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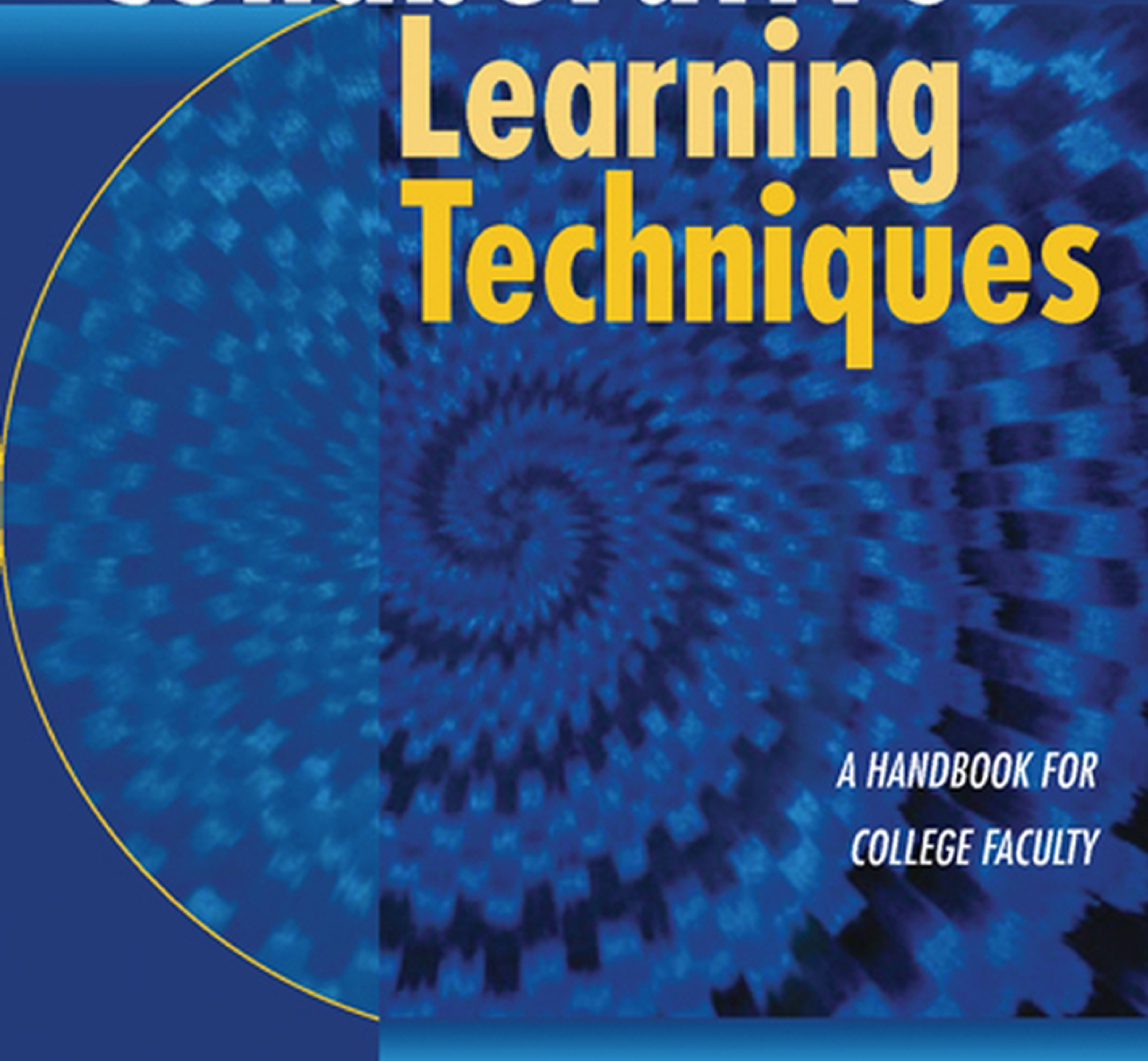
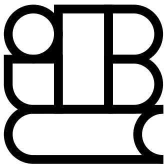
Collaborative Learning Techniques

A HANDBOOK FOR COLLEGE FACULTY





Collaborative Learning Techniques

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A Handbook for College Faculty

