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ABSTRACT

Recent advances in instructional knowledge, as well as their usefulness for fitting instructional strategies to individual students, are the subject of this four-chapter survey of research literature. Chapter 1 summarizes research on learning styles--the ways in which individuals perceive, analyze, interpret, and respond to learning situations. Examined in this chapter are cognitive styles, including data reception and concept formation and retention; affective styles, comprising attention, expectancy, and incentive styles; physiological styles, such as developmental and sex- and health-related differences; and practical considerations in the use of instruments to measure learning styles. Chapter 2 covers research on brain lateralization (the location of different functions in the brain's right or left hemispheres), the brain's building of models of reality, and brain growth stages. Learning time research is considered in chapter 3, which reviews findings about time on task and about variations among students in the time needed to master a subject. The final chapter looks at the administrative implications of recent research, noting first the problems with earlier attempts to individualize instruction and then discussing the implications of findings in the three areas of learning styles, brain development, and learning time. (RW)

The Emerging Science of Individualized Instruction

A Survey of Findings on Learning Styles, Brain Research, and Learning Time with Implications for Administrative Action

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Clearinghouse on Educational Management
College of Education · University of Oregon

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FOREWORD

The ERIC Clearinghouse on Educational Management is pleased to add this report to the School Management Digest, a series designed to offer educational leaders essential information on a wide range of critical concerns in education.

At a time when decisions in education must be made on the basis of increasingly complex information, the Digest provides school administrators with concise, readable analyses of the most important trends in schools today. The goal of this analysis is improvement of educational practice. Each Digest points up the practical implications of major research findings so that its readers might better grasp and apply knowledge useful for the operation of the schools.

The author of this report, John Lindelow, was commissioned by the Clearinghouse as a research analyst and writer. We deeply appreciate his skill in organizing and bringing clarity to the large amount of information on the topic.

Philip K. Piele
Professor and Director

INTRODUCTION

Since its inception, educational research has had one consistent (though, at times, obscured) purpose. the improvement of the instructional process. In times past, researchers attempted to improve instruction by asking how learners could be better "fit" into standard educational programs. In recent decades, however, the motif of research and reform has been the individualization of instruction. Researchers now ask how the educational program can be designed to better meet the needs of individual learners.

We appear to be entering a stage, says Mario D. Fantini, "in which the notion of *designing programs to fit learners* is replacing the older notion of *fitting learners to standard programs*." Under this new orientation, "it is not the student who fails but the method or program. Consequently, all methods become a reservoir from which to draw in the quest for a match with learners."

Most experienced educators naturally develop some intuitive sense for matching teaching strategies to different students. But only in the past decade or two have educational researchers focused their attention on this area. They have found, not surprisingly, that students vary tremendously in the ways they learn. Moreover, these researchers have begun to determine the "rules" for matching learners with methods.

This digest will review some of the important advances in this and other areas—advances that are providing an increasingly solid foundation for the science of individualized instruction. The first chapter will review recent research on "learning styles," which are the characteristic ways individuals perceive, analyze, interpret, and respond to learning situations. The second chapter will discuss advances in our understanding of the brain, including the concepts of brain lateralization and the growth stages of the brain.

Another intuitive and seemingly obvious notion confirmed by recent research is that students learn more when they spend more time engaged in their lessons. The third chapter will discuss this "new" finding along with yet another

obvious concept, this one linking learning, time, and individualized instruction. different students take different lengths of time to achieve the same level of learning. This simple concept provides the foundation for one important approach to individualized instruction called mastery learning.

At times, the ideas discussed in this digest might seem overly obvious, and the impatient reader may exclaim, "Of course, I've known this intuitively all along." But when one attempts to find how these obvious facts of learning are being incorporated into the instructional process in conventional schools, scant evidence presents itself. The mismatch between the emerging science of individualized instruction and the practice in most of today's schools is strikingly evident.

There is reason to believe, however, that this hiatus between potential and practice may soon be bridged, as will be discussed in the last chapter of this digest. The final chapter will also discuss the implications of the emerging science of individualized instruction for administrative action today.

CHAPTER 1

LEARNING STYLES

> Learning style diagnosis opens the door to placing individualized instruction on a more rational basis. It gives the most powerful leverage yet available to educators to analyze, motivate, and assist students in school. As such, it is the foundation of a truly modern approach to education. James W. Keefe

Every classroom teacher knows that students are unique individuals who think and learn in a variety of equally unique ways. Educational researchers, too, know well the range of student differences: a plot of almost any student trait—whether cognitive, affective, or physical—shows a wide distribution of scores. Each student is indeed unique—whether looked at as a whole individual or as a pattern of high, medium, and low scores.

It is indeed ironic, then, that public education most often operates as if all students were quite similar. To be sure, public education is already knee-deep in the rhetoric of individualized instruction. But in actual practice, most instruction is still delivered in the same fashion it has been for a great many decades—via group instruction in a classroom setting with little true individualization actually taking place.

Many attempts have been made to individualize instruction in the past, and most have failed. "Previous efforts have been unsuccessful because they were based on a false epistemology, on a misunderstanding of how students learn," says Keefe.

> When we consider the dearth of professional knowledge about learning, the reliance largely on student or parental preference rather than on professional analysis, the futile attempts to innovate by making *all* students take independent study, or large group or whatever, is it any wonder that individualization has faltered? Now, however, we have the *beginning* of a science of human learning that can be applied in schools.

The cornerstone of the science Keefe refers to is the no-

tion of student learning styles, which he defines as "characteristic cognitive, affective, and physiological behaviors that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment." The modus operandi of this new learner-centered science is to adjust both teaching style and the instructional environment to the needs of the individual learner.

The following discussion will provide a general overview of the learning styles field. This field is already vast and is growing daily, thus, a comprehensive treatment will not be attempted. For readers interested in more detail, an excellent starting point is the National Association of Secondary School Principal's *Student Learning Styles. Diagnosing and Prescribing Programs.*

CLASSIFICATION SYSTEMS

Numerous schemes for classifying the many different "elements" of learning style have been devised. Some researchers have constructed models of learning style that include only variables in the cognitive area. Others have focused their attention on the perceptual or affective domains. Finally, some researchers and writers have attempted to compile the varied research on learning style into general models. Two of the more comprehensive of these typologies will be outlined below.

The learning style field, it should be noted, is still in a formative stage of development. A great deal of disagreement still exists among researchers, particularly in regard to the importance of various measured differences and their implications for instruction. This kind of disagreement is to be expected in such a young and complex science.

Keefe's classification of learning style has three broad divisions. cognitive style, affective style, and physiological style. Each of these divisions will be discussed in turn below.

