Introduction

> *You start out as a single cell derived from the coupling of a sperm and egg; this divides into two, then four, then eight, and so on, and at a certain stage there emerges a single cell which will have as all its progeny the human brain. The mere existence of that cell should be one of the great astonishments of the earth.*
>
> —Lewis Thomas,
> *The Medusa and the Snail*

The human brain is an amazing structure—a universe of infinite possibilities and mystery. It constantly shapes and reshapes itself as a result of experience, yet it can take off on its own without input from the outside world. How does it form a human mind, capture experience, or stop time in memory? Although it does not generate enough energy to light a simple bulb, its capabilities make it the most powerful force on Earth.

For thousands of years, humans have been delving into this mysterious universe and trying to determine how it accomplishes its amazing feats. How fast does it grow? What impact does the environment have on its growth? How does it learn language? How does it learn to read? What is intelligence?

Just how the brain learns has been of particular interest to teachers for centuries. Now, in the 21st century, there is new hope that our understanding of this remarkable process called teaching and learning will improve dramatically. A major source of that understanding is coming from the sophisticated medical instruments that allow scientists to peer inside the living—and learning—brain.

LOOKING INSIDE THE BRAIN

New technologies for looking inside and seeing the workings of the living brain have advanced faster than scientists predicted just a few years ago. The more we learn about the brain, the more remarkable it seems. Hardly a week goes by when some major news story about the brain appears in the press or on television. Consequently, most of us have heard about the imaging technologies, and some readers may have even experienced a brain scan. Because we will be mentioning brain scans throughout this book, here is a brief review of the more common scanning instruments that have contributed to our understanding of brain structure and function.

Types of Brain Imaging

The imaging technologies fall into two major categories: those that look at brain *structure* and those that look at brain *function.* When aimed at the brain, **computerized axial tomography** (CAT, or simply CT) and **magnetic resonance imaging** (MRI) are very useful diagnostic tools that produce computer images of the brain's internal structure. For example, they can detect tumors, malformations, and the damage caused by cerebral hemorrhages.

Different technologies, however, are required to look at how the brain works. An alphabet soup describes the five most common procedures that can be used to isolate and identify the areas of the brain where distinct levels of activity are occurring. The scanning technologies for looking at brain function are the following:

- Electroencephalography (EEG)
- Magnetoencephalography (MEG)
- Positron-Emission Tomography (PET)
- Functional Magnetic Resonance Imaging (fMRI)
- Functional Magnetic Resonance Spectroscopy (fMRS)

Here is a brief explanation of how each one works. A summary chart follows.

- **Electroencephalography (EEG) and Magnetoencephalography (MEG).** These two techniques are helpful in determining how quickly something occurs in the brain. To do that, they measure electrical and magnetic activity occurring in the brain during mental processing. In an EEG, anywhere from 19 to 128 electrodes are attached to various positions on the scalp with a conductive gel so electrical signals can be recorded in a computer. In a MEG, about 100 magnetic detectors are placed around the head to record magnetic activity. EEGs and MEGs can record changes in brain activity that occur as rapidly as one millisecond (one thousandth of a second), a typical time when the brain is processing language. When a group of neurons responds to a specific event (like a word), they activate, and their electrical and magnetic activity can be detected above the noise of the nonactivated neurons. This response is called an *event-related potential,* or ERP. ERP evidence has provided information about the time needed for the brain to do mathematical calculations or process reading. EEGs and MEGs do not expose the subject to radiation and are not considered hazardous.

- **Positron-Emission Tomography (PET).** The first technology to observe brain functions, PET involves injecting the subject with a radioactive solution that circulates to the brain. Brain regions of higher activity accumulate more of the radiation, which is picked up by a ring of detectors around the subject's head. A computer displays the concentration of radiation as a picture of blood flow in a cross-sectional slice of the brain regions that are aligned with the detectors. The picture is in color, with the more active areas in reds and yellows, and the quieter areas in blues and greens. Two major drawbacks to PET scans are the invasive nature of the injection and the use of radioactive materials. Consequently, this technique is not used with healthy children because the radioactive risk is too high.