Elizabeth F. Barkley,
K. Patricia Cross, and
Claire Howell Major

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Published by Jossey-Bass

A Wiley Imprint

989 Market Street, San Francisco, CA 94103-1741 www.josseybass.com

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Library of Congress Cataloging-in-Publication Data
Barkley, Elizabeth F.
Collaborative learning techniques : a handbook for college faculty / Elizabeth F. Barkley, K. Patricia Cross, Claire Howell Major.— 1st ed.
p. cm.
Includes bibliographical references and index.
ISBN 978-0-7879-5518-2 (alk. paper)
1. Team learning approach in education—Handbooks, manuals, etc. 2. College teaching—Handbooks, manuals, etc. I. Cross, K. Patricia (Kathryn Patricia), 1926- II. Major, Claire Howell. III. Title.
LB1032.B318 2004
378.1′2—dc22
2004015337

Printed in the United States of America

FIRST EDITION

PB Printing 10 9 8 7 6 5 4 3 2 1

The Jossey-Bass Higher and Adult Education Series

Contents

Preface xi
The Authors xv
PART 1: INTRODUCTION 1
1 The Case for Collaborative Learning 3
PART 2: IMPLEMENTING COLLABORATIVE LEARNING 27
2 Orienting Students 29
3 Forming Groups 43
4 Structuring the Learning Task 55
5 Facilitating Student Collaboration 69
6 Grading and Evaluating Collaborative Learning 83
PART 3: COLLABORATIVE LEARNING TECHNIQUES (CoLTS) 95
7 Techniques for Discussion 101
  CoLT 1: Think-Pair-Share 104
  CoLT 2: Round Robin 108
  CoLT 3: Buzz Groups 112
  CoLT 4: Talking Chips 117
  CoLT 5: Three-Step Interview 121
  CoLT 6: Critical Debate 126
8 Techniques for Reciprocal Teaching 133
  CoLT 7: Note-Taking Pairs 135
  CoLT 8: Learning Cell 140
  CoLT 9: Fishbowl 145
  CoLT 10: Role Play 150

CoLT 11: Jigsaw 156
CoLT 12: Test-Taking Teams 163
9 Techniques for Problem Solving 169
CoLT 13: Think-Aloud Pair Problem Solving TAPPS 172
CoLT 14: Send-A-Problem 177
CoLT 15: Case Study 182
CoLT 16: Structured Problem Solving 188
CoLT 17: Analytic Teams 193
CoLT 18: Group Investigation 199
10 Techniques Using Graphic Information Organizers 205
CoLT 19: Affinity Grouping 207
CoLT 20: Group Grid 211
CoLT 21: Team Matrix 216
CoLT 22: Sequence Chains 221
CoLT 23: Word Webs 226
11 Techniques Focusing on Writing 233
CoLT 24: Dialogue Journals 236
CoLT 25: Round Table 241
CoLT 26: Dyadic Essays 246
CoLT 27: Peer Editing 251
CoLT 28: Collaborative Writing 256
CoLT 29: Team Anthologies 262
CoLT 30: Paper Seminar 267
Appendix A: Key to Professor Names in CoLT Examples 273
Appendix B: Additional Ideas for Integrating the Learning Task into a Curricular Framework 275
References 285
Index 295

Preface

THE TWENTY-FIRST CENTURY poses a paradox for higher education. At a time when students and parents consider a college education a necessity and getting into a "good" college is more important and more competitive than ever before, legislators, accrediting agencies, the American public, and educators themselves are raising questions about what students are learning in college—and they are asking for evidence.

Widespread concern has spawned more research, more publications, more legislation, and more exhortation for improvement focused on teaching and learning than at any other time in history. The major questions driving this attention involve how to improve the quality of student learning, how to improve the effectiveness of teaching, and how to do both affordably and efficiently. While opinions differ on how much progress we have made in this quest thus far, there is virtually unanimous agreement on the enduring need for improvement.

Collaborative learning continues to attract interest because it addresses several major concerns related to improving student learning. First, the predominant conclusion from a half-century of research is that teachers cannot simply transfer knowledge to students. Students must build their own minds through a process of assimilating information into their own understandings. Meaningful and lasting learning occurs through personal, active engagement. The advantages of collaborative learning for actively engaging students are clear when compared with more traditional methods—such as lecture and large-group discussions—in which only a few students typically can, or do, participate.