Cognitive Styles

Following Samuel Messick (*Individuality in Learning*),

Keefe defines cognitive styles as "information processing habits representing the learner's typical mode of perceiving, thinking, problem solving, and remembering." In other words, cognitive styles are the distinctive and consistent ways that learners perceive, organize, and retain information.

Cognitive styles are *not* the same as intellectual abilities, Keefe emphasizes. Abilities refer to innate capacities for processing certain kinds of information. "Styles, on the other hand, illustrate the *process* of cognition. they tell *how* information is being processed."

As table 1 shows, Keefe divides cognitive styles into those that deal with the perception and analysis of data (reception styles) and those that deal with hypothesis generation, problem-solving, and memory processing (concept formation and retention styles). The reception styles are as follows:

1. *Perceptual modality preferences* are learner preferences for kinesthetic, visual, or auditory modes of perception. Children's preferences appear to develop from kinesthetic to visual to auditory as they develop. Adults use all three, but most people prefer one.

2. *Field independence vs. field dependence* is congruous to the dichotomy between analytical (left-hemisphere dominated) and global (right-hemisphere dominated) modes of thinking. Patricia Kirby (in Rita Dunn and Thomas DeBello) refers to these types of thinkers as being either "splitters" or "lumpers." "Independents perceive things as discrete from their background field, while dependents tend to be influenced by any embedding context," Keefe explains.

3. *Scanning*. Some learners "deploy attention" by scanning (broad attention), while others tend to focus more (narrow attention).

4. *Constricted vs. flexible control* also refers to how attention is "structured." "The constricted style is more susceptible to distraction while the flexible style tends to concentrate on the task at hand," says Keefe.

5. *Tolerance for incongruous or unrealistic experiences.* Highly tolerant individuals accept unorthodox experiences with ease. Less tolerant learners tend to hold on to conventional ideas.

6. *Strong vs. weak automatization*. A learner with a strong

TABLE 1: STUDENT LEARNING STYLE

Cognitive Styles

Reception Styles
- Perceptual modality preferences
- Field independence vs. dependence
- Scanning
- Constricted vs. flexible control
- Tolerance for incongruous or unrealistic experiences
- Strong vs. weak automatization
- Conceptual vs. perceptual-motor dominance

Concept Formation and Retention Styles
- Conceptual tempo
- Conceptualizing styles
- Breadth of categorizing
- Cognitive complexity vs. simplicity
- Leveling vs. sharpening

Affective Styles

Attention Styles
- Conceptual level
- Curiosity
- Persistence or perseverance
- Level of Anxiety
- Frustration tolerance

Expectancy and Incentive Styles
- Locus of control
- Achievement motivation
- Self-actualization
- Imitation
- Risk taking vs. cautiousness
- Competition vs. cooperation
- Level of aspiration
- Reaction to reinforcement
- Social motivation
- Personal interests

Physiological Styles

- Masculine-feminine behavior
- Health-related behavior
- Time rhythms
- Need for mobility
- Environmental elements

Source: Keefe

automatization style can easily perform simple repetitive tasks, probably because attention is focused on the obvious properties of the task, not on the details of the situation. Persons with weak automatization style, on the other hand, also usually have strong "restructuring" abilities probably because of their attention to detail.

7. *Conceptual vs. perceptual* refers to the ability to perform novel or difficult tasks. Perceptually dominant learners easily perform perceptual-motor behaviors but have less ability in conceptual areas. Conceptual learners have the opposite pattern.

The concept formation and retention styles that have best been characterized by research, according to Keefe, are as follows:

1. *Conceptual tempo* refers to "differences in the speed and adequacy of hypothesis formulation and information processing." On one extreme are "impulsives," who tend to give the first answer that comes into their head. "Reflectives," on the other hand, deliberate before making decisions.

2. *Conceptualizing styles.* Some learners tend to conceptualize by categorizing, some use descriptive approaches, while others look for thematic relationships among data.

3. *Breadth of categorizing.* Broad categorizers "lessen the risk of leaving something out" by including many items in their categories. Narrow categorizers exclude doubtful items and thus reduce the chance of including deviant items.

4. *Cognitive complexity vs. simplicity.* Individuals with a high complexity style can handle many variables at once and can bring order to dissonant information. Those with a low complexity style prefer consistency and regularity in their environments. Moving from a low to a high complexity style appears to correlate with the change from concrete to formal thinking in Jean Piaget's developmental hierarchy.

5. *Leveling vs. sharpening* refers to differences in the processing of memory. "Levelers" tend to blur distinctions in memories and are able to easily merge new experiences with past. "Sharpeners" tend to magnify small differences and differentiate more between new experience and memory. At least one researcher, says Keefe, believes this style category could have "particularly important implications for education."

Affective Styles

The learning styles in Keefe's second major category are those having to do with "attention, emotion, and valuing." The fifteen "affective" learning styles in this category describe "the learner's typical mode of arousing, directing, and sustaining behavior." Thus, affective learning styles are intimately involved with the motivational processes of the learner.

These motivational processes—and the overall affective style they produce—are open to a wide variety of influences, including the cultural environment, personality influences, peer and parental pressures, and values. "Not every student can be successful in every learning environment," Keefe points out, "because accustomed habits may prove to be at odds with the school values. Diagnosis of affective learning style is critical, then, to the effective functioning of the school learning process."

Keefe classifies the affective styles as being either "attention" or "expectancy and incentive." The five attention styles are as follows:

1. *Conceptual level* refers to the amount of "structure" that a student needs to learn most efficiently. Generally, younger learners need more structure in their instructional environment and are said to have a low conceptual level style.

2. *Curiosity* is the extent to which individuals are attracted to novel aspects of the environment.

3. *Persistence or perseverance*. Highly persistent learners work until a task is completed. Learners with low persistence have a short attention span and little ability to work on a lengthy task.

4. *Level of anxiety*. Some learners are usually tense and worried, others are extremely "cool." When presented with a difficult task, learners with low anxiety levels perform better than those with high anxiety.

5. *Frustration tolerance*. Learners low in frustration tolerance are more likely to get involved in conflict situations, accepting the challenge presented.

The expectancy and incentive styles outlined by Keefe total ten in number.

1. *Locus of control*. Some learners believe that cir-

cumstances are out of their control and, thus, have an external locus of control. Others believe they are responsible for their actions and are said to have an internal locus.

2. *Achievement motivation* is probably the most thoroughly researched affective style, says Keefe. It refers to "individual differences in patterns of planning and striving for some internalized standard of excellence."

3. *Self actualization* refers to differences in learner's feelings of adequacy, as defined by Maslow.

4. *Imitation* is the tendency to imitate the behaviors of others that appear to be desirable.