- **Functional Magnetic Resonance Imaging (fMRI).** This technology is rapidly replacing PET scans because it is painless, is noninvasive, and does not use radiation. The technology helps to pinpoint the brain areas of greater and lesser activity. Its operation is based on the fact that when any part of the brain becomes more active, the need for oxygen and nutrients increases. Oxygen is carried to the brain cells by hemoglobin. Hemoglobin contains iron, which is magnetic. The fMRI uses a large magnet to compare the amount of oxygenated hemoglobin entering brain cells with the amount of deoxygenated hemoglobin leaving the cells. The computer colors in the brain regions receiving more oxygenated blood and can locate the activated brain region to within one centimeter (less than a half-inch).

- **Functional Magnetic Resonance Spectroscopy (fMRS).** This technology involves the same equipment as fMRI but uses different computer software to record levels of various chemicals in the brain while the subject is thinking. Like the fMRI, fMRS can precisely pinpoint the area of activity, but it can also identify whether certain key chemicals are present at the activation site. fMRS has been used to study language function in the brain by mapping the change in specific chemicals, such as lactate, that respond to brain activation during tasks involving language.

Researchers are also learning much more about several dozen brain chemicals called *neurotransmitters.* These substances bathe the brain cells and either permit signals to pass between them or inhibit them. Wide fluctuations in the concentration of neurotransmitters in certain brain areas can change our mood, affect our movement, diminish or enhance our alertness, and interfere with our ability to learn.

To determine which parts of the brain control various functions, neurosurgeons use tiny electrodes to stimulate individual nerve cells and record their reactions. Besides the information collected by these techniques, the growing body of case studies of individuals recovering from various types of brain damage is giving us new evidence about and insights into how the brain develops, changes, learns, remembers, and recovers from injury.

Techniques for Mapping Brain Functions

Technique	**What It Measures**	**How It Works**
Electroencephalography (EEG) Magnetoencephalography (MEG)	The electrical and magnetic activity occurring in the brain during mental processing. The spikes of activity are called event-related potential (ERP).	In EEG, multiple electrodes are attached to the scalp to record electrical signals in a computer. In MEG, magnetic detectors are placed around the head to record magnetic activity. EEGs and MEGs record changes in brain activity that occur as rapidly as one millisecond. When a group of neurons responds to a specific event, they activate, and their electrical and magnetic activity can be detected. This response is called an event-related potential, or ERP.

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Technique	What It Measures	How It Works
Positron-Emission Tomography (PET)	Amount of radiation present in brain regions.	The subject is injected with a radioactive solution that circulates to the brain. Brain regions of higher activity accumulate more radiation, which is picked up by a ring of detectors. A computer displays the concentration of radiation in a cross-sectional slice of the brain regions aligned with the detectors. The picture shows the more active areas in reds and yellows and the quieter areas in blues and greens.
Functional Magnetic Resonance Imaging (fMRI)	Levels of deoxygenated hemoglobin in brain cells.	Any part of the brain that is thinking requires more oxygen, which is carried to the brain cells by hemoglobin. The fMRI uses a large magnet to compare the amount of oxygenated hemoglobin entering brain cells with the amount of deoxygenated hemoglobin leaving the cells. The computer colors in the brain regions receiving more oxygenated blood and locates the activated brain region to within one centimeter (half-inch).
Functional Magnetic Resonance Spectroscopy (fMRS)	Levels of specific chemicals present during brain activity.	This technology involves the same equipment as fMRI but uses different computer software to record levels of various chemicals in the brain while the subject is thinking. fMRS can not only precisely pinpoint the area of activity, but it can also identify whether certain key chemicals are present at the activation site.