Second, many employers consider willingness and readiness to engage in productive teamwork a requirement for success. For some companies and professions, it is a prerequisite for employment. Collaborative learning offers students opportunities to learn valuable interpersonal and teamwork skills and dispositions by participating in task-oriented learning groups; thus, even beyond enhancing the learning of content or subject matter, collaborative groups develop important skills that prepare students for careers.

Third, our increasingly diverse society requires engaged citizens who can appreciate and benefit from different perspectives. At the same time, most local, national, and global challenges require long-term, collective responses. Learning to listen carefully, think critically, participate constructively, and collaborate productively to solve common problems are vital components of an education for citizenship in the twenty-first century.

Finally, colleges and universities want to provide greater opportunities for a wider variety of students to develop as lifelong learners. In traditional lectures, students generally are treated as a single, passive, aggregated entity. Collaborative learning engages students of all backgrounds personally and actively, calling individuals to contribute knowledge and perspectives to the education developed from their unique lives as well as academic and vocational experiences.

Background and Audience

It is in this context that we came to this work, a collaborative endeavor in itself. We share some characteristics: we are educators seeking to make higher education better, we are researchers seeking evidence about how to accomplish that, and we are teachers with a vested interest in improving practice. We came to this project with the following questions about collaborative learning:

- How will collaborative learning improve learning? What is the pedagogical rationale for collaborative learning?
- What is the evidence that collaborative learning promotes and improves learning? And how convincing is that evidence?
- Which students are most likely to benefit from collaborative learning? And for which learning tasks is it most appropriate?
- How can discipline-oriented college teachers organize effective learning groups in their classrooms? How are groups formed and learning tasks structured?
- What are some imaginative and creative strategies and techniques for challenging students? How can teachers adapt Collaborative Learning Techniques (CoLTs) to their courses and teaching goals?

In this handbook, we address these questions, and many others as well.

After several years spent preparing this book, we considered the evidence for collaborative learning sufficiently compelling to add a new question: *Given the evidence demonstrating that most students learn more, and more deeply, when teachers employ collaborative methods effectively, why don't more teachers use collaborative learning?* We believe the answer may lie in the following reasons: Many teachers are unaware of the evidence about the benefits of collaborative learning, and many teachers do not know how to implement group learning activities effectively. The primary purpose of this handbook, therefore, is to provide college and university teachers—regardless of prior knowledge and experience with instructional design or pedagogy—a resource for implementing collaborative work successfully.

A second purpose of this handbook is to encourage faculty to experiment with collaborative learning methods in well-informed and reflective ways. It is no more possible to learn to teach effectively by reading alone than it is to learn to practice medicine by only studying books. Both are part art and part technique. Both take practice. For that practice to be most effective, however, it should be well informed and reflective. Informed teaching requires making instructional decisions based on the collected wisdom from scholarship and practice. Reflective teaching implies assessing and documenting its efficacy. Without this, it is difficult to know whether even well-informed innovations actually make a positive difference in student learning, or enough difference to justify the effort invested. To that end, we have included advice on assessment techniques that can help document and determine the effectiveness of collaborative learning activities.

This handbook is written for the use of college and university teachers, current and aspiring. We hope it will be read and used in collaborative ways, and not just by individual teachers. We hope that this handbook will be useful to faculty developers, instructional designers, department chairs, and other academic administrators interested in promoting teaching and improving learning. The use of this book by teaching circles, seminars, departments, and other groups of teachers can provide participants with opportunities to try out collaborative learning techniques on themselves before employing them in the classroom. Furthermore, these groups of teachers can discuss and get each other's perspectives on their experiences using collaborative learning.

How to Use This Book Effectively

This handbook is divided into three parts, in which we attempt to address the *Why, How,* and *What* questions of collaborative learning. Part One: Introduction is a brief but comprehensive review of the literature and research on collaborative learning. It addresses the question, *Why use collaborative learning?* It explains the epistemological underpinnings that differentiate cooperative and collaborative learning, summarizes current learning theory, presents the pedagogical rationale for collaboration, and synthesizes the research regarding the effectiveness of collaborative learning.

