A PRACTICAL SYNTHESIS OF BRAIN FUNCTION RESEARCH WITH IMPLICATIONS FOR EDUCATION

By

Judy L. LaCavera

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirement
for the degree of

DOCTOR OF PHILOSOPHY

Department of Teacher Education

Fall 1985

ABSTRACT

A PRACTICAL SYNTHESIS OF BRAIN FUNCTION RESEARCH WITH IMPLICATIONS FOR EDUCATION

By

Judy L. LaCavera

This study represents an exploratory effort to consolidate the current findings and claims from brain function research, along with an effort to consider implications for classroom practice. The brain is the center of our learning, and yet knowledge of its function as a vital part of our professional educational equipment is largely overlooked. Most current writings focus on particular needs and concerns of the different areas of brain function research. The areas chosen for this study; hemisphericity, brain growth periodization, the triune brain and sex differences, seemed to present the most potential for significant synthesis and implementation into the curriculum. There seems to be a need to evaluate these writings for sound research practices, and to determine general agreement on their application to education.

The methodology for this study was to read current literature representing a wide range of research on brain function, and to assess its relevance to education. Primary and secondary sources were used that focused on those areas selected. Using criteria established, the literature was evaluated for sound research practices and feasibility. It also seemed important that the research be applicable and

practical for the typical classroom, be reliably organized and validly established. In addition, the views expressed should be in general agreement with other sources meeting the same criteria.

No matter what particular type of research is discussed, it is apparent that educators are barely beginning to understand how to utilize brain potential. Professionals should be concerned with extending thinking skills by incorporating the educational implications of brain function research. Additionally, there should be concern for minimizing threatening situations and for seeking equity between the sexes to increase learning. Activities and materials should be presented wherever possible, to encourage the whole brain to function at more optimal levels and improve thinking skills. These, and other related implications from the research, need to be presented to educators in a practical and applicable manner.

TABLE OF CONTENTS

	Page
LIST OF FIGURES	iv
CHAPTER I - INTRODUCTION	1
A. Purpose of the Study	3
B. Methodology	4
C. Limitations	6
D. Significance of the Study	6
E. Definition of Terms	7
Summary	10
CHAPTER II - REVIEW OF THE LITERATURE	11
Section I. Brain Function Research	12
A. Hemisphericity	13
B. Brain Growth Periodization	27
C. Triune Brain	32
D. Sex Differences	37
Section II. Classroom Applications	43
A. Thinking Skills	44
B. Problem Solving	47
C. Manipulatives	52
D. Classroom Management	58
E. Time Management	60
F. Collegiality	61
Summary	63
CHAPTER III - METHODOLOGY	66
A. Criteria for Evaluation	67
B. Synthesis	72
Summary	73

CHAPTER IV - FINDINGS 74

A. Hemisphericity 75
B. Brain Growth Periodization 81
C. Triune Brain 85
D. Sex Differences 87
E. Thinking Skills 91
F. Problem Solving 93
G. Manipulatives 96
H. Classroom Management 98
I. Time Management 100
J. Collegiality 101

Summary 102

CHAPTER V - APPLICATIONS 104

A. Hemisphericity 104
B. Brain Growth Periodization 107
C. Triune Brain 108
D. Sex Differences 109
E. Thinking Skills 111
F. Problem Solving 112
G. Manipulatives 113
H. Classroom Management 114
I. Time Management 115
J. Collegiality 116

Summary Figures of Chief Implications 116

Summary 124

CHAPTER VI - SUMMARY, CONCLUSIONS AND
REFLECTIONS 125

BIBLIOGRAPHY 134

GENERAL REFERENCES 142

LIST OF FIGURES

Page

Figure I. Hemispheric Characteristics Suggestive of Curricular Goals and Practices 119

Figure II. Contrasting Practices 120

Figure III. Chief Curricular Recommendations in Brain Research Literature 121

CHAPTER I

INTRODUCTION

One of the topics drawing significant attention in educational journals in the past decade, is research on how the brain functions, and what it means to the field of education. For example, given what is inferred to be the potential of the brain, a very small portion of it appears to be put to use on a regular basis. Several writers deplore this imputed "underuse" of the brain. Noone, however, appears yet to have established the "optimal" level of use. Since much discussion today is centered around preparing students for the advanced technology of tomorrow, it may be helpful now to consider seriously what brain function research is claiming about the way the brain functions, and what can be done in the classroom to improve education. As described by Leslie Hart (1983), "as brain-antagonistic elements are eliminated from schooling and brain-compatible factors are enhanced, the push-pull effect could conceivably bring about levels of student achievement that now seem incredible." Yet despite findings on brain function, and implications for improving learning, there seems to have been little impact as yet on educators, their classrooms, and their teaching methods. It may prove valuable to identify these areas of potential improvement now.

Much that has been written about the human brain comes from the field of neuroscience. David Hamburg, president of the American Association for the Advancement of Science, at the annual meeting in 1985, said that although the brain was regarded with extreme caution a few years ago, it is now "moving into the top category in all sciences." Examples include Roger Sperry's research on hemisphericity, which shows two distinct sides of the brain, with each having distinguishably different areas of specializations for learning and thought. Herman Epstein's work on brain growth challenges the traditional idea of the brain growing at a gradual and continuous rate, showing that the brain grows in spurts, and with in between levels of plateau periods. Paul MacLean has shown that the brain has evolved, expanding to a greater size with newer levels added as evolution proceeded, but the brain apparently still retains elements of the earlier, ancestral brain. Richard Restak indicates that there are differences in the male and female brain that are biological.

Some of the findings of these various research areas of the human brain suggest that many of today's classroom practices are parallel with brain utilization recommendations, and should presumably, therefore, be continued. However, other findings seem to indicate that brain function might improve through use of different, presumably more effective, learning strategies. In order to better prepare for a future of challenges and advanced technology, it may become necessary to maximize each individual's learning patterns by considering the educational implications of brain function research.

In discussing learning, Ferguson (1980) points out the human paradox: "a plastic brain capable of endless transcendence, equally capable of being trained into self-limiting behavior." She describes the educational reform that is taking place as a new paradigm reflecting both the discoveries of modern science and the discoveries of personal transformation. Brain function research is a part of the assumptions of the new paradigm of learning. For instance, what is called "a whole brain education" is frequently recommended, augmenting "left-brain rationality" with holistic, nonlinear, and intuitive strategies, usually associated with "right brain," as opposed to the traditional emphasis on analytical, linear, left-brain thinking. Also frequently mentioned by reporters of brain research is a concern with the individual's performance in terms of potential, with an interest in testing outer limits, and transcending perceived limitations, versus a more traditional concern with norms.

A. Purposes of the Study

This study represents an exploratory effort to consolidate the current array of findings and claims, along with an effort to consider implications for classroom practice. The brain is the center of our learning, and yet knowledge of its function is largely overlooked as being a vital part of our professional educational equipment. Many of the current writings focus on particular needs and concerns of the different areas of brain function research. There seems to be a need to evaluate these writings for sound research practices, and to determine general agreement on their application to education. Additionally, it should be considered if these findings might be operative in the typical classroom.

B. Methodology

The methodology for this study was to read the literature from generally the last ten years, representing a wide range of research on brain function, and to assess its relevance to education. Primary and secondary sources were used that focused on hemisphericity, brain growth periodization, the triune brain, and sex differences of the brain. Using criteria established, the literature was evaluated for sound research practices and feasibility. Implications and applications were explored for utilization in the average classroom.

Criteria, used in this study for evaluation of the writings on brain research included, therefore, criteria for assessing both primary and secondary sources. When considering the primary sources, it seemed important that the research be both (a) applicable to education and (b) practical for the typical classroom. That the research was

(c) reliably organized and validly established, were other concerns. Criteria for the secondary sources sought (a) well founded opinions, and (b) valid interpretations. In addition, the views expressed should be (c) operative in the typical classroom, and should be (d) in general agreement with other secondary sources similarly meeting the criteria. Fuller elaborations of these criteria (e.g., what may be meant by well-founded) are presented in Chapter III.

The areas of brain function research that were chosen for this study (hemisphericity, brain growth periodization, the triune brain and sex differences) seemed to be the most promising topics represented in the literature. These topics appear to have the most potential for synthesis. Each is concerned with increasing learning and making an improvement in the utilization of the brain. These areas also seemed to promise significant degrees of feasibility for implementation into the curriculum of the typical classroom, given a minimal amount of training for practical application.

An attempt also was made throughout the study to consider the generalizability of the ideas presented. Teachers are individuals with separate needs, concerns and abilities. There can be improvement at many different levels. In this way, consideration for each individual and each classroom was given, so that a general framework could be established that individuals might apply, according to their own situations. The ideas from brain function research and other related areas were concerned mainly with general application to typical classrooms.