IMPLICATIONS FOR TEACHING

As we examine the clues that this research is yielding about learning, we recognize its importance to the teaching profession. Every day teachers enter their classrooms with lesson plans, experience, and the hope that what they are about to present will be understood, remembered, and useful to their students. The extent that this hope is realized depends largely on the knowledge base that these teachers use in designing those plans and, perhaps more important, on the instructional techniques they select during the lessons. Teachers try to change the human brain every day. The more they know about how it learns, the more successful they can be.

Educators in recent years have become much more aware that neuroscience is finding out a lot about how the brain works, and that some of the discoveries have implications for what happens in schools and classrooms. There is a growing interest among educators in the biology of learning and how much an individual's environment can affect the growth and development of the brain. More teacher training institutions are incorporating brain research into their courses. Professional development programs are also devoting more time to this area, more books about the brain are available, brain-compatible teaching units are sprouting up, and the journals of most major educational organizations have devoted special issues to the topic. These are all good signs. I believe this focus on recent brain research can improve the quality of our profession's performance and its success in helping others learn.

Teachers try to change the human brain every day. The more they know about how it learns, the more successful they can be.

Some Important Findings

As research continues to provide a deeper understanding of the workings of the human brain, educators need to be cautious about how they apply these findings to practice. There are critics who believe that brain research should not be used at this time in schools and classrooms. Some critics say it will be years before this has any application to educational practice. Others fear that unsubstantiated claims are being made, usually referred to as "neuromyths," and that educators are not sufficiently trained to tell scientific fact from hype. The concerns are understandable but should not prevent educators from learning what they need to know to decide whether research findings have application to their practice. For those who wonder how recent discoveries about the brain can affect teaching and learning, we can tell them that this research has done the following:

- Reaffirmed that the human brain continually reorganizes itself on the basis of input. This process, called *neuroplasticity*, continues throughout our life but is exceptionally rapid in the early years. Thus, the experiences the young brain has in the home and at school help shape the neural circuits that will determine how and what that brain learns in school and later.
- Startled the scientific world with evidence that neurons in the brain do slowly regenerate, thereby enhancing learning and memory.
- Challenged the notion that the brain can multitask.
- Revealed more about how the brain acquires spoken language.
- Developed scientifically based computer programs that dramatically help young children with reading problems.
- Shown how emotions affect learning, memory, and recall.
- Suggested that movement and exercise improve mood, increase brain mass, and enhance cognitive processing.
- Tracked the growth and development of the teenage brain to better understand the unpredictability of adolescent behavior.
- Developed a deeper understanding of circadian cycles to explain why teaching and learning can be more difficult at certain times of day.
- Studied the effects of sleep deprivation and stress on learning and memory.
- Recognized that intelligence and creativity are separate abilities, and that both can be modified by the environment and schooling.
- Highlighted the degree to which a school's social and cultural climates affect teaching and learning.

- Updated our understandings about working memory.
- Added to our knowledge of how the arts develop the brain.
- Recognized that omnipresent technology is rewiring toddlers' and students' brains.

Other researchers strongly disagree with the critics and support the increased attention that educators are giving to neuroscience. Several universities here and abroad have established dedicated research centers to examine how discoveries in neuroscience can affect educational practice. As a result, educational theory and practice will become much more research based, similar to the medical model. In fact, the body of knowledge that represents this application of brain research to classroom practice has grown so much in the past two decades that it is now recognized as a separate area of study. Known as *mind, brain, and education* or ***educational neuroscience***, this field of inquiry looks at how what we are learning about the human brain can affect the curricular, instructional, and assessment decisions that teachers make every day. These implications do not represent an "in-the-box program" or the "strategy du jour" that teachers sometimes view with a wary or cynical eye. Rather, the goal of educational neuroscience is to reflect on this research and decide whether it should have an impact on educational practices.

There is, of course, no panacea that will make teaching and learning a perfect process—and that includes brain research. It is a long leap from making a research finding in a laboratory to the changing of schools and practice because of that finding. These are exciting times for educators, but we must ensure that we don't let the excitement cloud our common sense.