Part Two: Implementing Collaborative Learning offers the benefit of the experience of many teachers who have used collaborative learning in their classrooms, across many types of colleges and disciplines. It addresses the issue of how to use collaborative learning effectively in the classroom, offering practical advice on how to form groups, how to structure the learning task, how to anticipate and solve problems, and how to ensure individual accountability through assessment and grading.

Part Three: Collaborative Learning Techniques (CoLTs) contains detailed descriptions of thirty techniques for creating effective group work assignments. It offers answers to the question, *What can I do, in a practical way, to engage students actively in collaborative learning?* Organized into five categories based on task, the CoLTs are simple and flexible tools that can be adapted to fit a wide variety of disciplines, instructional goals, and learning contexts.

We are deeply indebted to many colleagues, past and present. The literature of collaborative learning is huge, and the number of practitioners quietly using collaborative learning in their classrooms is even larger. Researchers, practitioners, workshop facilitators, even students have been generous in sharing their knowledge with us—contributing and reviewing CoLTs, revising techniques, critiquing chapters, and talking with us about their experiences and experiments in collaborative learning. Very little in this handbook is new. Our contribution is to pull together the vast resources that exist in collaborative learning and cast the results in a format accessible to discipline-oriented faculty. Since the format of *Classroom Assessment Techniques* (Angelo & Cross, 1993) proved enormously popular with college teachers, we have adapted that practical format here.

Collaborative Learning Techniques is not a book that must be read in a linear fashion. Readers may start at the point that is most useful and appealing and read the rest of the text out of order. Thus, experts at collaborative learning may want to skip directly to Part Three to find new techniques. Those familiar with the theory and research regarding collaborative learning but have little classroom experience with it may benefit from starting with Part Two. The majority of teachers, however, will find it most useful to begin with Part One.

The Authors

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Cross has been recognized for her scholarship by election to the National Academy of Education, receipt of the E. F. Lindquist Award from the American Educational Research Association, the Sidney Suslow Award from the Association for Institutional Research, and the Howard Bowen Distinguished Career Award from the Association for the Study of Higher Education.

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Major's research centers on teaching and learning in higher education, focusing largely on innovative instructional methods. She has published numerous articles and has presented her research nationally and internationally. She has worked with faculty at institutions around the country to promote teaching excellence. And she has firsthand experiences using active and collaborative methods for teaching diverse groups of students.

Major holds a bachelor's and master's degree in English from the University of South Alabama and the University of Alabama at Birmingham, respectively, and a Ph.D. in higher education from the University of Georgia.

Part One

Introduction

Chapter 1

The Case for Collaborative Learning

MAKING THE CASE FOR collaborative learning seems almost too easy. More research on learning in small groups exists than on any other instructional method, including lecturing (Johnson, Johnson, & Smith, 1991; Slavin, 1989–90). While most of this is credible and positive, it is dominated by research and investigation in K–12, and higher education is coming late to the scene.

Exploding research on cognition and the brain confirms so much of what we have learned about the effectiveness of peer interaction in promoting active learning that college teachers need not fear that experimenting with collaborative learning in their classrooms will plunge them into uncharted territory. Unlike much research in higher education that is often reported in unrelated studies, scholars studying collaborative learning have mapped the terrain and conducted helpful meta-analyses that synthesize findings across topics and institutions.

The purpose of this introduction to the extensive literature on interactive group learning is to glean from experience and research information that is useful to college teachers in deciding whether collaborative learning will be effective in accomplishing their teaching goals. Specifically, this introduction addresses the following questions:

- What do we mean by *collaborative learning?*
- What is the difference between collaborative learning and cooperative learning?
- What are the defining characteristics of effective learning groups?
- What is the pedagogical rationale for collaborative learning?
- What is the evidence that collaborative learning promotes and improves learning?

- Which students gain the most from collaborative learning?
- Is everyone happy with collaborative learning?

Thus, Part One of this handbook provides an overview of the theoretical and research bases for collaborative learning.

What Do We Mean by *Collaborative Learning?*

To *collaborate* is to work with another or others. In practice, collaborative learning has come to mean students working in pairs or small groups to achieve shared learning goals. It is learning through group work rather than learning by working alone. There are other terms for this kind of activity, such as *cooperative learning, team learning, group learning,* or *peer-assisted learning.* In this handbook, however, we use the phrase *collaborative learning* to refer to learning activities expressly designed for and carried out through pairs or small interactive groups. While we believe that a flexible definition of collaborative learning is best, there are some features that we see as essential.