5. *Risk taking vs. cautiousness.* Risk takers, says Keefe, "prefer low probability-high payoff alternatives, cautious persons like high probability-low payoff ones."

6. *Competition vs. cooperation.* Some learners appear to be motivated by rivalry, whereas others are stimulated by sharing an experience with others.

7. *Level of aspiration,* also called *academic self-concept* by Benjamin Bloom and his colleagues, refers to differences in learners' perceptions of their past successes and failures. Past successes build modest self-confidence, while past failures can lead to despair or "unrealistic optimism."

8. *Reaction to reinforcement* refers to classic behavioral responses to reward and punishment. "Generally speaking," says Keefe, "students are motivated by reinforcement and variable in response to punishment."

9. *Social motivation* describes the degree to which a learner's behaviors are influenced by the standards and expectations of family, racial or ethnic group, or peer group. A learner's social motivation is closely tied to his or her value system.

10. *Personal interests.* Some preferences stem not from external pressures but from individual interests. High interest in an activity, of course, will motivate a learner, whereas low interest will not.

Physiological Styles

Keefe's final category of learning styles is based on the customary functioning of the human body. "Physiological styles are biologically-based modes of response that are founded on sex-related differences, personal nutrition and

health, and accustomed reaction to the physical environment." The five learning factors in this category are as follows.

1. *Masculine-feminine behavior*. Boys and girls display variations in certain areas. Boys, for example, are more sensitive to spatial or visual relations, while girls are more verbal and dextrous.

2. *Health-related behavior* includes malnutrition, hunger, and disease.

3. *Time rhythms*. Some individuals perform best in the morning, others in the afternoon or evening.

4. *Need for mobility* refers to learner needs for change in posture and location. Younger learners and males generally require more mobility.

5. *Environmental elements* include individual preferences for certain levels of light, sound, or temperature.

Another scheme for categorizing the elements of learning style has been outlined by Rita Dunn. The emphasis in Dunn's model is on what Dorothy S. Davis and Phyllis Chiasson Schwimmer call the "input/output" factors of style, such as the environment surrounding a learner, the learner's perceptual preferences for receiving information, and the learner's preferred means of expression. There is less emphasis on the ways learners internally process and organize ideas (Keefe's cognitive styles).

Dunn categorizes the elements of learning style as being environmental, emotional, sociological, physical, and psychological. Environmental elements include sound, light, temperature, and design of surroundings. "Well-designed and well-conducted research studies," Dunn states, confirm that each individual has unique environmental needs in learning situations. For example, some learners require absolute silence when concentrating, some can block out distractions, and some simply cannot concentrate in a silent setting. "People in the last group are so sound sensitive," says Dunn, "that when their surroundings are quiet, they hear all the extraneous noises they're usually not aware of, and those sounds actually prevent them from thinking."

One recent study isolated two groups of learners—those who required sound and those who couldn't tolerate it. Both groups did significantly better on achievement tests when their preferences were matched, and both did signifi-

cantly worse when their preferences were unmatched.

Different learners also have different light needs. Some need bright light, whereas others prefer soft or dim lights. "Members of the first group often become apathetic or sleepy when lights are dim," says Dunn; "those in the second are not able to internalize information until the lights are soft enough to permit relaxation."

Students also vary in the environmental temperatures at which they function best and in their needs for an "informal" or "formal" design. For example, some students study best in a lounge chair, or on a bed, couch, or the floor. Others can't focus unless they are sitting at a desk or table.

The "emotional" elements of learning style that Dunn identifies include motivation, persistence, responsibility, and need for either structure or options. Motivated, persistent, and responsible students function best, says Dunn, when they are told "what they are required to learn (their objectives), what they may use as resources, how they may show that they have mastered their objectives, and where to get help if they need assistance." These students appreciate feedback and praise *after* they have completed their tasks.

On the other hand, unmotivated students who are less responsible and persistent function best when they are given "short assignments with very few objectives, frequent feedback, a great deal of supervision, and genuine praise *as they are working*."

The "sociological" elements of learning style have to do with the "people" environment surrounding the student. Some students need to learn alone and will "gain very little from even the most charismatic teacher or well-planned lesson." Peer-oriented students, on the other hand, learn best in small groups that utilize such techniques as team learning and brainstorming. "Such youngsters are more concerned with what their classmates think than they are with their teacher's or parents' reactions," says Dunn.

Some students respond well to adults. But it is important, Dunn stresses, that the teacher's style (for example, collegial or authoritarian) complement the student's. "Research verifies that the closer the match between the student's and teacher's styles, the higher the grade point average and the more the student likes school."

One of Dunn's "physical" elements of learning style is the "perceptual strength" of each student. Primary grade and kindergarten children tend to be strongly tactual and kinesthetic in their approach to learning. Visual strength begins to develop by the third or fourth grade, while auditory strength develops in the fifth and sixth grades. Girls, Dunn points out, tend to develop their auditory skills earlier and hold their edge throughout life.

Three approaches to teaching reading include phonics, word recognition, and tactual/kinesthetic methods (for example, blocks). "Several studies," says Dunn, "have shown that when the reading approach is matched correctly to individual children's perceptual strengths, they learn more words more easily and remember them longer."

Other physical elements of learning styles include "intake" and "time of day." Some people learn better when they eat, drink, smoke, or chew gum while studying. These "intake" activities may either give the learner nutritional energy or help relieve the tension of learning.

Time of day studies show that "each person enjoys different peak energy times during the day or night." Thus, teaching students their most important subjects during their most alert periods would be a wise practice. One study, says Dunn, "found that when students were scheduled for classes at a complementary time of day, school records showed a reduction in chronic truancy and lateness."

Students can also differ in their "psychological" learning styles. Some learners, for example, learn best when material is presented sequentially "in a well-ordered continuum." This type of learning is called analytic. Other learners, though, "cannot even begin to focus on the lesson without an overall gestalt of what will be taught," says Dunn. This type of learning is called global.

"When analytic learners are taught analytically," Dunn continues, "and when global learners are taught globally, both achieve significantly better than when learning styles and teaching styles are mismatched." The analytic/global dichotomy may be a reflection of which hemisphere of the brain tends to be dominant. The right side of the brain tends to process information in a global manner, in most individuals, whereas the left side is primarily analytic.

PRACTICAL CONCERNS

As can be seen, Keefe and Dunn have very different ideas about how the elements of learning style should be classified, and about the importance of the different elements. These differences illustrate the still rather unorganized and unstructured state of the learning styles field.

Taken together, though, the research on learning styles clearly indicates that individuals *do* differ significantly in the ways they perceive, process, remember, and organize information. It is thus not unreasonable to assume that adjusting teaching styles and the instructional environment to complement individual learners' differences will promote a more efficient learning process.