WHY THIS BOOK CAN HELP IMPROVE TEACHING AND LEARNING

What I have tried to do here is report on research (from neuroscience as well as the behavioral and cognitive sciences) that is sufficiently reliable that it can inform educational practice. This is hardly a novel idea. Madeline Hunter in the late 1960s introduced the notion of teachers using what science was learning about learning and modifying traditional classroom procedures and instructional techniques accordingly. Her program at the UCLA School of Education came to be called "Instructional Theory Into Practice," or ITIP. Readers familiar with that model will recognize some of Dr. Hunter's work here, especially in the areas of transfer and practice. I had the privilege of working periodically with her for nine years, and I firmly believe that she was the major force that awakened educators to the importance of continually updating their knowledge base and focusing on research-based strategies and the developing science of learning.

This book will help answer questions such as these:

- When do students remember best in a learning episode?
- To what extent is technology changing the brain?

- How can I help students understand and remember more of what I teach?
- Why is focus so important, and why is it so difficult to get?
- How can I teach motor skills effectively?
- How can humor and music help the teaching-learning process?
- How can I get students to find meaning in what they are learning?
- Why is transfer such a powerful principle of learning, and how can it destroy a lesson without my realizing it?
- What classroom strategies are more likely to appeal to the brain of today's student?
- What important questions should I be asking myself as I plan daily and unit lessons?

Chapter Contents

Chapter 1. Basic Brain Facts. Because we are going to talk a lot about the brain, we should be familiar with some of its anatomy. This chapter discusses some of the major structures of the human brain and their functions. It explores how the young brain grows and develops, focusing on those important windows of opportunity for learning in the early years. There is an explanation of how students' brains today are very different from those of just a few years ago, especially in what they expect from their school experiences.

Chapter 2. How the Brain Processes Information. Trying to develop a simple model to describe the complex process of learning is not easy. The model at the heart of this chapter outlines what cognitive researchers believe are the critical steps involved in the brain's acquisition and processing of information. The components of the model are discussed in detail and updated from previous editions. Also included is an instrument to help you determine your modality preferences.

Chapter 3. Memory, Retention, and Learning. Teachers want their students to remember forever what they are taught, but that does not happen too often. The third chapter focuses on the different types of memory systems and how they work. Those factors that affect retention of learning are discussed here along with ideas of how to plan lessons that result in greater remembering. Also included are some cautions about commercial brain-training programs.

Chapter 4. The Power of Transfer. Transfer is one of the most powerful and least understood principles of learning. Yet a major goal of education is to enable students to transfer what they learn in school to solve future problems. The nature and power of transfer are examined in this chapter, including how to use past knowledge to enhance present and future learning.

Chapter 5. Brain Organization and Learning. This chapter explores how areas of the brain are specialized to perform certain tasks. It examines the latest research on how we learn to speak and read, and learn mathematics, along with the implications of this research for classroom instruction and for the curriculum and structure of schools.

Chapter 6. The Brain and the Arts. Despite strong evidence that the arts enhance cognitive development, they run the risk of being abandoned so more time can be devoted to preparing for mandated high-stakes testing. Public support for keeping the arts is growing. This chapter presents the latest evidence of how the arts in themselves contribute to the growth of neural networks as well as enhance the skills needed for mastering other academic subjects, including in the STEM areas.

Chapter 7. Thinking Skills and Learning. Are we challenging our students enough to do higher-level thinking? This chapter discusses some of the characteristics and dimensions of human thinking. It focuses on the recent revision of Bloom's taxonomy, notes its continuing compatibility with current research on higher-order thinking, and explains the taxonomy's critically important relationship to difficulty, complexity, and intelligence.

Chapter 8. Putting It All Together. So how do we use these important findings in daily practice? This chapter emphasizes how to use the research presented in this book to plan lessons. It discusses different types of teaching methods, including the flipped classroom, and suggests guidelines and a format for lesson design. Because neuroscience continues to reveal new information about learning, the chapter describes support systems to help educators maintain expertise in brain-compatible techniques and move toward continuous professional growth.