The first feature of collaborative learning is intentional design. All too often, teachers simply tell students to get into groups and work. In collaborative learning, however, faculty members structure intentional learning activities for students. They may do this by selecting from a range of prestructured activities, such as those we have included in Part Three of this text, or they may do this by creating their own structures. Whether using existing or new structures, the focus is on *intentional* structure.

In addition to intentional design, co-laboring is an important feature of collaborative learning. The meaning of the Latin-based term *collaborate* shines through as clearly today as in antiquity: to co-labor. All participants in the group must engage actively in working together toward the stated objectives. If one group member completes a group task while the others simply watch, then it is not collaborative learning. Whether all group members receive the same task, or whether members complete different tasks that together comprise a single, large project, all students must contribute more or less equally. Equitable engagement is still insufficient, however.

The third feature of collaborative learning is that meaningful learning takes place. As students work together on a collaborative assignment, they must increase their knowledge or deepen their understanding of course curriculum. The task assigned to the group must be structured to accomplish the learning objectives of the course. Shifting responsibility to students, and having the classroom vibrate with lively, energetic small-group work is attractive, but it is educationally meaningless if students are not achieving intended instructional goals, goals shared by the teacher and students. Collaborative learning, then, is two or more students laboring together and sharing the workload equitably as they progress toward intended learning outcomes.

What Is the Difference Between Cooperative and Collaborative Learning?

Although to most educators—and indeed to the lexicographers who compile dictionaries—the terms *collaborative* and *cooperative* have similar meanings, there is considerable debate and discussion as to whether they mean the same thing when applied to group learning. Some authors use the terms *cooperative* and *collaborative* interchangeably to mean students working interdependently on a common learning task. Others, however, insist on a clear epistemological distinction (Bruffee, 1995). Advocates for distinguishing between the two suggest that cooperative learning differs from collaborative learning in that, in cooperative learning, the use of groups supports an instructional system that maintains the traditional lines of classroom knowledge and authority (Flannery, 1994). To other authors, cooperative learning is simply a subcategory of collaborative learning (Cuseo, 1992). Still others hold that the most "sensible approach" is to view collaborative and cooperative learning as positioned on a continuum from most structured (cooperative) to least structured (collaborative) (Millis & Cottell, 1998). Since those who insist on a sharp distinction between cooperative and collaborative learning do so for epistemological reasons, it may help to clarify the nature of the argument.

Cooperative Learning

The most straightforward definition of cooperative learning is "the instructional use of small groups so that students work together to maximize their own and each others' learning" (Smith, 1996, p. 71). Cooperative learning arose primarily as an alternative to what was perceived as the overemphasis on competition in traditional education. Cooperative learning, as the name implies, requires students to work together on a common task, sharing information and supporting one another. In cooperative learning, the teacher retains the traditional dual role of subject matter expert and authority in the classroom. The teacher designs and assigns group learning tasks, manages time and resources, and monitors students' learning, checking to see that students are on task and that the group process is working well (Cranton, 1996; Smith, 1996).

Most research and most discussion of group learning assumes a traditional view of the nature of knowledge, namely that there is a "correct" answer or at least a "best solution," and that different students will have knowledge about different aspects of the task. There is also the assumption that the teacher is an expert in the subject matter, knows the correct answers, and that ultimately the group should arrive at "the best" or "most logical" or "correct" conclusion. Most teachers using interactive student learning in their classrooms and writing about their experiences are talking about cooperative learning. Knowingly or not, they are capitalizing on the research findings that students who establish social relationships with faculty and other students in the community are more actively involved in learning, report greater personal and academic growth, and are better satisfied with their education than are students who are more isolated (Astin, 1993; Light, 2001; Pascarella & Terenzini, 1991).

Collaborative Learning

Collaborative learning is based on different epistemological assumptions, and it has its home in social constructivism. Matthews captures the essence of the philosophical underpinnings of collaborative learning: "Collaborative learning occurs when students and faculty work together to create knowledge. . . . It is a pedagogy that has at its center the assumption that people make meaning together and that the process enriches and enlarges them" (Matthews, 1996, p. 101).