C. Limitations

The limitations of this study derive mainly from the fact that professional discussion in neuroscience and in education usually occur on different levels of abstraction. It has been only recently that an attempt has been made to bring the two together. Journal articles and books were limited to those from brain function research that appeared to have educational implications. Given that professional biases may creep into the "findings" of any given reporter, an attempt was made to evaluate all reported findings as objectively as possible.

D. Significance of the Study

The educational value of research pertaining to brain function seems to point to needs for change and revision in educational systems. Neuroscience has presented the research details, and it may now be a good time to explore those findings. Since the brain is the center of our learning and knowledge, it would seem important for educators to consider facilitating the usage of the brain to as high a level as possible, or - perhaps better - to optimal levels, whatever "optimal" may be. There appears to be a need to analyze the literature and present the findings and conclusions, so that educators can begin utilizing the concepts in a practical and operative manner. If educators are serious about improving the curriculum and increasing learning, then it seems logical to look at the fundamental tool in the whole process -- the brain.

E. Definition of Terms

"Brain function research" relates to that research which aids in explaining the function of the brain. For this study, the areas from the literature that were chosen, appear to have clear educational implications. These include hemisphericity, brain growth periodization, the triune brain, and sex differences of the brain.

"Hemisphericity" refers to the existence of a distinct right and left brain with seemingly different functions, and it indicates a dominant preference of each individual for either the right or the left. Indications favor teaching to both sides, encouraging whole-brain thinkers.

"Brain growth periodization" is the term given to the theory that the brain grows in definite spurts and then plateaus until the next growth spurt.

"Triune brain" describes the evolutionary pattern of the brain into three separate parts. These include the oldest part concerned with survival, the next to evolve incorporates emotion, and the last involves the development of rational thought.

"Sex differences" refers to biological differences in functions in the male and female brain, indicating different areas of specialization for learning for each.

"Primary source" indicates an author who was an intentional and careful observer of the recorded event.

"Secondary source" implies an author who is reporting the observations of others and is one or more times removed from the original event.

"Applicable" indicates the idea that the concepts presented can be applied to a given situation, in this case, the field of education. It is important that the research presented on how the brain functions best, can then be implemented into the classroom and into present curricula.

"Practical" refers to the feasibility of a particular concept for utilization in the classroom. The teachers in the classrooms have many responsibilities and are held accountable for the learning that is to take place. Consideration needs to be given to what is practical and can be implemented easily.

"Typical classroom" describes what is found in the majority of the classrooms, including a traditional framework using directed teaching, textbooks, and little student input. The textbooks are generally the major source of information.

"Educational implications" refers to what has been implied from the research about how the brain functions for the field of education. Given what the research seems to be saying, these implications, in general, can assume to follow the outlines of the outcomes of the studies.

"Thinking skills" indicates those skills that can be taught to increase the quality of thinking in students. These can be integrated into the regular curriculum and seem to lead to greater student achievement.

"Problem solving" refers to the skills utilized to solve various types of problems in order to achieve higher level thinking. This skill can be taught, infused into the curriculum, and means more than answering story problems in math class.

"Manipulatives" describes the use of concrete objects in order to develop more abstract concepts. The use of materials that can be manipulated is required in order to achieve a higher understanding of what is to be learned.

"Classroom management" refers to the idea of effectively managing the classroom environment. This includes the sort of atmosphere and teacher behavior that is conducive to higher level learnings.

"Time management" indicates the optimum use of managing time in the classroom, so that the most learning can take place. By becoming more aware of time and effective ways of managing it, the teacher should be able to increase the achievement level of the students and maximize their learning capabilities.

"Collegiality" describes the concept of teachers working with each other and providing support so that achievement can be increased. The concept of working with one's colleagues enables a better framework within which to establish optimum learning conditions.

SUMMARY

In the introduction of this study, the areas of brain function research to be reviewed and critiqued were outlined as hemisphericity, brain growth periodization, the triune brain, and sex differences. These will be considered for practical application in the classroom. It appears to be of importance to first consider the brain as the center of knowledge, in order to improve learning.

CHAPTER II

REVIEW OF THE LITERATURE

The brain is the most complex and the most powerful information processor known to man, according to Russell (1979), who makes comparisons to illustrate this point. Unlike the computer, the brain can carry on a thousand different functions simultaneously. A transistorized version of the brain would fill Carnegie Hall, and with the use of microchips, it would weigh ten tons. In comparison, the whole world's telephone system equals only one gram of the brain, or the size of a pea. The brain is said to be the most evolved system on this planet, yet as Russell states, we have hardly begun to use its potential, and we are not taught how it works or how to use it. Russell indicates that we probably use approximately one percent or less of our brain's full mental potential. The limit seems to be only what we believe is possible.

Let it be noted in passing, however, that no one appears yet to have established optimal levels of what use for the brain should be. As more is learned about the ways in which the brain functions, it seems that more can be expected. In this way, then the percentage levels for the actual usage of the brain continues to drop.

This chapter has been divided into two sections in presenting a review of the literature. The first section is concerned with brain function research, describing what it is, and offering some suggestions that have been made for applying to education what has been learned about how the brain functions. The second section, on the other hand, is concerned with discussions of what might be called "arenas of application." That is to say, the second part of this chapter takes up various areas of educational practice to which it would seem classroom applications of brain research findings might most readily be applied: development of thinking skills, problem solving, the use of manipulatives, and staff development techniques. There is also a need for definitions of key concepts which pertain to each area of brain research and to each area of application. These definitions as presented in Chapter I and will apply throughout this and the following chapters.

Section I. Brain Function Research

Much has been written concerning the brain and different types of research that have been done. In the review that follows, an attempt is made to concentrate on those areas that would be the most practical and applicable for educators. One of the major areas covered is hemisphericity. Other areas frequently mentioned include brain growth periodization, the triune brain, and sex differences. In addition to an explanation of the research in these areas, the educational implications suggested in the literature are also reviewed.

In the review of the literature that follows, many references will be made to a wide array of authors. To maintain as concise a report as possible, including their views, findings, and positions, the paragraphs that follow are to be considered as outlining and characterizing the claims of the authors referred to, and are not to be considered the views of this researcher. In reporting the views of authors cited below this researcher may occasionally insert a qualifying "seems to" or "appears to" which are not present in the sources but the substantive ideas recorded are efforts faithfully to represent only the views of these citations employed.

A. Hemisphericity

Research in hemisphericity has shown that the brain has two halves, as explained by Andrews (1980). The left side of the brain specializes in data, both sequential and analytical. This side learns facts, makes patterns of learning material, utilizes routine memory, and is concerned with external manifestation of an abstract and mechanical nature. The right side specializes in emotion, motives, and appreciates intrinsic forces, both inner and outer. This side of the brain generates alternatives, finding joy in continuous searching - not goal-oriented,but searching for the sake of searching. The left side is generally cognitive, while the right is generally affective. Probably due to training and cultural bias, the left hemisphere appears dominant. For balanced learning neither side should probably be dominant. Since most input is to the left hemisphere, input must follow through to the right for integrated learning.

The work of Roger Sperry and his associates at the California Institute of Technology has pioneered much of the discussion in hemisphericity. As Sperry (1964) reveals, each hemisphere of the brain is associated with one side of the body,the right brain, as researchers agree, presiding over the left side, and the left brain presiding over the right side. Each hemisphere's influence, though, is not restricted to only one side. When one hemisphere has been damaged, the corresponding area in the other side can take over and control the functions for both sides of the body. The two halves of the brain, function as one organ, and are linked by bundles of nerve fibers called the corpus callosum. Severing the fiber connections seemed to produce little or no change in the capacities of humans or monkeys. This concept initiated the split brain studies, where if the connections are cut, the organism functions quite well but behaves much as though it had two brains. The experiments done using monkeys and humans enabled various centers to be located, and opened up new lines of thought for further investigation.

It is the corpus callosum that transmits information for integrated brain functions. With this integration the subconscious can open up, utilizing intuition and imagination. Reality, as Andrews (1980) indicates, can then be perceived by a whole individual. Feelings complement reason and reason complements feelings. Every healthy individual, whether right or left dominant in experiencing, appears to function more effectively when the two modes of consciousness are symbiotically integrated.

Much of the research done on hemispheres and their functions was accomplished through the study of persons with incurable epilepsy, as explained by Gray (1980). To limit the seizures to one side of the brain, the corpus callosum was severed, enabling each hemisphere to operate separately. Studies showed that these patients could feel an object, yet be unable to verbally recall the item. They were, however, able to select correctly from a group of pictures of the items. Shown pictures of one thing, the response of the patients would indicate something else. One message apparently reached one hemisphere, while another reached the other hemisphere. The experiments were accomplished by devising a means of showing things to one eye or the other, thus directing messages to one hemisphere or the other. These studies of hemisphericity help us to see that schools are stressing more the measurable left side of our brain with the basics, but are virtually ignoring the right and its more intuitive thinking. We learn to calculate but not to conceptualize - to master formulas but not to apply them.