At the end of each chapter are the Practitioner's Corners. Some include activities that check for understanding of the major concepts and research presented in the chapter. Others offer my interpretation of how this research might translate into effective classroom strategies that improve the teaching-learning process. Readers are invited to critically review my suggestions and rationale to determine if they have value for their work.

Main thoughts are highlighted in boxes throughout the book. At the very end of each chapter, you will find a page called Key Points to Ponder, an organizing tool to help you remember important ideas, strategies, and resources you may wish to consider later.

Where appropriate, I have explained some of the chemical and biological processes occurring within the brain. However, I have intentionally omitted complex chemical formulas and reactions and have avoided side issues that would distract from the main purpose of this book. My intent is to present just enough science to help the average reader understand the research and the rationale for any suggestions I offer.

Who Should Use This Book?

This book will be useful to classroom teachers because it presents a research-based rationale for why and when certain instructional strategies should be considered. It focuses on the brain as the organ of thinking and learning, and takes the approach that the more teachers know about how the brain learns, the greater the number of instructional options that become available. Increasing the options that teachers have during the dynamic process of instruction also increases the likelihood that successful learning will occur.

The book should also help professional developers who continually need to update their own knowledge base and include research and research-based strategies and support systems as part of their repertoire. Chapter 8 offers some suggestions to help professional developers implement and maintain the knowledge and strategies suggested here.

Principals and head teachers should find here a substantial source of topics for discussion at faculty meetings, which should include, after all, instructional as well as informational items. In doing so, they support the attitude that professional growth is an ongoing school responsibility and not an occasional event. More important, being familiar with these topics enhances the principal's credibility as the school's instructional leader and promotes the notion that the school is a learning organization for *all* its occupants.

College and university instructors should also find merit in the research and applications presented here, as both suggestions to improve their own teaching and information to be passed on to prospective teachers.

Some of the information in this book will be useful to parents, who are, after all, the child's first teachers.

Indeed, the ideas in this book provide the research support for a variety of initiatives, such as cooperative learning groups, differentiated instruction, integrated thematic units, and the interdisciplinary approach to curriculum. Those who are familiar with constructivism will recognize many similarities in the ideas presented here. The research is yielding more evidence that knowledge is not only transmitted from the teacher to the learners but is also transformed in the learner's mind as a result of cultural and social mediation. Much of this occurs through elaborative rehearsal and transfer and is discussed in several chapters.

This book can help teachers, professional developers, principals, college instructors, and parents.

Try It Yourself—Do Action Research

Benefits of Action Research

One of the best ways to assess the value of the strategies suggested in this book is to try them out in your own classroom or in any other location where you are teaching. Conducting this action research allows you to gather data to determine the effectiveness of new strategies and affirm those you already use, to acclaim and enhance the use of research in our profession, and to further your own professional development.

Other benefits of action research are that it provides teachers with consistent feedback for self-evaluation, it introduces alternative forms of student assessment, and its results may lead to important changes in curriculum. Action research can be the work of just one teacher, but its value grows immensely when it is the consistent effort of a teacher team, a department, a school staff, or even an entire district. Incorporating action research as a regular part of the K–12 academic scene not only provides useful data but also enhances the integrity of the profession and gains much-needed respect from the broad community that schools serve.