Practitioners interested in applying the findings of learning style research in the classroom may have the following questions. How can learning style be measured? Which instrument should I use? and, Should teaching style and the instructional environment be matched to students' strengths or to their weaknesses? These questions will be addressed in turn below.

Numerous instruments have been developed for measuring the elements of student learning style. They differ widely in the types of elements they measure, in how the data are collected (self-report forms versus classroom observation, for example), and in the possible applications and implications of the data collected. Rita Dunn and Thomas DeBello review ten existing instruments. New instruments are being developed and tested regularly.

But which instrument should be used? Debate rages among researchers regarding the validities and reliabilities of most of these instruments, and it is difficult to say which are currently the best. Until the dust settles, practitioners could follow the example of David P. Cavanaugh: examine and experiment with several of the available instruments and then decide, based on careful judgment and experience, which to use.

Anthony F. Gregorc mentions some other considerations practitioners should keep in mind when using learning style instruments:

1. Instruments, by their very nature, are exclusive;

that is, they focus on certain variables and therefore sacrifice other possibilities.

2. Some students wittingly or unwittingly lie on any type of self-reporting instrument. Others read elements into questions and statements that are simply not there.
3. Some students have used artificial means of adapting for so long that they report these as "preferred means of learning." By doing so they run the risk of receiving prescriptions that continue to reinforce artificiality rather than receiving means that could encourage and draw upon their natural abilities.
4. An educator's attitude (either positive or negative) toward a particular student or toward the concept of diagnosis/prescription itself can drastically influence both instrument interpretation and consequent prescription.

Because of the limitations of currently available instruments, Gregorc continues, "educators must be wary of making prescriptions solely on the results of the instrument itself." Teachers should use learning style data only in combination with their intuition and sound judgment.

But how, exactly, should learning style data be applied? Specifically, should teaching and the instructional environment be altered to capitalize on learners' strengths, or should they be geared to learners' weaknesses so that learners can fully develop all their latent abilities?

A useful background for this discussion is Gregorc's premise that "every environment places demands upon individuals for adaptation." In practical terms, this means that whatever style of presentation a teacher uses, all students will have to adapt themselves to it to some degree.

Students vary widely in the degree to which they must adjust their minds to "align" with the teacher's style. But they also vary in their abilities to adapt to their nonpreferred styles. In other words, some students are more flexible and can learn under a variety of conditions, whereas other students require a close alignment between teaching and learning styles before productive learning can take place.

According to Rita Dunn and Thomas DeBello, some researchers insist "that students should always be taught through their strengths," whereas others "advocate selective

teaching of students through their weaker characteristics to build upon those." Both these views are rather simplistic, considering the complexity of individual learners. Some learners may be so "fragile" that only a close match of teaching and learning styles would be productive. Others may be completely capable of adapting to "nonpreferred" styles, and may benefit from the change.

Ronald Schmeck (in Dunn and DeBello) suggests that the most important element of style may be the ability of the learner to select the appropriate strategy for a particular learning context, and that educators can

> facilitate the development of this higher level skill by periodically exposing students to contextual demands that do not precisely match their styles. This must, of course, be done very cautiously in order to avoid instilling in the student a feeling of incompetence. However, if we roughly match our instructional technique to the student's style while simultaneously providing experience in strategies that are outside that style, we may prompt the development of flexibility. This may be a greater service than always structuring the context to match the student's preferred style.

It is clear, then, that simply matching teaching style to a student's preferred (or nonpreferred) learning style is not an adequate procedure. Rather, the judgment and expertise of the educator should be the final determinants of how closely teaching and learning styles are matched. Learning style data should provide the information on which these matching decisions are based, but they should not dictate these decisions.

CHAPTER 2

BRAIN RESEARCH

In recent decades, tremendous advances have been made in our understanding of the human brain. These advances have great potential for adding to our understanding of the educational process. Because of this potential, many educators and scientists have freely speculated about the implications of brain research for education. But there is need for some caution in this area, as M. C. Wittrock sagely notes:

> In the everyday sense of the term, there are no educational implications in recent research on the human brain. The reason is that neuroscience and education exist at different levels of study and abstraction. As a result, attempts to develop educational implications by equating educational issues to neurological phenomena, by overlaying education upon neuroscience, or by reducing behavior and psychological function to neural structure and physiology are not likely to lead to useful educational implications, in the sense of answers to practical problems important to teachers and administrators. Educational problems involve levels, contexts, and multivariate complexities not encompassed in neurological esearch.

This is not to say, Wittrock is quick to add, that there is nothing of value for educators in the recent advances in neurosciences. Powerful new ideas are sprouting every day in neuroscience research labs, many of which can indirectly ben efit education: "Because neuroscience, behavioral science, and educational research study such different levels of related phenomena," Wittrock explains, "research on the human brain can provide useful analogies, suggest new hypotheses, revise old theories, and even eliminate some otherwise attractive but unproductive ideas about teaching and learning." The full integration of the fields of neuroscience, behavioral science, and educational research, however--with all its potential benefits—is still far in the future.

With Wittrock's caveat in mind, then, what are some of

these new ideas about the brain that may be of benefit to educators? Perhaps the most well known to date is that of brain lateralization.

BRAIN LATERALIZATION

The largest portion of the human brain—the cerebrum or neocortex—consists of two hemispheres. In most people, the various functions of the cerebrum are lateralized in one or the other hemisphere. In the most common pattern of lateralization, speech, language, and rational, linear thought are localized in the left hemisphere, while artistic ability and appreciation, form recognition, color perception, spatial abilities, and other nonverbal types of thought are localized in the right hemisphere.

How did researchers find this out? To control the seizures of some severely epileptic patients, brain surgeons cut the main communications link between the two hemispheres, called the "corpus callosum." Researchers noticed that these patients had some unusual characteristics after their surgery. For example, the patients were allowed to feel an object—say a pencil—with their left hand (which is connected to the right brain) without looking at it. Researchers then asked what it was they were touching. The patients replied that they knew what they were holding, and they could, when asked, pick the object out of a collection of objects with their left hand. But they could not *say* what they were holding. Because their corpus callosum was cut, the information in the right hemisphere could not be transmitted to the left hemisphere to be verbalized.

Other experiments further clarified the separation of functions between the hemispheres of these patients. And, needless to say, the intriguing concept of brain lateralization became widely popularized.

Many educators interpreted the brain lateralization studies as follows: contemporary schools teach almost exclusively to the verbal and analytic left brain and almost totally ignore the creative right brain. Therefore, the curriculum should be adjusted so that both halves of the brain are developed.