A message that emerges from hemispheric specialization, as Sperry (1975) suggests, is that our educational system and society in general, discriminates against one half of the brain. With heavy emphasis on communication and the three R's, minor attention is given to the hemisphere that is non-verbal and non-mathematical. The right hemisphere has its own perceptual, mechanical, and spatial means of reasoning. Its training is minimal compared to that of the major or left hemisphere. (It is noteworthy that Sperry uses the adjective "major" to refer to the left hemisphere and "minor" for the right hemisphere.)

In describing hemispheric research, Gilsdorf (1982) demonstrates the appropriateness of structuring environmental science curricula by considering the thought patterns that are characteristic of the right brain. The right brain's ability to relate parts and wholes, hopefully may aid students in visualizing themselves as a species within a world that needs to value every other species. By perceiving that the human species is only a small part of a much larger system, an appreciation might be gained of belonging to the cycle of nature.

By looking at brain function research, Sinatra (1983) proposes right hemisphere stimulation as important for language learning. The implication is made that when the right hemisphere is given a commanding role in stimulating verbal behavior, integration of the hemispheres is easier. As words and sentences are used to describe concrete experiences, right hemisphere concepts are provided for the language meaning. It seems then, that right hemisphere stimulation during the early years of development may be important for later verbal learning. For example, making sure that children (a) get to draw or paint pictures which express their own experiences, which is also perhaps crucially important for facilitating verbal development -- (b) that they get opportunities to speak and tell about what they draw or paint.

Glassner (1980) reports on a study that examined right and left hemisphere relationships between writing in the extensive mode and writing in the reflexive mode. By using EEG amplitude ratios measured from the right and left temporal areas, he suggests that the writing focused on communicating information familiar to the writer, shows greater left hemisphere stimulation. Writing that focuses on discovering means and is more exploratory in nature shows greater right hemisphere stimulation.

Split-brain theory may provide the answer to the current dilemma of the extent to which art should take a significant place in the schools, as discussed by LeCompte and Rush (1981). Although existing research cannot claim to teach either hemisphere separately, the concept of multiple ways of knowing can help students expand their abilities. Hemispheric specialization research has not yet provided a rationale for arts programs, but teachers, not researchers will ultimately be likely to provide the most effective ways to use arts in educating the whole person. Once these learning situations based on hemispheric research have been developed, then teachers and researchers can perhaps better determine the importance of arts in the educational system.

Caution is advised by Fagan (1979) that the concept of brain hemispheres does not provide a panacea for school crises. The search for a single solution has been simplistic and embarrassing. Given the uniqueness of individuals, solutions to any educational problem almost always needs to be pluralistic. The current reports about brain hemisphere study, particularly the tendency to view it as a unilateral solution, is potentially misleading.

It has been difficult to study hemisphericity in normal individuals, but Ornstein (1978) through the use of EEG readings has been able to come to some conclusions. He states that the brain's hemispheres are specialized, not for different types of materials, but rather specialized for different types of thought. Depending on the type of story read and for what purpose, the right hemisphere can be used. It is also possible that spatial tests can be accomplished by the left hemisphere. There seems to be a need to educate the whole brain, and in order to do this, a better balance in our educational curriculum to stimulate both sides of the brain would appear to be desirable. (It is worth noting that Ornstein, while endorsing the concepts of "balance" and "whole brain" education, conceives of these as being achieved by uses of differing "purposes" and differing "types of thought.")

In reviewing the responsibilities of the left and right brain, Lord (1985) discusses the misinterpretations of research findings. These have resulted in confusion and often contradiction. A frequent misconception is that a problem presented to an individual can be solved by using only one hemisphere. Actually, it is the nature of information processes and not what information is processed that seems to indicate the difference between the hemispheres. There are many instances where problems can be solved just as effectively using either hemisphere. It does not appear to be the performance as much as the method.

Recent research done by Elliot Ross confirms the specializations of the hemispheres. By studying stroke victims, Ross (1982) discovered that just as damage to the left region impairs speech, damage to the right region impairs the ability to know or express feelings. He had suggested earlier that the left hemisphere is responsible for what we say, and the right for how we say it.

Staley (1980) suggests that in order to develop the whole brain, outdoor education is needed. Using real life situations, the learner would be able not only to look for problems, but also to solve the problems. The outdoors would provide resources that emphasize learning by doing, as well as thinking about what is being done. Outdoor education may be one aspect of education that can contribute to developing both sides of the brain.

To specialize in hemispheres means increased emphasis on process rather than content, as suggested by Haglund (1981). If the subject matter is of importance, then teaching should presumably involve learning by doing, mental imaging, conversational interaction, and field experience. It is not necessary to overstress abstract information, authority based instruction, and verbal-oral recitation. The brain should not be filled only with facts, but be acknowledged as an instrument to be used.

Another advocate of teaching to the whole brain, Hunter (1976) makes some suggestions. Information should be presented to both sides of the brain. A different technique to reach each side is advised. If the learner is not getting the material presented, present the same material in a different manner to the other side of the brain. For example, directions can be given verbally and then further explained using the chalkboard. In order to develop the whole brain, it is necessary, she advocates, to improve each side to strengthen the abilities of that hemisphere. To begin, we could increase the input to the right brain, the side neglected in our left-brained schools.

By combining experiences of sensory awareness, relaxation, imaging, and other mental activities, a workshop has been devised for participants to engage in "full-brain learning." Barzakov (1982), the director, describes the intent as activating and stimulating both hemispheres to gain the brain's full functional capacities. The ultimate purpose is to enable participants to interact with anyone on any level, to learn anything that they want to learn.

Although there are inconsistencies in the research, the evolutionary brain continues daily to affect behavior, as Webb (1983) discusses. The two hemispheres differ in function, not more or less able, but different. The best academically and socially developed students seem to use both brains. The greater the difference in functioning, the greater the emotional dissonance. The larger percentage of school failures prefer the right brain, so it would appear to be important to introduce tasks visually and translate to language. The visual learner might then use the visualization to express ideas, build a foundation for expression, and be encouraged to talk. Talk, not silence, will develop the language skills. In order to be strengthened, these skills must be practiced. The most competent and effective learners apparently use both sides of the brain.

In order to complete the educational process, Samples (1975) suggests that the right hemisphere has been ignored. Students cannot be fully educated unless importance is given to the functioning of metaphorical and intuitive capabilities, as well as the rational and linear capacities. Samples describes the right hemisphere as a "natural pond" of metaphor, analogy, and intuition. Besides extending students' rationality and logic, it may be desirable to encourage creativity and invention. Some teachers, however, may find a risk is involved: environments could be created where minds will become greater than the sum of their parts and function more fully, but less predictably.

A study conducted by Herrmann (1982) between poor students attending a session for remedial work, and good students involved in an accelerated program, showed differentiation. The data reveal that poor students are clearly right-brained oriented and that good students are either left-brained or double dominant. Accordingly, creativity seems to be whole-brained, and one can presumably learn to be more effective in the creative thinking sense, if both hemispheres are working together cooperatively, and interactively.

In teaching secondary students, it apparently is important not only to consider the right and left brain, but as Johnson (1985) advocates, brain development for this age group has shifted to the frontal lobe, the control center for the right and left hemispheres. It may therefore be necessary to concentrate on the activity in the frontal lobe, and to include activities that enhance the development of the skills of comparison, evaluation, and synthesis. In order to be realistic at this stage of development, the right and left brain model needs to encompass a theory of the whole brain.

The two sides of the brain do appear to differ in important ways, but the whole brain actively participates in the hemispheric processes, as Levy (1983) cautions. The evidence disputes that students learn with only one side,but there is a tendency to bias in favor of one side or the other. For instance, damage to either side of the brain results in disorders of music or art production. The hemispheres differ in their roles, but both are involved in the production. It is suggested that whole brain learning may mean different methods for different people. Individuals may need to learn about their brains and their ways of learning to further develop both sides and synthesize the mind.

Springer and Deutsch (1981) critique the material that has been presented on the right and left hemispheres. They suggest that educational systems may be deficient and may limit human capabilities, but not necessarily along hemispheric lines. There is no conclusive evidence as to exactly what right hemisphere functions are. It is possible that the educational system may miss developing half of the brain, but it is probably missing talents of both sides.

An instructional model combining learning style research and hemispheric research was developed by Bernice McCarthy. It is a teaching technology that enables all students an opportunity to excel, as McCarthy (1985) explains, while at the same time stretching them to be proficient in other areas as well. Learners are classified into four learning styles; sensing/feeling, watching, thinking, and doing. Right and left brain techniques are

part of each type of learner. The resulting model is a cyclical teaching method in which all learning styles are considered, and simultaneously, right and left brain teaching modes are used.