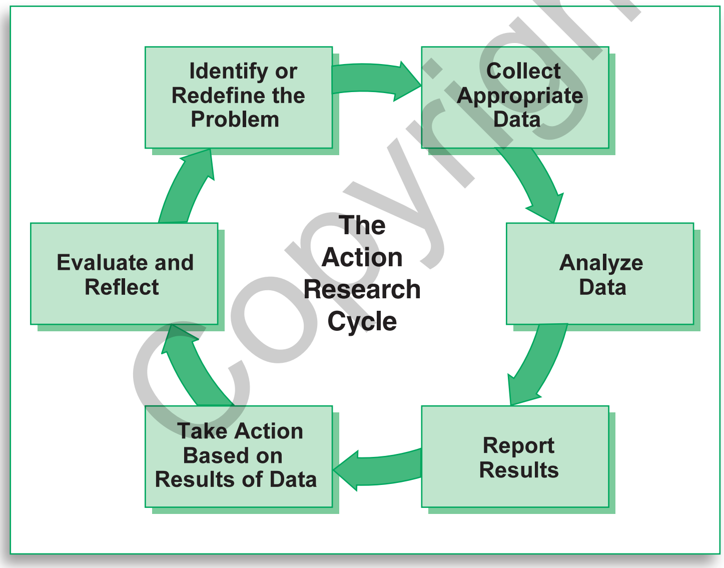
Teachers are often hesitant to engage in action research, concerned that it may take too much time or that it represents another accountability measure in an already test-saturated environment. Yet, with all the programs and strategies emerging today in the name of reform, we need data to help determine their validity. The valuable results of cognitive neuroscience will continue to be ignored in schools unless there is reliable evidence to support their use. Action research is a cost-effective means of assessing the effectiveness of brain-compatible strategies that are likely to result in greater student learning. Several studies in PreK-12 schools have shown that action research has a positive effect on teacher confidence and practice (e.g., Brown & Weber, 2016; Calvert & Sheen, 2015).

Using action research provides valuable data, affirms best practices, and enhances the integrity of the profession.

The Outcomes of Action Research

The classroom is a laboratory in which the teaching and learning processes meet and interact. Action research can provide continual feedback on the success of that interaction. Using a solution-oriented approach, action research includes identifying the problem, systematically collecting data, analyzing the data, taking action based on the data, evaluating and reflecting on the results of those actions, and, if needed, redefining the problem (see Figure I.1). The teacher is always in control of the type of data collected, the pace of assessment, and the analysis of the results. This process encourages teachers to reflect on their practices, to refine their skills as practitioners, and to direct their own professional development. This is a new view of the profession, with the teacher as the main agent of change.

Figure I.1 The diagram illustrates the six steps in the action research cycle.



Building administrators have a special obligation to encourage action research among their teachers. With so much responsibility and accountability being placed on schools and teachers, action research can quickly assess the effectiveness of instructional strategies. By supporting such a program, principals demonstrate by action that they are truly instructional leaders and not just building managers. See the Practitioner's Corner: Using Action Research at the end of this chapter for specific suggestions on using action research in the classroom.

Finally, this fifth edition of the book reflects what more I have gathered about the brain and learning at the time of publication. Because this is now an area of intense research and scrutiny, educators need to constantly read about new discoveries and adjust their understandings accordingly. As we discover more about how the brain learns, we can devise strategies that can make the teaching-learning process more efficient, effective, and enjoyable.

WHAT'S COMING UP?

As neuroscience advances, educators are realizing that some basic information about the brain must now become part of their knowledge base. Educators are not neuroscientists, but they are members of the *only* profession in which their job is to change the human brain every day. Therefore, the more they know about how it works, the more likely they are to be successful at changing it. To that end, Chapter 1 will take the reader through a painless and easy-to-read explanation of some major brain structures and their functions as well as a peek at the brain of today's students.

Educators are in the only profession in which their job is to change the human brain every day.

PRACTITIONER'S CORNER

What Do You Already Know?

The value of this book can be measured in part by how it enhances your understanding of the brain and the way it learns. Take the following true-false test to assess your current knowledge of the brain. Decide whether the statements are generally true or false and circle T or F. Explanations for the answers are identified throughout the book in special boxes.