Rather than assuming that knowledge exists somewhere in reality "out there," and that it is waiting to be discovered by human endeavors, collaborative learning, in its tightest definition, assumes that knowledge is socially produced by consensus among knowledgeable peers. Knowledge is "something people construct by talking together and reaching agreement" (Bruffee, 1993, p. 3). Bruffee, the most ardent advocate of collaborative learning, wants to avoid having students become dependent on the teacher as the authority on either subject matter content or group process. Thus, in his definition of collaborative learning, it is not up to the teacher to monitor group learning, but rather the teacher's responsibility is to become a member, along with students, of a community in search of knowledge.

Collaborative Versus Cooperative Learning

In an article for *Change* magazine, subtitled, "Cooperative Learning *versus* Collaborative Learning" (Bruffee, 1995, emphasis added), Bruffee contends, "Describing cooperative and collaborative learning as complementary understates some important differences between the two. Some of what collaborative learning pedagogy recommends that teachers do tends in fact to undercut some of what cooperative learning might hope to accomplish, and vice versa" (p. 16).

The essence of his position is that, whereas the goal of cooperative learning is to work together in harmony and mutual support to find the solution, the goal of collaborative learning is to develop autonomous, articulate, thinking people, even if at times such a goal encourages dissent and competition that seems to undercut the ideals of cooperative learning.[1] While cooperative education may be appropriate for children, he says, collaborative learning is more appropriate for college students.

Bruffee has made something of a brand name of collaborative learning in higher education circles. He intends the role of the teacher to be less the traditional expert in the classroom and more the peer of students. Knowledge at the college level, he says, is "likely to address questions with dubious or ambiguous answers, answers that require well-developed judgment to arrive at, judgment that learning to answer such questions tends, in turn, to develop. . . . The authority of knowledge taught in colleges and universities should always be subject to doubt" (p. 15).

As a practical matter in planning and operating college classroom learning groups, most teachers will not be much concerned with the philosophical and semantic distinctions between cooperative and collaborative learning, but will use the level of authority and control that feels comfortable for them and that accomplishes their goals. If there is a trend in clarifying the nomenclature of interactive group learning, however, it seems to be in the direction of using the term *collaborative learning* in higher education and *cooperative learning* in K–12 education.

In this handbook, we have labeled our techniques *CoLTs, Co* standing for either "Cooperative" or "Collaborative" and *LT* standing for "Learning Techniques," because the techniques described come from the literature of both cooperative and collaborative learning. Inventing a new term would free us from the baggage accumulated by the advocates of the postmodern version of collaborative learning, but it would also add to the jargon of education. Instead, we follow the growing practice of using the term *collaborative learning* to refer to interactive learning groups in higher education, from structured to unstructured. It is important to be aware, however, that massive confusion reigns in the literature of higher education over terminology. Some authors writing today in higher education use the term *cooperative learning,* and where this is the case, we will use their terminology when discussing their work.

What Are the Defining Characteristics of Effective Learning Groups?

Learning groups exist in many sizes and forms and are created for a wide variety of purposes. Some learning groups are ad hoc, in-class arrangements of convenience that last only a few minutes. For example, in *CoLT 1: Think-Pair-Share,* the instructor asks students to turn to a nearby neighbor to discuss briefly a point made in the lecture. Other teachers may use *CoLT 3: Buzz Groups,* consisting of four to six students grouped for ten to fifteen minutes. This CoLT gives students an opportunity to explore other learners' reactions to course-related questions. There are also more intentionally structured groupings, often organized around specific assignments, such as *CoLT 15: Case Studies* or *CoLT 18: Group Investigation.* In these activities, students may work together for days or weeks until the assignment is completed.

Sometimes groups work together on a course-long project. Membership can remain the same or change depending on the learning goals. There are also long-term "learning communities" that may last a semester or an academic year. Learning communities typically involve integration of curricula, team teaching, and other institutional changes designed to give students a feeling of belonging to a "community" of learners (Gabelnick, MacGregor, Matthews, & Smith, 1990; Matthews, Smith, MacGregor, & Gabelnick, 1997; Tinto, Love, & Russo, 1994).

Groups may be identified with particular teaching methods—such as the case-study method or problem-based learning—in which the purpose is to accomplish specified cognitive goals such as critical thinking and problem solving. There are groups based on an epistemology, such as Bruffee's purist definition of collaborative learning. When interacting, these groups purposely implement social constructivist learning theory, a theory contending that knowledge is socially constructed by consensus among knowledgeable peers (Bruffee, 1995; Vygotsky, 1978).