Evidence suggests that the cognitive domain may be a function of the left hemisphere, and that the affective domain may be a function of the right hemisphere, as Sonnier (1983) describes. However, stronger evidence suggests that both hemispheres have equal and important roles in the learning process. A model for holistic education is presented by Sonnier, so that affective and cognitive objectives may share desirable outcomes with equal effort. It appears that holistic education is better applied by teachers who use student-projects and student-activities.

In order to apply hemispheric specialization, the holistic model is presented as a means, by Yellin (1983). Holistic approaches to learning, which include biofeedback, Yoga, and other relaxation techniques, may either individually or collectively improve the teaching of various subject areas. The author states that teachers using these techniques of relaxation, mental concentration, and belief in one's own mental powers, have helped students learn more efficiently.

Employing the hemispheric specialization theory supports holistic subjects in the curriculum, advocates Grady (1984), along with instructional methods that use visual-spatial strategies. The most important goal of

t
r
f
s
t
l
a
d
w
t
t
l
a
te
r
fu
sy
to
le
ex
th

education, according to the author, is integrated thinking. Suggestions are made that include giving directions, both visually and verbally in written and manipulative forms, allowing students the option of illustrating an idea or expressing it in words, and encouraging a variety of thinking skills to solve problems.

While discussing a right-brain orientation for education, Blakeslee (1983) suggests that the real problem is the basic thinking of the entire educational establishment. Teachers who normally think in a verbal orientation have a difficult time in teaching students intuitive thinking. The author suggests that the real patterning must occur on a daily basis in all subjects taught, and after years of verbal thinking, it may be difficult to change to intuitive thinking, but change may come slowly as the teachers themselves change. The important thing appears to be learning to make full use of both kinds of thinking appropriately.

To teach drawing, Edwards (1979) has devised a technique of shifting from the left mode of thinking to the right mode. Drawing appears to be a right hemisphere function. In order to draw a perceived form, the author suggests that it is important for the left side to give way to the right, so that the right hemisphere can take the lead. By setting the conditions for the shift and experiencing the different feelings produced, it is said that one will be able to draw.

Achieving natural writing seems to depend on hemispheric cooperation, each contributing to the writing process at the appropriate times, as described by Rico (1983). Suggestions are made to improve one's expressive capabilities utilizing right brain techniques. Clustering, as developed by the author, seems to favor the right brain's apparently random association and non-linear patterning. This technique appears to involve the right brain through a flow of ideas, images, and memories, which lead to a vision of the whole, thus enabling writing to become easier and more coherent.

Techniques for using both sides of the brain are described by Buzan (1983). By properly organizing reviews of material, it is suggested that a better memory can be achieved. Note taking, if done in a non-linear direction forming a map, seems to encourage the brain to handle the information more in the way that the mind functions.

Hemispheric research presents a brain that is specialized for different but complementary forms of processing, as noted by Williams (1983). Affective thinking seems to require both hemispheres. Practical teaching techniques are suggested that include both right and left brain thinking. Each of these techniques can be integrated into what is already in the classroom, rather than something to be added on. Metaphorical teaching uses metaphors to make a connection for students between something that is familiar to them and something that is new. Visualization provides images to integrate information by using pictures, diagrams, and maps. Fantasy makes use of mental imagery to help students comprehend something that cannot be experienced directly. In addition, the author suggests the use of multisensory learning and direct experiences as part of possibly encouraging both sides of the brain.

The area of hemisphericity provides many ideas that can be incorporated into the classroom. Integrating both sides of the brain seems to be important to provide improved whole brain thinking. These concepts will be further explored and synthesized for practical application in Chapter IV and Chapter V.

B. Brain Growth Periodization

During certain age intervals, there is significant brain growth, according to Epstein (1978), challenging the traditional idea of the brain growing on a continuum. These growth stages seem to correlate with mental growth and also with the developmental stages of Piaget. The brain growth spurts were discovered by comparing the increase in brain weight to the increase in body weight. Between five and ten percent brain growth was discovered during the ages of two to four, six to eight, ten to twelve, and fourteen to sixteen. For girls, the growth appears to be slightly earlier, and for boys later. Between the ages of ten to twelve, brain growth for girls is three times that of the boys, while during the ages of fourteen to sixteen, the rapid growth is reversed, with the boys catching up.

These same growth periods were found when correlated with data collected on head circumference, as Epstein (1978) relates. After the age of one and one-half, the increase in brain weight reflects a change in the cells themselves, not the addition of new cells. This change seems to increase the functional capacity of the brain. Environmental deprivation, such as lack of proper nutrition, may affect these brain growth spurts, particularly in early development. Lack of educational experiences apparently also affects the growth. If certain functions are not developed, the possibility of losing the ability to operate those functions is evident, with the loss never being fully compensated.

In addition to the rapid brain growth periods, there are longer plateau periods in between the growth spurts. The brain seems to slow down in growing during these times. Epstein and Toepfer (1978) claim that the failure of Head Start programs occurs during the plateau period of ages four to six, and the problem of junior high and middle schools occurs during grades seven and eight, the plateau period of ages twelve to fourteen. An increased input of information, at a time when students are unable to comprehend, may cause rejection of that input and an inability to develop any novel cognitive concepts. If new concepts are introduced at proper growth levels, and existing skills are developed during plateau periods, greater learning capacity may develop. There is evidence also that this may aid in developing a positive self-concept, rather than a poor self-concept associated with a lack of cognitive achievement. Middle grades should restructure their curriculum to include educational experiences and practice skills, while interacting with the outside world, the authors advocate. Cognitive information could be introduced in relation to what is already known by the individuals.

Toepfer (1979), in observing middle grades where suddenly students lose all apparent capacity to learn cognitively, suggests that IQ should not stand as a primary basis for challenging learners during their plateau periods. In addition to teaching cognitive and thinking skills, affective and personal development should be emphasized. The primary objective during the trauma of middle grades seems to be to improve self-concept and self-esteem to produce better adjusted, high achieving learners.

In a review of Epstein's findings, Cramer (1981) states that middle schools have been asking students to attend classes using a language that contains concepts they cannot possibly understand. During this plateau period the students should be kept busy with challenging, intellectual tasks, but at their appropriate level of learning. This would also be a good time to develop memory skills incorporating information that is useful and interesting.

Also concerned with the plateau period, Horst and Johnson (1981) suggested students may reject academic skills needed for the next growth period. Experiential programs should include studying and writing about what is known. Students can deal with exploring alternatives and effective experiences. Enjoyment should be fostered while concrete materials can be available to allow manipulation for increased learning.

A comparison of Epstein's biological basis for brain growth to Piaget's stages of cognitive development, was made by Johnson (1982). In stage one of sensory-motor development up to two years of age, the maturation seems to depend on proper environmental and social stimulation. The pre-operational stage during ages two to seven, appears to show a rapid development of motor skills and language. This may require an extensive social experience with language. From ages seven to eleven, the concrete operational stage shows an ability to organize and perform operations involving more than one variable, while using concrete objects, according to the author. If tasks or requirements are presented to the learner before the learner's brain has developed, the areas needed to handle the operation, less appropriate networks might be used, resulting often in failure and frustration. The stage of formal operations from age eleven to adult is now possible, if the previous stages have been adequately developed. This may enable learners to handle logic and abstract thought. It appears that prior active sensory stimulation is more necessary to the development of logic and abstract ideas, than is doing the volumes of rote written work which is so prevalent currently in classrooms.

A critique of Epstein's work is made by McQueen (1984), who claims that the data sources do not support the brain growth periodization notes, and additionally, that the use of the data is careless and misleading. Teachers are cautioned not to think that some of their students may be unable to learn because they are in brain growth plateaus, since this assumption is invalid. The author states that scholars of national and international reputation say that although information from the neurosciences is abundant, it is difficult to interpret, and applying it to the classroom at this point is irresponsible.

Research in the areas of brain growth and Piagetian periods is reviewed by Fischer and Lazerson (1984). Investigations of large groups seem to show that some broad characteristics of the brain do change in spurts during the ages when new periods are beginning. Individuals do seem to grow in spurts, and some do seem to coincide with Piagetian periods. However, spurts in head growth for individuals do not appear to coincide with spurts in their cognitive development. The authors suggest that conclusions based upon these findings on educational implications do not seem to be warranted. There does not seem to be support that new skills cannot be learned during the plateau periods.

In commenting on the criticism of his work, Epstein (1984) indicates that McQueen's article is mainly irrelevant. In regards to the brain study analyses, he states that the original correlation-based suspicion that there are brain growth stages paralleling mental growth stages, has grown, in his opinion, into an experimentally demonstrable fact. Additional data seem to ensure that the correlation holds. Also the point is made that the apparent tie to Piaget is only that: apparent.