1. T F The structures responsible for deciding what gets stored in long-term memory are located in the brain's rational system.
2. T F Learners who can perform a new learning task well are likely to retain it.
3. T F Reviewing material just before a test is a good practice to determine how much has been retained.
4. T F Increased time on task increases retention of new learning.
5. T F Two very similar concepts or motor skills should be taught at the same time.
6. T F The rate at which a learner retrieves information from memory is closely related to intelligence.
7. T F The amount of information a learner can deal with at one time is genetically linked.
8. T F It is usually not possible to increase the amount of information that the working (temporary) memory can deal with at one time.
9. T F Most of the time, the transfer of information from long-term storage is under the conscious control of the learner.
10. T F Bloom's taxonomy has not changed over the years.

PRACTITIONER'S CORNER

How Brain-Compatible Is My Teaching/School/District?

Directions: On a scale of 1 (lowest) to 5 (highest), circle the number that indicates the degree to which your teaching/school/district does the following. Connect the circles to see a profile.

1. I/We adapt the curriculum to recognize the windows of opportunity students have during their cognitive growth. 1—2—3—4—5

2. I/We are trained to provoke strong, positive emotions in students during the learning process. 1—2—3—4—5

3. I/We are trained to help students adjust their self-concept to be more successful in different learning situations. 1—2—3—4—5

4. I/We provide an enriched and varied learning environment. 1—2—3—4—5

5. I/We search constantly for opportunities to integrate curriculum concepts between and among subject areas. 1—2—3—4—5

6. Students have frequent opportunities during class to talk about what they are learning, while they are learning. 1—2—3—4—5

7. I/We do not use lecture as the main mode of instruction. 1—2—3—4—5

8. One of the main criteria I/we use to decide on classroom activities and curriculum is relevancy to students. 1—2—3—4—5

9. I/We understand the power of chunking and use it in the design of curriculum and in daily instruction. 1—2—3—4—5

10. I/We understand the primacy-recency effect and use it regularly in the classroom to enhance retention of learning. 1—2—3—4—5

PRACTITIONER'S CORNER

Using Action Research

Basic Guidelines

Action research helps teachers assess systematically the effectiveness of their own educational practices using the techniques of research. Because data collection is essential to this process, teachers need to identify the elements of the research question that can be measured.

- **Select the Research Question.** Because you need to collect data, choose a research question that involves elements that can be easily measured quantitatively or qualitatively. For example,

1. How does the chunking of material affect the learner's retention? This can be measured by a short oral or written quiz.
2. How does teaching material at the beginning or middle of a lesson affect learner retention? This can be measured by quizzes.
3. How does changing the length of wait time affect student participation? This can be measured by comparing the length of the wait time to the number of subsequent student responses.
4. Does using humor or music increase student focus? Can either be measured by the number of students who are on/off task with or without humor or music?
5. Does teaching two very similar concepts at different times improve student understanding and retention of them? This can be measured by oral questioning or quizzes after teaching each concept.

- **Collect the Data.** Remember that you need baseline data before you try the research strategy to provide a comparison. Plan carefully the methods you will use to measure and collect the data. Try not to use paper-and-pencil tests exclusively. You will collect pretrial and posttrial data.

Pretrial. Select a control group, which is usually the same group of students that will be used with the research strategy. Collect test data without using the research strategy.

Posttrial. Use the strategy (e.g., chunking, prime-time-1, wait time, humor) and then collect the appropriate data.

- **Analyze the Data.** Use simple analytical techniques, such as comparing the average group test scores before and after using the research strategy. What changes did you notice in the two sets of data? Did the research strategy produce the desired result? If not, why not? Was there an unexpected consequence (positive or negative) of using the strategy?

- **Share the Data.** Sharing the data with colleagues is an important component of the action research process. Too often, teachers work in isolation, with few or no opportunities to interact continuously with colleagues to design and discuss their lessons.

- **Implement the Change.** If the research strategy produced the desired results, decide how you will make it part of your teaching repertoire. If you did not get the desired results, decide whether you need to change some aspect of the strategy or perhaps use a different measure.

- **Try New Practices.** Repeat the above steps with other strategies so that action research becomes part of your ongoing professional development.