Johnson and colleagues (Johnson et al., 1991) distinguish types of groups on the basis of duration and purpose. *Formal* learning groups last from one class period to several weeks, whatever it takes to complete a specific task or assignment. The purpose is to use the group to accomplish shared goals, to capitalize on different talents and knowledge of the group, and to maximize the learning of everyone in the group. *Informal* groups are temporary groups that last for only one discussion or one class period. Their major purpose is to ensure active learning. They might be used, for example, to break up a lecture with peer exchanges that require students to organize, explain, and otherwise cognitively process their learning. *Base* groups are long-term groups with a stable membership, more like learning communities. Their main purpose is to provide support and encouragement and to help students feel connected to a community of learners.

In the extensive literature on cooperative learning in K–12, there are dozens of "brand-name" types of cooperative learning groups, each endowed by its creator with particular structural elements that are thought (or demonstrated through research) to enhance learning. Slavin (1996), for example, describes in some detail five methods that have been developed and extensively researched. Although there are distinctive differences in the purposes and philosophies guiding the formulation and operation of groups for learning, it is nevertheless true that all groups share two fundamental purposes: to engage students actively in their own learning and to do so in a supportive and challenging social context.

There is substantial agreement in the literature on what interactive group learning is, as well as what it is not. Karl Smith captures nicely some common misunderstandings about the nature of cooperative/collaborative learning.[2]

> *Many faculty who believe they are using cooperative learning are in fact missing its essence. There is a crucial difference between simply putting students in groups to learn and structuring cooperation among students. Cooperation is not having students sit side by side at the same table to talk with one another as they do their individual assignments. Cooperation is not assigning a report to a group of students, on which one student does all the work and the others put their names. Cooperation is not having students do a task individually and then having the ones who finish first help the slower students. Cooperation is much more than being physically near other students, discussing material with other students, or sharing material among students, although each of these is important in cooperative learning (Smith, 1996, p. 74).*

In contrast to what cooperative learning is *not,* Smith (1996, pp. 74–76) identifies what it *is* by listing five elements that he considers essential for successful cooperative learning groups (see also Johnson, Johnson, & Smith, 1998, pp. 21–23).

1. *Positive interdependence:* The success of individuals is linked to the success of the group; individuals succeed to the extent that the group succeeds. Thus students are motivated to help one another accomplish group goals.

2. *Promotive interaction:* Students are expected to actively help and support one another. Members share resources and support and encourage each other's efforts to learn.

3. *Individual and group accountability:* The group is held accountable for achieving its goals. Each member is accountable for contributing his or her share of the work; students are assessed individually.

4. *Development of teamwork skills:* Students are required to learn academic subject matter (task work) and also to learn the interpersonal and small-group skills required to function as part of a group (teamwork). Teamwork skills should be taught "just as purposefully and precisely as academic skills" (p. 75).
5. *Group processing:* Students should learn to evaluate their group productivity. They need to describe what member actions are helpful and unhelpful, and to make decisions about what to continue or change.

Virtually all collaborative learning methods emphasize the importance of *promotive interaction* and *individual accountability.* Students must not only learn to work together, but they must also be held responsible for their teammates' learning as well as their own. Slavin, in particular, has been insistent that successful groups must endorse individual accountability and team rewards. "It is not enough," he says, "to simply tell students to work together; they must have a reason to take one another's achievement seriously" (Slavin, 1996, p. 21).

Collaborative learning, then, is a structured learning activity that addresses major concerns related to improving student learning. It involves students actively, thereby putting into practice the predominant conclusion from a half-century of research on cognitive development. It prepares students for careers by providing them with opportunities to learn the teamwork skills valued by employers. It helps students appreciate multiple perspectives and develop skills to collaboratively address the common problems facing a diverse society. And it engages all students by valuing the perspective each student can contribute from his or her personal academic and life experience. That said, collaborative learning is not an educational panacea. Collaborative learning is an appropriate method for achieving some learning goals and tasks, but not for others. In most cases, we see collaborative learning not as a replacement for lecture, discussion, or other traditional methods, but rather as a useful complement.