Toepfer (1980) indicates that more recent research has been done to support the findings of brain growth periodization. An electro-microscopic technique was developed which can identify the density of synapse or the shift of synapses of the frontal cortex. There are also various areas where the implications of brain growth periodization have been applied to education. It seems to be clear that if students are taught in terms of when they can be challenged and when they cannot, there appears to be greater achievement and maturation of thinking skills.

Although there is some controversy over the research of brain growth periodization, the criticisms seems to be minor compared to the total concept. Further study is needed in this area before firm conclusions can be made. In the meantime, the implications for education seem to be important enough to consider seriously and will be explored in Chapter IV and Chapter V.

C. Triune Brain

One view of the evolution of the brain is the successive addition and specialization of three further layers on top of the spinal cord, hindbrain, and midbrain, as described by Sagan (1977). After each evolutionary step, the older portions of the brain still exist and function, but a new layer has been added with new functions. The primary advocate of this view, according to the author, is Paul MacLean, chief of the Laboratory of Brain Evolution and Behavior of the National Institute of Mental Health. The distinguishing feature of MacLean's work is that it encompasses many different animals from lizards to squirrel monkeys. Another point, as Sagan relates, is that MacLean and his colleagues have carefully studied the social behavior of these animals to further improve their prospects of discovering what part of the brain controls what type of behavior.

According to MacLean (1978), the forebrain has evolved and in so doing has expanded to a greater size,but has still retained the basics of its ancestral brain. Each brain is different in structure and chemistry, as the author relates, and although generations apart, a hierarchy of different mentalities has developed. The two older brains lack the mentalities for verbal communication, he has found, but through actions show a distinct intelligence and consciousness.

The oldest, as MacLean describes the Reptilian brain, dates back to a time when reptiles had developed mammal-like characteristics, similar to that of present day lizards.

This brain was, and is, mainly concerned with self-preservation and preservation of the species, as he has observed. One behavior it exhibits is that of defense of territory and a challenge to any intruder. Present day behavior would include that of ganging up on a stranger. This type of action is not learned, but rather considered instinct or innate. The Reptilian brain is responsible for rituals and routines; for example the idea of preferring the same seating arrangement. Displacement activity, another trait of the Reptilian brain as described by MacLean, refers to the idea of a type of grooming when threatened. Biting nails, or scratching when a threat is present, would be examples. Other characteristics of the Reptilian brain include deceptive behavior, imitative behavior, and migrational behavior. Present day behaviors would include deception during competition or struggle, imitation of fads or fashions, and migrations to music festivals.

The Old Mammalian brain, the second to develop, as MacLean relates, is better equipped to cope with new situations, and thus better prepared for survival. This brain exhibits a responsibility to the family, particularly maternal behavior. For self-preservation, he has observed, emotions are present. The New Mammalian brain, the last to develop, is our rational side. It is responsible, asserts the author, for the procreation of ideas and abstract thought or reason. Speech and memory are developed in this part of the brain. Empathy is also developed, and it is believed that if this capacity is not encouraged early, it may never develop.

The triune brain raises questions about moral judgments and cultural values as discussed by Grady (1984). There is evidence that seems to suggest that if certain neural circuits of the brain do not become operational at certain critical periods of development, they may never be capable of functioning. Generally, it is assumed that we are dealing with one intelligence, as the author states, but because the two older mentalities lack communication skills, does not mean that their influence on learning should be ignored.

Bringing the triune brain closer to the classroom has been done by Hart (1981). It is the Reptilian brain that clings to ancient ways; liking familiar places, and clinging to certain work procedures, as he relates. The Old Mammalian brain is preoccupied with emotions and on guard against the hostile, discusses Hart, where the New Mammalian brain demands fresh input and variety, and is involved in taking risks. The classroom on the other hand seems to fight against this by penalizing risks and seeking compliance. All three of the brains are in deliberate balance, as the author relates, with a shifting of influences among the three as the brain deals with various situations. Through the evolution of the brain, it seems survival has been the all important need. In sudden danger the brain was forced to act quickly, as he states, something the New Mammalian is too slow to respond to effectively. A present day example of the older brain's taking over, would be in the case of severe threat, such as when the victim has reported a temporary loss of speech. For the New Mammalian brain to function well, it appears that threat must be minimal. In the classroom, where threat seems to be implicit in the system, intellectual and creative thinking may be discouraged by inhibiting full use of the brain. At a time when school implied rote learning and discipline was severe, correct answers seemed to be the sole purpose of learning. This is evidence that simple learning could go on, but nothing more complex, as Hart discusses. As life has become more complex and knowledge has expanded, learning correct answers appears to have become inadequate. Even though memorization is not as popular, currently the system with tests and quizzes seems to be designed for rote learning. Under threat, Hart states, only simple learning can go on, but nothing more complex.

In discussing the triune brain and the importance of the reduction of threat, Hart (1983) describes the cerebrum as being slow and complicated, while the other brains are simpler and faster responding. Even today, he states, if the older portions detect threat of any kind, they tend to partially shut down the slower cerebrum and let the older parts have more say. Teachers have long observed this downshifting, as Hart calls it, where students seem frozen, unable to think, and either cannot talk or make wild stabs at the answer. The less able students in particular seem to downshift under threat of public failure. To the degree that the cerebrum is inhibited by threat, as the author states, school learning tends to stop.

Restak (1979) describes the importance of Paul MacLean's work on the triune brain. Religious and moral leaders, he says, have long asserted that all men are brothers and emphasized the kinship of all living things. Now the knowledge of the triune brain provides scientific basis for these assertations. This implies to Restak that what has been called human nature is largely genetically programmed. The question is asked as to how we can retain what is conceived as good and control some of the destructive consequences that may result.

The triune brain makes an interesting point for reducing threat in the classroom and creating an atmosphere more conducive to learning. In addition, empathy appears to be an emotion that may require early teaching. The findings and applications will be discussed in Chapter IV and V.

D. Sex Differences

In discussing work on cerebral asymmetry, Kimura (1973) relates that males tend to perform better in right hemisphere tasks, and females tend to have greater verbal fluency, largely a left hemisphere task. It appears that for some intellectual functions, the brains of males and females may be organized differently. Most of human evolution must have taken place under conditions, as the author suggests, where for the male hunting members of society, accurate information about both the immediate and distant environment was important. The females probably stayed closer to home, as she says, where those particular processes were not needed.

Schools and testing seem to discriminate against boys in one way and girls in another. Many differences are based on stereotypes, but brain research, according to Restak (1979), indicates that there are differences in brain function that are biologically inherent. These differences are not likely to be modified by cultural factors alone. Boys appear to generally suffer in the elementary classroom, where the atmosphere is more suited to the way girls think. Later on in education, girls seem to suffer where learning is more geared to male performance. Generally males are superior in spatial adaptation, as the author discusses, while females excel in areas of language.

Restak (1979) points out that there are other differences apparent even from birth. Girls, he relates, are more sensitive to sounds, and more attentive to social contexts such as faces and speech patterns. By four months of age, girls can distinguish photographs and recognize their mothers as persons. Boys, as Restak states, react to inanimate objects as easily as to a person. Girls sing in tune earlier, speak sooner, have larger vocabularies, and read sooner, the author declares. Foreign languages are easier for girls, who also develop fine motor capabilities.

Boys, on the other hand he says, develop earlier visual superiority and total body coordination. They are curious to explore their environment and manipulate three dimensional objects. Boys can mentally rotate or fold an object in their mind using their right hemisphere, the author relates, while girls activate both hemispheres. Girls reach puberty with less lateralized brains, with the left and right sides sharing more of the thought processes. The concept of feminine intuition, as he discusses, is the ability to integrate fine details of an intricate situation. It is males though, who are able to hone in on a few separate details. Boys with their gross motor coordination and highly developed visual ability have many difficulties in their early school years. The elementary school's curriculum is designed for the girls, as Restak discusses, with their fine motor coordination and highly developed auditory ability.

Shucard (1982) studied how infants processed speech and music that they heard. He discovered that almost without exception, girl babies process both speech and music that they heard. He discovered that almost without exception, girl babies process both speech and music with their left hemisphere and boys with their right. Apparently, according to the author, this difference indicates that the sexes favor different hemispheres even early in life.

The action of imagery and verbal codes in processing facial expression of emotion, was examined by Safer (1981) in a study of the effects of sex, hemisphere, and perceptual strategy on accuracy. It was concluded that sex, hemisphere, and perceptual strategy differences do exist. Females seem to have privileged access to left hemisphere, which includes verbal codes. Both hemispheres process emotions, but each does so in a unique way, states the author. Males may lack verbal codes for emotion, or may lack the connections between the verbal and the motor codes for emotion.

