session. The criteria were incorporated into an initial draft of a scoring guide. After a few revisions, the scoring guide became more useful to the students in registering their evaluations of the commercial (see Attachment C at the end of the chapter). One of the major differences in the drafts was that the early versions of the scoring guide reflected too much of my own language and not enough of that of the students.

COMMENTARY

Here the focus shifts to *Evaluate.* In order to *Evaluate,* students must possess knowledge of the criteria that they generated to define "being convincing" (*Conceptual knowledge*). Again, we must emphasize that the commercials themselves are simply the materials used to teach the knowledge; they are not the knowledge to be learned per se. Ms. Nagengast clearly intends the students to use their knowledge with commercials encountered outside of class and in the future.

The culminating activity in this unit had students, in groups of two to four, working to create their own commercials. Each group was to select a food product and to **prepare a tentative advertising plan** for the product. These plans would then be shared with another group in the class and **feedback would be provided using the scoring rubric developed for evaluating commercials**, along with the nutrition concepts from earlier lessons in the larger unit.

COMMENTARY

In Table 5.1 *planning* is a cognitive process in the category *Create*. Because the students are to plan their commercials based on their knowledge of how to design commercials to influence potential clients, the knowledge component of the objective would fall into the *Procedural knowledge* category. Because the plans are to be evaluated on the basis of explicit criteria, *Conceptual knowledge* is also involved. Nonetheless, we would classify this objective as *Create* [based on] *Procedural knowledge*.

After receiving feedback about their planning from their peers and from me, the students rehearsed their commercials and then presented them to the whole class. Subsequently, the groups presented their commercials to a larger audience including parents, teachers, and other second-grade classes. Each effort was videotaped so that I could analyze it carefully at my leisure rather than "on the fly" while it was being presented.

Once all the commercials were performed, I convened the groups again and asked them to **summarize what things they had done as a group that had been particularly useful in producing the commercials and what things the group might have done to do a better job**. Students were reminded **not to blame individuals** within their group but instead to focus on those elements of the group process that might be useful to remember the next time they worked in groups. Each group reported the products of their thinking to the entire class, and I recorded the insights generated by the class on a sheet of poster paper.

COMMENTARY

We assume that the scoring guide in Attachment C provides the criteria used to *Evaluate* the final commercials. Note that Ms. Nagengast avoids the word *Evaluate*, choosing *Analyze* instead. Clearly, the scoring guide requires analysis; however, the analysis performed provides the basis for evaluating the quality of the commercials. In addition to the criteria included in Attachment C, students are asked to evaluate the group process according to three criteria:

(1) areas of strength, (2) ways of improving the process, and (3) avoidance of the placement of blame. Because these are "non-cognitive" criteria, we do not classify them in the Taxonomy Table.

Throughout this final segment of the nutrition unit, the **purpose of each activity became more clear to the students.** Students became enthralled in singing and/or reciting commercials verbatim and consequently completing the worksheet.

COMMENTARY

The students themselves are learning the difference between the activities and the objective (i.e., the purpose of the activity in terms of the intended learning outcome).

Our analysis of the entire set of instructional activities over the ten-day period was summarized in Table 8.2 shown earlier. To aid in comparing the activities with the stated objectives, the objectives from Table 8.1 were reproduced in **bold** type in Table 8.2. The instructional activities were *italicized.*

PART 3: ASSESSMENT

I assessed the students in various ways. Class discussions provided useful information as to whether the students were grasping the objectives. As the students began working in groups, I would walk around the room monitoring their progress and checking to make sure each person in the group was contributing to the project. These unobtrusive observations provided me a true indicator of their progress.

In addition to monitoring the discussion in which students were engaged, I read the worksheets the students generated as part of their study (e.g., their plans for their commercials). Ultimately, I did a **rigorous evaluation of the commercials** the students prepared for signs of understanding of the **principal ideas associated with nutrition.**

I graded them for completion of class work and homework. Throughout the unit, I kept a record of each student's effort in this regard with the distinctions of a check-plus, check, or check-minus entered into the grade book.

Finally, the students engaged in an oral evaluation of both their final commercials and their work as cooperative groups. After they had completed the unit, students occasionally commented on the commercials they saw on television and often wrote about the unit as one of the favorite activities done that year.

COMMENTARY

The vast majority of Ms. Nagengast's discussion of assessment pertains to informal assessment and grading. She developed separate assessment tasks for only the first objective. For all other objectives she used selected instructional activities as assessment tasks; that is, the activities were intended to help students learn **and** to allow Ms. Nagengast to assess students' learning. This dual function of instructional activities (for facilitating both learning and assessment) is fairly common for the teachers who prepared the vignettes. In most instances, although it may contribute to student grades, the assessment is considered formative because its primary purpose is to put students "on the right track."

The one aspect of assessment that lends itself to analysis in terms of the Taxonomy Table is Ms. Nagengast's "rigorous evaluation of the commercials" prepared by the students. The scoring guide used to evaluate the commercials contains six criteria ("scoring elements") (see Attachment C). The first scoring element (A) pertains to the general appropriateness of the commercial to the unit (i.e., nutrition) and so was not classified. The second scoring element (B) is tangentially related to Objective 1. Rather than identify the type of appeal (i.e., *Conceptual knowledge*), the emphasis is on whether the commercial appealed to "wants and needs" (a more affective than cognitive concern). The third scoring element (C) is the one related most directly to the knowledge contained in Objective 4 (i.e., *Procedural knowledge*). The scoring element criterion (D) pertains to realism (and therefore is tangentially to the objectives as stated). However, we place this in cell B6 (*create* [based on] *conceptual knowledge*). Both the fifth (E) and sixth (F) criteria address the audience of the commercial. Did the commercial make the audience want to buy the food? Was the commercial aimed at the intended audience? These criteria are related to Objective 2, if one assumes the students see themselves as the intended audience.

Our analysis of the assessments in terms of the Taxonomy Table is presented in Table 8.3. Again, for comparison purposes, the entries from Tables 8.1 (**objectives**) and Table 8.2 (*instructional activities*) are reproduced in Table 8.3.

Part 4: Closing Commentary

In this section we examine the vignette in terms of our four basic questions: the learning question, the instruction question, the assessment question, and the alignment question.

The Learning Question

The overall purpose of the unit is for students to learn to create commercials about common food products that reflect their understanding of how commercials are designed to influence potential consumers (Objective 4). As mentioned in our summary of the instructional activities, the unit builds from objective to objective, culminating in Objective 4. In terms of emphasis, fully five of the ten days spent on the unit are devoted to the fourth objective. In addition, the fourth objective is the only one subjected to formal assessment and evaluation.

The Instruction Question

It is interesting that the order of the instructional activities corresponds to the sequence of the stated objectives. That is, the activities are used to move