Curtis Hardyck and Randy Haapanen caution educators to more closely examine the evidence on brain lateralization before making drastic changes in the curriculum. The split-brain patients on which much of the lateralization theory is based, they point out, had been severely epileptic since childhood. The brain of a child is able to reorganize itself if it is damaged or a disorder occurs. Thus, the brains of these patients may have functionally reorganized prior to their surgery.

Hardyck and Haapanen also question whether studies on lateralization in normal subjects can be generalized to brain function in everyday life. "Before reorganizing the curriculum, buying new right and left brain tests, or learning to think in 'right brain' or 'left brain' terminology," they advise, "we should ask for more evidence that these differences really exist outside a narrow experimental context unrepresentative of either the educational process or the course of daily life."

The skepticism of these authors, it is hoped, will not discourage educators from exploring the implications of brain lateralization, rather it should encourage them to carefully study the evidence supporting lateralization—or any theory—before acting on it.

THE BRAIN AS MODEL BUILDER

The concept of brain lateralization can help administrators better understand the learning process. There is another recent concept of learning, though, that may have broader implications for educators. This is the concept of the brain as "model builder," which was derived from research on perception and cognitive psychology.

In this view of the learning process, the brain "functions to make sense out of reality by applying models to it," as Wittrock states. Using sensory input from the environment, "the cortex, midbrain, and brainstem actively influence attention, perception, motivation, and the use of memory" to "construct" an internal model of reality.

Students learn and remember only "what they actively construct mentally during teaching and studying," Wittrock continues. What the teacher presents is not necessarily what

students reconstruct and thus learn, because students' model-building activities are influenced by internal factors as well, such as the "intentions, dispositions, sets, and memories" that the students bring to the classroom.

Adults teach children in ways dictated by adult conceptualizations of the learning process, as Constance Kamii states:

> If we believe that children learn by internalizing knowledge from the environment, our approach is one of instructing, giving ready-made knowledge and values to children and reinforcing what we have taught. But if we believe that children learn by constructing knowledge and values from within, through interaction with the environment, our notion of teaching becomes instead one of fostering whatever helps the constructive process.

With a proper understanding of learning as a generative process, says Wittrock, teachers can facilitate students' learning by "guiding attention, asking questions, providing images, propositions, hypostatizations, metaphors, [and] similes," and by "stimulating motivation and arousal appropriate for the generation of mental elaborations." Again, many teachers already intuitively teach in a manner that facilitates the "construction process" in students' brains. But a rational understanding of this process may help both successful and developing teachers become better at what they do.

GROWTH STAGES OF THE BRAIN

A third advance in our understanding of the human brain has to do with the growth stages of the brain. Between the ages of two and sixteen years, the human brain grows from two pounds to its adult weight of three pounds. "This growth involves the development of more remote axon/dendrite extensions throughout the neural network, and the formation of an insulating layer (myelin) around axons," Robert Sylwester explains.

But the brain's growth does not occur slowly and continuously; rather, it grows in rapid bursts that are separated by longer periods of practically no growth. According to Sylwester:

> Most normal children experience a rapid 5 to 10 percent brain weight increase between ages of 2-4, 6-8, 10-12+, and 14-16+. In normal children this growth spurt occurs during a period of about six months sometime during the two-year period, generally earlier for girls and later for boys. During the 10-12+ growth spurt, female brain growth is about three times that of males, and the situation is reversed, favoring males, during the 14-16+ brain growth period.

During each stage of brain growth, the neurons are growing, branching, and making synapses with other neurons. This growing complexity of the brain, Herman T. Epstein suggests, "permits the processing of more complex input information." Thus, with each burst of brain growth, "children should show appreciable changes in the complexity of their thought processes." And, indeed, the earliest ages at which children enter Piaget's stages of cognitive development correspond precisely to the onset ages of the brain growth stages.

Other advances in modern neuroscience have educational implications as well, as Wittrock points out. For example, lesions of the brain that sometimes cause learning disabilities are now easier to detect, and their effects are becoming better known. Also, the effects of environmental and nutritional factors on brain development and function are better understood. Some research, for example, suggests that the "dendritic branches of neurons in the cortex sometimes increase in density in response to stimulating environments."

Educators interested in further readings on brain research and implications for education can consult the following excellent resources. *Education and the Brain. Seventy-Seventh Yearbook*, Part II, *of the National Society for the Study of Education* (1978), edited by Jeanne Chall and Allan Mirsky; *A Triune Concept of the Brain and Behavior*, by Paul D. MacLean (1973); and the *Brain/Mind Bulletin*, a triweekly publication reporting recent advances in understanding the brain.

CHAPTER 3

LEARNING TIME

It seems obvious that the more time students spend engaged in learning tasks, the more they will learn. Yet this notion has only recently been tested by researchers. Their findings have confirmed the intuitive beliefs of many educators, thus providing what Marjorie Powell calls "new evidence for old truths." In addition, these studies have helped identify the "kind" of time that is most strongly related to student learning.

TIME-ON-TASK

The most extensive recent study of the time-learning relationship—the Beginning Teacher Evaluation Study (BTES)—was conducted in the midseventies by researchers at the Far West Laboratory for Educational Research and Development in San Francisco. The original purpose of this complex six-year study was to identify desirable competencies for beginning teachers. For a variety of reasons, however, the focus of the study shifted to the identification of teaching activities and learning conditions that foster student achievement in the classrooms of experienced second- and fifth-grade teachers. In particular, the study came to focus on the relationship between time and learning. (The study's unlikely title, however, was retained.)

The researchers measured three aspects of learning time. From teacher logs, they determined the time set aside each day by the teacher for work on a particular subject, which they called "allocated time." Of course, simply allocating time to a subject will not guarantee student attention to the work at hand. Thus, using extensive direct observations, Charles Fisher, Richard Marliave, Nikola Filby, and their colleagues also measured "engaged time," which they defined as "that portion of allocated time during which the student is paying attention." Finally, the researchers measured the success

rates in academic tasks that different students experienced.

When achievement data were collected, the researchers found that all three variables—allocated time, engaged time, and student success rate—were positively related to student learning. The BTES researchers coined a new term to designate that prime time when a student is actively engaged in a learning task and is experiencing a high rate of success: Academic Learning Time, or ALT.

"The amount of student learning is influenced not only by the amount of engaged time," state Fisher and his colleagues, "but also by the 'match' between the task and the particular student. If the task is so difficult that the student produces few correct responses, then not much learning will result. On the other hand, if the student produces many correct responses, he/she is more likely to be learning."

"The rate of success is not inherent in the instructional task," Powell adds, "but is a function of the relationship between the task and the student's skill level. The same task may be easy for one student and hard for another, or a task may be hard for a student at one time in the year but easy at another time."