What Is the Pedagogical Rationale for Collaborative Learning?

The closing decades of the twentieth century were exceptionally rich in producing a better understanding of the learning process. Critical to our understanding of that process is the basic tenet of modern cognitive theory: learners must be *actively engaged* in learning. Neurologists and cognitive scientists agree that people quite literally "build" their own minds throughout life by actively constructing the mental structures that connect and organize isolated bits of information. Much as we would like to think that we as teachers can "tell" students what we have learned and thus transfer it into their heads efficiently and accurately, the evidence is clear that we cannot "transfer" our knowledge ready-made into student minds. Instead, students must do the work of learning by actively making connections and organizing learning into meaningful concepts.

The Importance of Making Connections

There is growing evidence that learning is about making connections—whether the mental connections are established by firing synapses in the brain, the "ah ha" experience of seeing the connection between two formerly isolated concepts, or the satisfaction of seeing the connection between an academic abstraction and a "hands-on" concrete application. The important concept is that learners must actively make the connections in their own brains and minds that produce learning for them (Cross, 1999).

Neurological Connections

Stunning new research on the brain by neuroscientists is adding a new dimension to our knowledge about learning, and it is reinforcing rather than changing the tentative conclusions from cognitive science. Neuroscientists have developed a rich imagery about how the brain works. Children do not come into the world with a brain that is hard-wired like a computer. Rather, throughout life, they "grow" their own brains by constantly making connections in the circuitry of the brain through experience and learning. Research is showing that the circuitry of the brain is wired by neurons that spin out axons. These axons connect with many targets to form the transmission lines that carry electrical impulses. At the end of each "wire" is a bulb-and-button unit called a *synapse.* When an electrical signal reaches the button-like ending, a chemical message crosses the gap in the synapse to connect with the receiving cell. Scientists believe that at birth a baby's brain contains 100 billion neurons. Sensory stimulation strengthens connections. Alternatively, "through a process that resembles Darwinian competition, the brain eliminates connections or synapses that are seldom or never used" (Nash, 1997, p. 50). "Use it or lose it" appears to be quite true when applied to the "brain work" of learning. Researchers find that children who are deprived of sensory stimulation develop brains that are 20–30 percent smaller than normal for their age. Although much remains to be learned about the neurological growth of the brain, new insights into the physical development of the brain closely parallel what we are learning about the mental processes of learning.

Cognitive Connections

The parallels between the neurological brain and the working mind envisioned by cognitive scientists are quite remarkable. Modern cognitive science postulates a structure of the mind known as the *schema*—or in plural form, *schemata,* since the brain develops many schemata for different topics. A schema is a cognitive structure that consists of facts, ideas, and associations organized into a meaningful system of relationships. People have schemata for events, places, procedures, and people, for instance. A person's schema for a place, such as a college, might include concepts such as location, reputation, the characteristics of the student population, style of campus architecture, even the location of campus parking lots. Thus, the schema is an organized collection of bits of information that together build the concept of the college for each individual. When someone mentions the college, we "know" what he or she means, but the image brought to mind may be somewhat different for each individual.

What students can learn depends, to a larger extent than previously assumed, on what they already know. It is easier to learn something when we already have some background than it is to learn something completely new and unfamiliar. For example, advanced courses in a subject are often easier to teach and to learn than introductory courses. Cognitive theory would explain that paradox by observing that if the schema is very sparse with respect to a particular subject, connections are hard to find and make, whereas if the schema already has a dense network of vocabulary, terms, and concepts, it is easier to make the connections that constitute learning.

This fundamental assumption about the role of prior knowledge in learning was tested in a classic experiment that compared novice and expert chess players' ability to memorize the layout of chess pieces (de Groot, 1966). Chess players of different skill levels were shown the game pieces on a chessboard for a few seconds and then asked to recall the position of the pieces. The novice players were able to place only five or six pieces correctly, but the experts could recreate nearly the whole board. However, when these players were shown the pieces placed randomly on the board (rather than positions from a real game), novices and experts performed about the same. The conclusion from this rather simple experiment is that the superior performance of experienced chess players in recalling chess positions was not due to higher IQs or to better memories, but rather to a schema for chess that enabled experienced players to associate the patterns shown with those already in memory. The point is that what one knows about a given subject has a substantial impact on the learning process. When teachers complain