Specialization of the right hemisphere for spatial processing was studied by Witelson (1976). Boys performed in a manner consistent with right hemisphere specialization as early as age six. Girls showed evidence of bilateral representation until the age of thirteen. The results suggest, as the author indicates, that boys have greater hemisphere specialization. Also that the same neural structures in males and females may have different functions with respect to at least one aspect of cognition during a major period of development.

Further investigations of the sex-linked brain functioning relationship may cause us to change the schools, as Helfeldt (1984) discusses. While some individuals may be able to compensate for their differences in brain functioning, certain implications such as prematurely labeling a student, may be made for those who are unable to compensate. We may need to have different expectations for boys and girls regarding their abilities to perform certain tasks.

An increased awareness of the information can provide a basis for using strategies in more efficient ways that are more compatible to the differences in the thinking abilities of children.

There are biologically caused differences in the normal male and female brain, as Levy (1985) states. She cautions against men as right hemisphere specialists, and women as left hemisphere specialists, since for each sex, each hemisphere may specialize in a different skill. It has been verified, she says, that males are superior in spatialization, but studies show females to have a larger left visual field, which suggests that the female right hemisphere is more specialized than that of the male, for that particular instance. She further discusses that males seem to be superior to using language as a tool for thinking or problem solving and females are superior in using language for social communication.

Springer and Deutsch (1981) advocate that although most would agree that there are sex differences in the brain functions, there would be less agreement in the practical meaning. They state that sex differences in higher mental functions are typically on the order of one-quarter of a standard deviation. This means, the authors indicate, that there is a great deal of overlap in the distribution of abilities between men and women. On the average, though, the groups do seem to differ in abilities, but it is important to consider individuals, since some women have better spatial abilities than men, and some men have better verbal abilities than women.

Since the movement of today's culture is for the equality of the sexes, Restak (1979) has made some suggestions. Scholarship tests which apparently guarantee male superiority should assure that both sexes have an equal opportunity. Teachers' attitudes toward hyperactive males should change, Restak believes, since those labeled learning disabled are ninety-five percent male. Boys seem to learn by manipulating their environment, but instead are forced to sit for long periods of time in school. They have superior visual ability, as the author relates, but classrooms demand attentive listening. Other than recess, boys seem to have little chance to use their gross motor abilities; rather they are required to use fine motor abilities to express themselves in writing, in which they are clumsy. The results, he indicates, are the hyperactive male who cannot sit still, cannot write legibly, is always trying to take things apart, is loud, clumsy, and will not follow directions. At the same time, teachers' attitudes at the more advanced level need to change to incorporate more verbal and linguistic skills, Restak discusses, so that girls may have better opportunities in such areas as physics, engineering, and architecture.

The area of sex differences of the brain has ideas that may be implemented into the classroom. The male and female brain appear to have different preferences for learning.

Also, these seem to agree with some of the other concepts presented. The implications and applications will be discussed in Chapter IV and Chapter V.

An extensive search of available literature found no attempt to analyze various areas of brain research for practical application in the classroom. Each area has been discussed and reviewed separately. However, there appears to be no synthesis in general of the educational value of brain function research.

In the following section, certain "arenas" have been selected as areas of educational practice where brain research findings might promise to have the most direct and fruitful results. The next chapter attempts to review the nature of these "arenas" with this purpose in mind.

Section II. Classroom Applications

Some areas of educational practice where brain function research seems particularly applicable and practical for the classroom, include more usage of the brain to achieve higher levels of thought, implementation of manipulative materials to better enhance conceptual understandings, and staff development techniques to encourage utilization of the educational implications of brain function research. To further substantiate the promise of these areas, a review of literature follows. In order to achieve higher levels of thought, the literature is concerned with thinking skills and problem solving. The literature on the usage of manipulative materials is limited to the areas of science and mathematics. Staff development techniques to utilize more of what has been proposed includes literature on classroom management, time management, and collegiality.

In the review of the literature that follows, many references will be made to a wide array of authors. To maintain as concise a report as possible including their views, findings, and positions, the paragraphs that follow are to be considered as outlining the claims of the authors referred to, and not as the views of this researcher, except for an occasional qualification or parenthetical expression which this researcher may insert from time to time where deemed appropriate.

A. Thinking Skills

Thinking skills are not explicitly taught by most teachers, not because of lack of time, according to Beyer (1984), but more due to ineffective use of time and poor selection of what is taught. The reasons seem to include little agreement on what thinking skills should be taught and exactly what thinking skills are. There also seems to be a problem with utilizing effective methods to develop thinking skills, as well as too many being taught at one time. It is mentioned that current testing procedures seem to hamper the learning of necessary skills, while inconsistently evaluating them. Beyer suggests that first we need to look at what we are presently doing to teach thinking skills, in order to make those changes needed to improve. How Beyer's call for improvement may in part be addressed will be discussed in later chapters.

In education, while a major thrust has been made on returning to the basics, Hansen (1982) makes a case that thinking skills are basic, too. With this direction, it seems that thinking has been replaced with memorization and recall for the means of producing improved test scores. It remains a challenge for the teacher to incorporate thinking skills so that one not only masters a subject, but those thinking skills associated with it as well, as the author relates. With planning, thinking skills may aid in better learning.

Teachers consider their main educational goal as that of promoting students' thinking capabilities, as Wassermann (1984) states, and she discusses the differences between what is stated and the actual outcomes. Students are merely learning lessons on a factual manner, she says. Teachers talk about high-order thinking, yet it is found to be the least emphasized skill in the classroom. Wassermann continues that materials require low level thought, teachers use restrictive methods of teaching, pupils are not encouraged to develop as thinkers, and growth development of teachers is not encouraged. It seems necessary for teachers to work together to promote thinking skills in their students.

Metacognition, or thinking about thinking, is a necessary part of the survival skills for the future, as discussed by Bondy (1984). By developing an awareness and providing opportunities for conscious thought, students could be encouraged to develop a systematic approach to solving problems. Through this method, students would not only be able to think, the author notes, but also develop some control over their thinking. The thinking skills could then become a part of the learning process.

Consideration is given to helping teachers think, so that they can better assist students and later integrate thinking skills into the curriculum, as discussed by Pendergrass and McDonough (1982). Teachers seem to have concerns about their abilities to think and should be made to feel confident prior to working with students. If teachers are provided with examples in a relaxed environment, are encouraged to participate in thinking activities, and are shown many different processes and variations from which to introduce thinking skills, they may be more confident and better prepared to work with students. By discussing together, openly, the idea of thinking skills, clarifying their own methods and means of expecting more from their students, the authors suggest, teachers could develop new ways to teach thinking skills, while at the same time providing a support system for further development. With this system, it seems, improvements can be made to teach students to use thinking skills.

Certain teacher behaviors can create a more conducive environment for students to effectively develop thinking skills, as listed by Costa (1981). Some of these are; enlarging student awareness, choosing appropriate teacher language, and making sequential arrangement of learning activities for extending thought. Materials need also to support thought, along with an adequate provision of time, he says. Different learning modalities need to be considered, the author discusses, and attention paid to where these modalities fit, according to developmental theory.

Bereiter (1984) is concerned with making thinking skills an integral part of what already exists in the curriculum and permeating the programs with thinking skills, so that they will not be utilized as isolated activities. Caution is given that many games used to promote thinking cannot produce the desired development of full utilization of thinking skills. The author believes that the games are used in isolation and do not allow for thinking to become an integral part of the curriculum. A better means, he suggests, is to permeate every possible aspect of the instructional program with thinking skills. In this matter, thinking could be encouraged and challenged, so that students could begin to apply these skills in all phases of their individual programs. He further relates that considerable thought should be given to those skills necessary to further develop thinking.

B. Problem Solving

Concern over the inability to think abstractly or use higher level thought processes, as Yeotis and Hosticka

(1980) discuss, has led to a greater reliance on problem solving skills. As in the case of improving the teaching of thinking skills, the potential of this reliance on problem solving which Yeotis and Hosticka indicate will be discussed further in Chapters IV, V, VI. A multitude of approaches has become available for teaching problem solving, they say, making analysis of the success of these programs difficult. Problem solving techniques seem to have become a major concern for educators, since good problem solvers show independence, responsibility, organized thinking and creativity, according to the authors.

Advanced technology, global problems, expanding knowledge, and changing lifestyles, suggest that teaching problem solving is an issue, as Dewald-Link and Wallace (1983) state. One of the proponents of the problem solving approach was John Dewey, as the authors discuss, who believed man to be a problem solving organism able to be taught to organize problem solving skills. The classroom could provide a place to learn these skills, the authors suggest, but should be related to one's experience in order to cope with the changing world.