The BTES also confirmed another intuitive notion of educators everywhere. students spend more time engaged in their work—and thus learning—in settings in which they interact with the teacher or another adult. When the students were supposed to be doing seatwork, says Powell,

> they spent more time doing it when the teacher circulated, checking work, than when he/she remained in one place. They also used their seatwork time more productively when more of their groupwork time was spent in interaction with the teacher (presentations or questions and answers) than when it was used for other things.

The results of the BTES and supporting studies, then, can be summed up as follows: students learn more about a particular subject when more time is devoted to teaching that subject, when they are actively engaged in the learning tasks presented, and when they experience a high level of success at these tasks. Engaged time, in turn, is increased when teachers or others interact with the students.

These research results present the classroom teacher

with a classic quandary: if the teacher assigns the same task to all students, some—those for whom the common tasks are too difficult—will experience low rates of success, whereas others—the fast learners—will finish early and wait, "unengaged," for another task. Students on both ends of the normal curve will suffer.

Some teachers, of course, may attempt the massive undertaking of individualizing instruction by keeping extensive records of skills mastered, assigning students learning tasks appropriate to their levels, and monitoring their progress along the way. Unfortunately, this approach may lead to a low rate of teacher-pupil interaction, because the teacher will be "stretched thin" among the twenty or thirty individuals in the class. Because each student has only a short time of contact with the teacher (about fifteen minutes per day in a class of twenty-five students), the risk is that he or she may not stay actively engaged in learning tasks.

MASTERY LEARNING

Another truism regarding time and learning is that students vary widely in the amount of time they need to achieve a given level of learning. Studies discussed by Benjamin S. Bloom, in fact, suggest that "learners differ by a ratio of about 5:1 in their learning rates." In other words, "the slowest 5% of the learners take about five times as much time to reach the criterion as do the fastest 5% of the learners."

In traditional forms of instruction, the amount of instructional time is a near constant for most students. Most students receive the same amount of instruction, even though it would take some students five times as long to master the material.

Bloom, J. B. Carroll, and many others believe, however, that mastery of a certain level of knowledge should be considered the constant of educational practice, while time to reach the criterion should be considered the central variable. Instructional time and student study time should be varied to help all students meet the set criterion. If the necessary time is provided, says Bloom, "then the attainment of the criterion is possible for all students who can be motivated to use the time

they need."

If time were considered the central variable of learning, educational researchers would direct their efforts toward studying the normal curve of learning times, with mastery held constant, instead of studying the normal curve of achievement with time held constant. Considering time the central variable, says Bloom,

> forces us to look again more directly at aspects of learning that have long been buried under a mass of publications and dogma about education in the schools. It once again raises questions for which we thought we had most of the answers, but for which we had developed a mythology that served to dull our perceptions of phenomena taking place before us.

Studies of mastery learning situations show that 90 percent or more of all students can attain the set criterion if additional time and help are provided. In the first learning unit, the slowest students take about five times as long as the fastest students to master the material. But after a number of sequential learning units, the slowest students take only three times as long as the fastest students. "Under mastery learning," says Bloom, "students become more effective in their learning of the subject and need less and less help and time to reach the criterion of mastery."

Using a mastery learning approach also appears to influence students' engaged time or "time on task," a finding that may explain the decrease in the ratio of learning times discussed above. In one set of studies, for example, the engaged times of students in conventional and in mastery learning classes were compared. At the beginning of the study, both groups spent an average of 65 percent of their time "on task." After several learning units, the students in the conventional classroom were spending only about half of their time on task, whereas the mastery students were spending 85 percent of their time on task.

"Under good conditions of learning," Bloom explains, "students put more of their class time into purposive activity (related to the learning activity), while under less favorable classroom conditions, students tend to decrease the percent of time in class they are putting into purposive learning activity." It seems, Bloom continues, "that one group is *learning to*

learn more effectively, while the other group is decreasing in their effectiveness as learners."

The reasons mastery students do better seem quite logical. Because of the feedback and additional time and help provided to these students, they have a better grasp of the material on which the next learning tasks will be based. Further, because most of the students succeed in reaching their achievement goals, they have a better attitude toward schooling. If students do not reach their achievement goals, Bloom points out, "they become frustrated and despair of their ability to learn the tasks, and they tend to develop some dislike for or disinterest in the subject."

CHAPTER 4

IMPLICATIONS FOR ADMINISTRATIVE ACTION

The advances in understanding reviewed above are providing a solid foundation for a new science of education. The major principles underlying this new science are that each student is a unique individual with unique learning requirements and that the educational system should be designed to meet the needs of each individual learner.

But wait—hasn't this rhetoric been heard before? Haven't educators been promoting the idea of individualized instruction for decades? And didn't the attempts to individualize in the sixties and seventies largely fail?

The first section below discusses some possible reasons for the failure of previous attempts to individualize education. Recent technological advances, however, now hold the promise of leading to a revival of not only the rhetoric but the practice of individualized instruction. This new computer technology—when combined with the advances in understanding the learning process—can have a profound effect on public education in the years and decades to come. But what can administrators do now to implement the findings on learning styles, brain research, and learning time discussed above? These issues will be taken up in turn in the last three sections of this chapter.

WALLS AND BRIDGES

Today, says John Goodlad (in Dayton Rothrock), individualized education in the public schools is rare. "One has only to crisscross the country, visiting schools as I have been doing lately, to know that our schools are group-oriented institutions. Individualization is a good word, but it is little found in practice."

So why did individualized instruction fail? Authorities

on this subject polled by Rothrock claim it was "too demanding, too costly, too difficult." Teachers were not capable or committed enough. The philosophy was misunderstood. It was not implemented properly. School systems supported the concept in name but refused to use the process of diagnosis.

Part of the problem, according to both Owen B. Kiernan and Mario D. Fantini, was that one single approach was usually applied to all students. "Each new practice was introduced and initiated as an 'across-the-board' solution," states Fantini. Method B replaced Method A for all students, even though some students had done well with Method A. "All students," states Kiernon, "were expected to blossom under independent study or small-group discussion or open classrooms, or whatever."

Of the many explanations provided by these authorities for the failure of individualized instruction, two stand out as being more likely candidates than the others. The first is money—specifically, a lack of it. Individualized instruction simply costs a lot more than group instruction. No matter how a teacher's time is spent in a classroom of twenty-five students, it is still impossible adequately to meet the unique learning needs of each and every student. So more teachers and resources are needed.

The second major reason for the failure of individualized instruction might be called the "inertia" of the public school system, that is, its tendency to continue operating the way it always has. Most educators agree that individualized instruction is a good idea. But when educators attempt the difficult process of change, they often run into a mire of resistance. Without a politically compelling reason to do so, the public schools as a whole will change only slowly.