The implications for teaching problem solving are outlined in the research as Suydam (1982) discusses. Problem solving, it seems, can be taught, yet there is no one strategy for all problems. Students need to be able to generate different approaches to solving problems, as she relates, so that problems of this type should be presented along with different strategies for solving them. Problem solving skills seem to be improved by incorporating them throughout the curriculum. The research suggests that teachers expose children to many and varied problems, teach a variety of strategies, provide problems at appropriate levels of difficulty, and utilize manipulative materials as aids to problem solving.

Lochhead (1981) highlights the research on problem solving with teaching it as a two step process. The first step, it appears, is to get students actively involved in thinking about problem solving through talking and writing their thoughts. The next step, he says, is to teach specific strategies. With an emphasis on the first step, the students may begin to develop their own reasoning.

Cooperative, competitive, and individualistic conditions were investigated by Johnson, et al. (1980) in relation to problem solving performance. The results indicated that those involved in a cooperative enterprise achieved more. In addition, students working cooperatively used higher quality strategies and perceived higher levels of peer support and encouragement for learning. High ability students working cooperatively achieved higher than high ability students working either competitively or individually.

Students who had a process oriented science curriculum scored higher in problem solving skills than those who had a science program emphasizing content, as Shaw (1983) discovered. The results implied that a curriculum is needed that has emphasis on problem solving skills, and that the processes learned can be applied to other areas. The teaching of problem solving skills, it seems, results in better problem solvers in general.

Implications for problem solving can be seen in hermisphericity research, as Myers (1982) discusses. The specialization of each hemisphere implies different means for solving problems. The left hemisphere depends primarily on linear, analytical thinking, and the right simultaneously integrates, according to the author. It is cautioned, however, that the brain uses both parts, and it is difficult to separate functions. An awareness, though, of the different modes for processing information, can provide educators more possibilities for integrating activities for problem solving.

Scandura (1981) suggests that problem solving behavior can be simply explained. Added to learner specific knowledge is the concept of how learners use the knowledge available, and the capacity for storing that amount of information. The naive learner's knowledge, as he describes, is in terms of rules that individually are not enough, but can work in a combination. The neophyte's knowledge has explicit rules for solving particular problems. The master's knowledge has the rules of more efficient procedures that operate in complex structures.

Process of transition between the stages can be made, it seems, through an awareness of the appropriate rules.

Visualization is an alternative approach to the teaching of problem solving as discussed by Moses (1982). Visual thinking seems to be composed of three overlapping strategies of thought: seeing, imaging, and designing. This approach appears to focus on mental images, translates to drawing, and then analyzes the drawing in terms of the questions asked. This mode of thinking may benefit students of low reasoning ability, by giving them a viable alternative, and may provide students with a better means for problem solving.

Several approaches were listed by Kulm (1982) to bridge the gap for students between intuition and formal process in becoming better problem solvers. These seem to assist students during the transition period between Piaget's concrete operational and the formal operational stage. Some of the approaches suggested include making drawings, a list of data, a graph, using symbols for variables, classifying objects into categories and breaking the problem into parts. The use of these approaches may lead to more formalized methods. It seems important to attend to the process, rather than to obtain answers.

Solving problems is not filling in the blanks in a workbook, but rather confronting situations where students are given an opportunity to solve problems of their own, as Krockover (1979) discusses. Sources for everyday problems can be found in the newspaper or magazines. Role playing can serve as a means to further develop problem solving skills so that decisions can be made that may be more suitable to real life situations, as he suggests. Solving everyday problems can include writing, drawing, comparing, graphing, calculating, using, preparing, selecting, making, creating, estimating, and measuring. DeBruin and Gibney (1979) also discuss using basic process skills to solve everyday problems. The students can use the process skills and engage in hands-on activities to solve their problems. Integrating the disciplines can include observation, measuring, classifying, and inferring.

Children learn to solve problems by solving problems, states Van de Walle and Thompson (1981). These opportunities should be constantly available, they say. Management and instructional strategies seem to be needed if problem solving is to be integrated into the daily schedule. Some ideas suggested include; providing bulletin boards for problem solving, using elapsed time for a directed problem, and including manipulatives for a problem solving activity. Good problem solving activities should be available all the time, the authors advocate.

C. Manipulatives

That manipulatives should precede the abstracting of an idea, as Jackson and Phillips (1973) discuss, is a concept that appears to have strong support among educators and psychologists. Sensory learning is basic to all other learning and can be utilized at different maturational levels and knowledge systems, they say. The evidence supports the fact that the study of mathematics can be improved, if one has an opportunity to manipulate material objects. It is suggested that manipulatives are essential for mathematics instruction.

Research tells us that pupils learn in different ways, as Berman (1982) discusses. Using a variety of manipulatives seems to increase the likelihood that learning will take place from at least one approach. Children appear to need to experience the idea of abstracting one concept common to several activities. Studies are cited that show that children learn arithmetic skills better by spending more time on development activities such as manipulatives, rather than on drill. Also, the use of manipulatives appears to increase retention and improve understanding over a period of time.

In the National Council of Teachers of Mathematics Yearbook (1973), it is stated that research on manipulatives is inconclusive. Some support and direction can be found for the use of manipulatives in various projects. It is concluded that the research gives credence to the hypothesis that manipulatives are useful in attaining the mathematics goals.

In looking at the adoption of a science program, Bredderman (1977) gives strong support for laboratory or manipulative programs. In thirty summarized studies on laboratory-type science programs, most showed improvement in cognitive or science process, as well as improved reading and mathematics skills. Only one study reported an overall advantage for the comparison group, and some reported no advantage for either approach. Twenty of the twenty-five studies, specifically looking at science achievement, reported statistically significant advantages for the laboratory program on one measure or more. The advantage was often for higher level thinking skill or problem solving. Studies looking at cumulative effects after several years of a manipulative program, showed positive results.

Bredderman (1983) used meta-analysis techniques to synthesize research from fifty-seven studies dealing with the effectiveness of activity-based science programs. Science process skills were measured in twenty-eight of the studies, and on the average, students from the activity-based programs performed twenty percentile units higher than those students in the comparison groups. Five studies used a test of creativity, and showed students in activity-based programs benefiting about sixteen percentile points. In the area of both science process and science content, disadvantaged students gained more, using activity-based programs. This included both academically and economically disadvantaged students. Modest increases were noted in the areas of perception, logic, language development, science content, and math.

Shymansky, Kyle, and Alport (1983) synthesized one hundred and five studies using meta-analysis techniques. Definite positive patterns seemed to be revealed for student performance using the new science curricula. The new science curricula refer to emphasizing the process of science and integrating laboratory activities. According to the study, students using the new science curricula performed better in general achievement, analytic skills, process skills, and related skills, compared to those students in traditional courses. The average student in the new science curricula exceeded the performance of sixty-three percent of those traditional curricula students. Achievement scores of students in the new science curricula improved across all grade levels, particularly those scores of female, urban, low and high socio-economic status students. Student attitudes toward science also showed an increase. The new science students showed an improvement in their performance in process skills, problem solving, and critical thinking. Additionally, according to the study, elementary students improved in related areas of mathematics, reading, social studies, and communication.

Suydam (1984), also considers the evidence from research on manipulative materials. Lessons using manipulative materials seem to have a higher probability of producing greater mathematics achievements. Achievement can be enhanced across topics, grade levels, and abilities. Manipulatives are not necessarily always needed to be manipulated by the learner, according to the author, as watching can also be effective.

The most important reason for the use of manipulatives is to make the abstract world of mathematics meaningful, as stated by Fennema (1973). This can be accomplished, she says, when manipulatives are used to enhance the relationship between symbols and reality. Unless knowledge of abstract mathematical concepts is based on meaningful concrete experiences, it appears that the learner will be unable to make full use of the symbols. Manipulatives can provide the learners with effective understanding of the symbols, and may assist them in becoming more efficient problem solvers.

Although the use of manipulatives is generally associated with elementary instruction, a number of reasons for their use can be applied to secondary as well, as discussed by Howden (1985). The use of manipulatives seems to promote problem solving, and recognition of patterns. These can be applicable to all levels. Manipulatives encourage a friendliness to mathematics, the author asserts, the opposite of anxiety, so prevalent at the secondary level. The use of manipulatives applies much of the recent research on how the brain functions, and how we process information, she says. Understanding and retention seem to be greater for the students who use manipulatives.

One needs to identify those manipulatives that best meet the criteria to be studied, and then develop effective ways for using them, cautions Reys (1971). Manipulatives should not be used indiscriminately or used excessively, he says. It seems important not to rush from the concrete to the abstract level. Integrating the materials into organized learning appears of importance, so that progress can be made from simple and concrete, to complex and abstract.