So the science of individualized instruction is advancing on all fronts, as we have seen. But the likelihood of serious change in the public school system seems remote. Or does it?

In fact, the resources needed for an increasingly individualized educational system are at the doorstep of public education and are already knocking for entry. These resources are the educational computers and their programs that the schools are now purchasing in rapidly growing numbers.

Only recently have powerful microcomputers become cheap enough to be considered "personal." And only recently has the educational potential of these "micros" started to be tapped. Though the beginnings so far have been small, it is clear that the potential of this technology for individualizing instruction is immense.

Today, affordable computers combined with good quality instructional programs, or "courseware," can provide interactive instruction in reading, mathematics, and a variety of other areas. Problems remain—most notably the production of good quality courseware—but there is little doubt that this technology will find growing use as a supplement to teachers' actions and as a means of delivering individualized instruction.

Already, researchers and educators are attempting to apply computer technology to the problems of individualized instruction. Michael J. Cosky, for example, discusses the use of learning style data to individualize the delivery of computer-assisted instruction (CAI).

Most courseware programs already adjust their delivery to the pace of the learner. Many also have different levels or "tracks" of presentation for learners with different levels of knowledge and competency. Switching to a higher or lower track occurs when a student understands or fails to understand the first level of presentation. Courseware is also "individualized," as any instructional material is, according to the entry-level knowledge required to use it and the proficiency level of learning it transmits to the learner.

But there are few if any programs available today that monitor aspects of student learning style (other than pace and level of delivery) and then adjust their "mode" of delivery accordingly. There are many reasons for this, one being the still disorganized state of the learning styles field. In the years to come, though, programs will be able to monitor many characteristics of the learner (through responses to questions, performance in gamelike tests, pattern of keyboard, and even tone of voice) and then adjust the delivery of instruction to the learner's optimum mode.

Some students, it should be noted, do not respond well to CAI, no matter what quality or kind of program is used. CAI itself, then, has certain learning style requirements. Stu-

dents must have a certain amount of manual dexterity at the keyboard, for example, and a willingness to sit still. CAI probably works best with students who are visually dominant, who prefer working alone, and who have strong intuitive and diagnostic abilities.

Continuing technological advances—such as miniaturization and the development of computers that can talk and hear—will solve some but not all of these incompatibility problems. Future courseware that adjusts to other aspects of learning style will help other students who now have difficulty working with computers. Even those students for which CAI does not click, though, should benefit from the extra teacher time that CAI will make available for individualization.

Besides bringing computers into the schools for classroom instruction and waiting for the emergence of courseware that adjusts readily to learner differences, what can administrators do now to implement the advances in understanding discussed above? The next three sections explore this topic.

INDIVIDUALIZING WITH STYLE

> The goal of individualizing learning and instruction is an historical one, stretching back to early modern times. It is a *quest*, one which now finally may be within our grasp with the emergence of learning and teaching style. James Keefe

In principle, creating an individualized educational system based on learning style research seems an easy task. First, become familiar with the variety of student learning needs and styles and with methods of measuring these variables. Next, become knowledgeable about the wide range of potentially useful teaching strategies and learning environments. Finally, apply the appropriate "mix" of strategies and environments to each student.

In practice, of course, there are many stumbling blocks on the path to implementation. lack of funds for diagnostic instruments and training, resistance to change, difficulty in identifying appropriate "matches," and so forth. Even with

limited resources, however, a school can begin implementing the concepts of learning style and individualized instruction. Keefe suggests the following basic steps, originally proposed by Patricia Cross and other writers:

1. Establish a systematic program of inservice on learning styles for teachers, students, and parents.
2. Work toward a more flexible learning environment in the school. No method of instruction works for all students. Provide alternatives. Avoid systematically biasing instruction in favor of any one learning style.
3. Make certain that basic skills instruction reflects some systematic form of student learning styles diagnosis.
4. Concentrate on better student advisement and guidance. The learning style concept is relatively value-fair and has great potential for academic program planning and career counseling.
5. Keep an open mind. Much is known already about cognitive styles, less in a systematic way about affective and physiological styles. The research is incomplete but growing rapidly. A few schools have done a great deal; others must accept the challenge.

One good way to motivate teachers to adopt a learning style approach is to administer one of the readily available learning style inventories to the teachers themselves. When teachers see how they themselves vary from their peers in learning style, they will be more inclined to appreciate differences among their own students and apply a learning styles approach in their own classrooms.

Patricia Lemmon, principal of Roosevelt School in Hutchinson, Kansas, used this strategy on her staff. The instrument used—the "Productivity Environmental Preference Survey"—she describes as "an adult version" of a learning styles profile. David P. Cavanaugh also began a learning styles program by testing his school's faculty members. "The teachers not only learned something about themselves but also were better prepared to diagnose their students' learning styles," he reports.

Even *without* instruments to profile learning styles, schools can start implementing a learning styles approach. Individual teachers can begin, says Keefe, "by observing stu-

dents and answering a few diagnostic questions." Keefe gives numerous examples of the kinds of questions a teacher might ask, such as: "Does [a student] remember better if he reads silently, reads and listens, listens only, or role plays an activity?" "Does the student work deliberately and accurately, or quickly and inaccurately?" and "Is he a morning or afternoon person?"

Just by considering some of these questions, teachers can start to appreciate individual learning styles and the potential teaching strategies that would complement such styles. Of course, inservice workshops on learning style, providing learning style instruments and encouraging their use, and classroom coaching can further facilitate the adoption of a learning styles approach.

Another approach to implementing a learning styles program is discussed by Susan S. Ellis, who served as a staff development consultant at Parkway School in Greenwich, Connecticut, in 1977. Teachers at the school wanted to improve the process by which students were assigned to different teachers. But they soon found that there were many difficulties in such a matching process. For example, what learning style characteristics of children should be matched with particular teaching styles? And what happens if a teacher leaves the school?

A more productive approach, they found, was to help each teacher develop a repertoire of teaching strategies. Teachers versed in several different approaches to teaching are more readily able to adjust their teaching to the needs of the student. So the Parkway teachers enlarged their number of teaching models and thus increased "their ability to provide alternative learning environments for their students," as Ellis states.

The approach taken by David P. Cavanaugh, then principal of Worthington High School in Worthington, Ohio, was to ask for faculty volunteers who wanted to learn more about learning style research. The teachers held monthly meetings with Cavanaugh, administered learning style instruments to their students, and discussed and demonstrated specific methods suggested in the literature.

Cavanaugh himself believed so strongly in the learning styles approach that he taught a history course himself and in-

troduced the concept of learning styles to his students. He tested his students with a learning style inventory, provided them with copies of their profiles, and suggested ways in which they "could use that information to improve their study habits and learning." Other teachers did the same, and some found ways to provide "selected instructional strategies that complemented specific learning style characteristics."

UNDERSTANDING THE BRAIN

Recent brain research also holds some implications for education. Robert Sylwester suggests that preservice and inservice education programs for teachers be updated to include information on brain research relevant to teaching and administration. "We ought to adapt our preservice and inservice programs so that we can become better acquainted with our own brains, and we ought to introduce our students to theirs."

Educators can also use the growing body of knowledge on brain function and individual student differences to implement a more diagnostic/prescriptive approach to education. "Brain discoveries," says Sylwester, "may encourage us to move away from our traditional proactive/group/normative approach to our students toward the more reactive/individual/diagnostic approach the medical profession uses."

Increased knowledge about the effects of brain damage and disease, says M. C. Wittrock, can help educators design "remedial treatments that build on intact functions." Without this knowledge, "time and energy may be wasted on ineffective treatments, or expensive trial-and-error attempts to discover effective behavioral treatments."

Research on the growth stages of the brain suggests that instructional interventions should be timed to correspond with these developmental stages. "Knowledge about different rates of intellectual development of different groups or individuals coupled with an understanding of brain development with age could inform and improve the timing of instruction in schools," Wittrock contends.

The Head Start program, some observers have suggested, had limited success because it was inappropriately

timed. Herman T. Epstein notes that

> there is a period of low brain growth between the ages of four and six. This is close to the age span at which traditional Head Start programs are run. If slow brain growth is paralleled by slow mental development, it would be expected that those traditional programs should be rather ineffective in attaining their cognitive goals.

Instead of being pushed to attain higher cognitive levels during periods of slow brain browth, Epstein suggests, students "might be encouraged to develop and consolidate already initiated skills."

MORE TIME, MORE LEARNING

The findings on student learning time have several clear implications for educators. First, since the time allocated for instruction is directly correlated with student learning, teachers and administrators should find ways of increasing allocated time. How is this done?

One approach is to cut down on the time "wasted" on noninstructional activities during the regular school day. After studying time use in their district's classrooms, researchers in the Austin (Texas) Independent School District found that "only about three hours and forty-five minutes of [the] six and one-half hour school day" were spent in actual instruction. One-fifth of each school day, Jack L. Davidson and Freda M. Holley remark, was taken by "noninstructional 'management' activities: listening to announcements; taking out and putting away supplies; bathroom trips; discipline; or simply waiting for teacher instruction." The rest of the noninstructional time was taken by lunch, recess, and other such activities.

The Austin district attempted to increase instructional time by improving classroom management practices, by making time use a high priority in supervision, and by reducing "the time wasted by the overlap of multiple federal programs." As a result of these actions, students received twenty-three to thirty-four more minutes of instruction per day in 1978 than in 1977.

"If these increases don't sound significant," says Davidson and Holley, "consider this: *Over the 175-day Texas school year, those 23 to 34 minutes we gained in instructional time per day give students an additional 10 to almost 16 full days (six and a half hours each) of learning.*" Not surprisingly, Austin's students also showed achievement gains in reading and mathematics at every grade level in 1978.

Another study, reported by Oneida Martin and Althia Canty, identified two teacher behaviors that maximize allocated time: teachers who are task-oriented and teachers who carefully plan and organize instruction allocate more time to actual instruction. C. Larry Hutchins (interviewed by Mary Saily) reports on other findings that "teachers who immediately establish and teach classroom rules run classes in which more time is devoted to instruction throughout the year."

So "one way to improve learning," Hutchins continues, "is to help teachers develop effective strategies for operating their classrooms during the first few days of school." An obvious strategy for administrators, then, would be to hold teacher workshops prior to the beginning of school to teach specific strategies for establishing a controlled and orderly classroom environment early in the school year.

The Mid-continent Regional Educational Laboratory (McREL), of which Hutchins is deputy director, offers such workshops for schools in the Midwest and elsewhere. Another approach taken by the McREL staff is giving individual teachers a means of analyzing their own use of time in the classroom.

> Participants calculate the amount of time they devote to instructional activities during the typical school day. They learn how to observe one another's classrooms to determine the percentage of time students are engaged in learning. And they analyze student success rates on different types of assignments for each subject matter area.

As mentioned in chapter 1, students tend to get off task easily when there is little student-teacher interaction, as in independent learning activities. But strategies *are* available that can help students remain on task while working alone. According to Saily, these strategies include

> explaining to students what independent learning means; defining rules for working alone; clarifying what's to be learned; identifying and discussing problems that might arise; setting up routines for when students are finished with their tasks; developing in students the expectation of a delayed teacher-response to their work; and evaluating with students their success at independent learning.

The previous chapter also pointed out that both engaged time and "academic learning time" are correlated with student learning. Academic learning time depends on the level of "academic stress" on a student: too much stress—caused by limited success at learning tasks—leads to discouragement; too little stress—caused by learning tasks that are too simple—leads to boredom. Thus, academic stress should be adjusted so that students experience a fairly high level of success, but not *too* much success.

Awareness of these concepts alone could help teachers improve their instructional practices. Workshops and inservice programs on specific classroom strategies could further help teachers adjust instruction to each student's needs.

An even more promising approach, though, may be the extensive use of computer-assisted instruction (CAI). CAI programs are by nature interactive and can thus help students to stay engaged in their learning tasks, often in very entertaining ways. In addition, many CAI programs already adjust their pace of presentation to the needs of the learner and provide instruction at the level most appropriate for the learner, based on the "feedback" of the learner's responses.

CONCLUSION

Educational researchers are daily learning more about how individuals differ in the ways they learn. Each learner can be said to have a certain "style" of learning—a set of characteristic behaviors for perceiving, analyzing, and responding to learning situations. Researchers are also finding that learning is optimized when there is a "match" between a learner's style and the instructional environment. Additional research on learning time and on the human brain have further elucidated the differences between individual learners.

These facts in themselves should not surprise experienced and insightful educators, who know well the range of learner styles and intuitively sense the best teaching strategies for particular students. What is new today, though, is that these learner differences are being extensively studied and systematized by educational researchers. Numerous instruments are being developed for measuring learner differences, and experiments are being conducted to determine the best complements of learning styles and instructional environments. In short, the *science* of individualized instruction is today coming of age.

From the vantage point of the future, this period may be looked upon as a turning point; the group-oriented instruction that is the norm today will likely be regarded as a curious, though necessary, relic of times past. During this period of transition, it is essential that educational administrators understand the emerging science of individualized instruction and its implications for their leadership actions today. It is hoped that this digest has provided the seed from which such an understanding can grow.

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