Snyder (1978), from a review of the research, cautions that it is difficult to generalize broadly about the effectiveness of programs. The concern here is with teachers and their behaviors, in using or not using manipulative programs. The methods and materials of the particular programs may be only as good as those who utilize them. There exists the need for working to implement the knowledge from the research. It is the teacher who makes the difference in the classroom, according to the author.

In a keynote address, Mechling (1984) states the importance of activity-based science programs. Students using activity-based science outperform students using non-activity-based science. They develop thinking skills through analyzing data and testing hypothesis, he says. Hands-on activities help students develop responsibility for their own learning; they are learning how to learn. He further discusses how Piagetian notions of developing intelligence are reinforced through the use of hands-on activities. Learning in other curricular areas can be reinforced through hands-on activities. According to

Mechling, these activities help us avoid the "mindless" curriculum, where science is taught without thinking of its value or purpose.

D. Classroom Management

Research conducted in the area of classroom management is synthesized by Brophy (1983). Assumptions in this study include; the teacher is the authority and instructional leader, good instruction is part of good classroom management, and optimal strategies are cost effective and practical for the majority. Effective classroom managers were found to be aware of what was happening and were able to detect inappropriate behavior early. Also, effective managers kept the group alert and accountable, as well as providing variety and challenge. The research agrees on commonalities such as respect for student individuality, reliance on instruction and persuasion -- not power assertion, understanding and assisting students, and generally utilizing humanistic values.

The effects of cooperative, competitive, and individualistic learning on student achievement in science class was studied by Humphrey, et al. (1982). It was discovered that cooperative learning, increased learning, and retention of material over competitive and individualistic experiences. The cooperative learning included working together, deciding by consensus, including all members, and completing assignments together. A more positive attitude toward science was also found, with cooperative learning.

Beasley (1983) studied the role of the teacher in relation to pupil task involvement during small group activities. It was reasoned that the teacher's role is crucial in managing effective laboratory activities. Higher levels of involvement seemed to be obtained while the students worked in small groups, but the teacher left the impression of managing the whole class.

Effective manager behaviors were identified in a study by Sanford (1984), related to high levels of student task engagement and freedom from disruption. It was concluded that effective management included efficient routines, skills in managing group work, and clear communication. Also important seemed to be the prompt stopping of inappropriate behavior and appropriate pacing of instructional activities.

Nelson (1980) suggests an inquiry approach to utilizing small groups. Teachers can learn to select students for effective team work. Problem solving roles can be assigned to each member of the team. This may provide the learners with high inquiry skills and the teacher becomes the manager of the learning process.

Students are capable of sharing in their own learning, as discussed by Metzger (1981). In this way, classroom management can be influenced positively. As students become involved in the learning experience, they can accept responsibilities and realize purposes for learning.

An approach to managing manipulatives in the classroom is that of creating inquiry centers, as suggested by Manning (1980). Rules can be established for appropriate behavior, and students can be placed into working groups for the centers. Directions should be clearly stated, and a data sheet provided to include evaluation and recording information, as the author relates.

E. Time Management

It is important to make time and stress management part of what students learn, as stated by Kozoll (1982). Some appropriate techniques reported include; using controlled intensity, focusing, pacing, and controlling potentially stressful situations. Teachers who have tried these with students, according to the author, have reported a generally enthusiastic response.

Learning is maximized when students are engaged in a task activity, as discussed by Capie and Tobin (1981). On the basis of analysis and studies, student engagement rates are closely related to achievement. Although little research has been done in this area, it is suggested that the teacher needs to maximize student involvement.

In a study by Wang (1979) the concepts of minimizing time needed to complete an activity were investigated. It was concluded that an instructional design can cause more effective use of teacher and student time. The approaches suggested include; reducing time needed by increasing the quality of instruction, and teaching students to maximize use of time by developing learning habits. Another approach suggested in another discussion by Wang (1979), was the increase of student motivation to spend time needed on learning.

Time using instruction is outlined by Moyer (1983). Students need to use time-telling devices in an active manner, she says, to monitor the passage of time. For many this means developing the habit, as the author suggests. One means related, of achieving this, would be predicting the amount of needed time for an activity.

Gettinger (1984) studied achievement as a function of time spent in learning and time needed for learning. It is important to spend adequate time in learning, relative to the amount needed to maximize achievement. The time needed for learning contributes significantly to achievement, she discovered. Another study by Gettinger and Lyon (1983) also concludes the importance of spending adequate time in learning, in order to maximize achievement.

F. Collegiality

In a program designed to provide the staff with proper instructional support, as discussed by Freeman, et al. (1980), clinical supervision was selected as a model to fit changing ideas and various teachers' views. Through formal evaluation, the results showed an increase in positive attitudes of the teachers toward supervision, and more interest in the improvement of instruction. (Such clinical supervision and collegial efforts to improve instruction may be buttressed by brain function research findings, it would appear to this researcher.) Teachers expressed confidence in the clinical supervision model, and confidence in using one's peers. As teachers began working with their colleagues to practice the supervision, it was found that new relationships developed, and many cases of rewarding interactions were reported.

McFaul and Cooper (1983) examined the outcomes of peer clinical supervision. After completing a graduate course, teachers assessed by the professor as having the most skills, were also named as being the most helpful by their colleagues. The successful portion, according to the teachers, was when they gained new information about themselves as teachers, felt comfortable with their colleagues, and often shared grade levels. It was concluded that a degree of congruence between the environmental setting and teacher development programs is an important consideration.

The purpose of a study by Roper, et al. (1976), was to field test the collegial evaluation process. The conclusions of this field test provide information that teachers can and will help each other in carrying out the tasks of their job better. The collegial evaluation plan does seem to be a useful approach, according to the authors, and one that can be adapted to individual programs.

A study by Little (1982), looked at the school as a workplace and was interested in determining how involved teachers become in learning on the job. The major conclusion was that staff development appears to have the greatest prospects for influence where there is a prevailing norm of collegiality. There also needs to be a norm of continuous improvement, she says, including analysis, evaluation, and experimentation. The school as a workplace appears to be quite powerful. The most successful schools studied, the author relates, shared both expectations in collegial work, and analysis and evaluation with their teaching, while continuous improvement was shared by the school.

Four studies were reviewed by Holdaway and Millikan (1980) to gain information about consultative needs and practices of teachers at different levels. It was found that a majority of teachers felt a need for consultative assistance, and the most frequent personnel consulted were teachers' colleagues. Lack of time was cited as the main reason for not seeking needed consultative assistance. The major conclusion deals with the support given to the importance of peer consultation. Recommendations were made to improve consultation by making better use of the in-school experts, including allowing non-teaching time to work with others.

SUMMARY

This chapter has reviewed the literature in the areas of brain function research that appeared most applicable to the classroom. The areas were discussed in terms of background of the research and opinions as to their utilization in the classroom. The areas were discussed in terms of background of the research and opinions as to their utilization in the classroom, and included hemisphericity, brain growth periodization, the triune brain and sex differences of the brain. Areas rich in educational implications that seemed apparent from the review of brain research were also reviewed. These included developing thinking skills, facilitating problem solving, and employing manipulatives. Staff development techniques, consisting of classroom management, time management, and collegiality, were discussed in terms of opportunities for better application of brain function research.

The underlying rationale for the selection of the areas of brain research and the arenas of application which have been selected for review above may be formulated as follows:

- Brain research ties into already existing understandings regarding the development of thinking skills, problem solving, and the use of manipulatives in that:

  a) Hemisphericity studies reveal an apparent over-emphasis on left-brained activities in our schools.

  b) Brain growth studies reveal increased usage of manipulatives and adding problem solving during plateau periods.

  c) Triune brain studies reveal we may be underestimating the need for reduced threat.

  d) Sex differences reveal a need for manipulatives to minimize the differences.

- Brain research ties into the areas of application in that:

  a) Thinking skills show increased usage of the brain for higher thought.

  b) Problem solving discusses again higher levels of thought and increased thinking.

  c) Manipulatives aid in developing concepts by using more of the right brain.

CHAPTER III

METHODOLOGY

The brain is the organ with which we learn, and yet knowledge of its function is largely overlooked as being a vital part of the professional training of educators. Many of the current writings focus on particular needs and concerns of the different areas of brain function research. There seems to be a need to evaluate these writings for sound research practices, and to determine general agreement on their application to education. Additionally, it should be decided if these findings would be operative in the average classroom.

An extensive critical search of the available literature pertaining to brain function research has provided both primary and secondary sources as related to educational settings. Each source has been critiqued for its positive and negative aspects, using the criteria previously established. The criteria utilized are discussed at length here, in order to provide a firm basis for application of the findings. Also presented is the methodology for a practical and applicable synthesis of brain function research.

A. Criteria for Evaluation

Primary sources for each of the major areas of brain function research discussed in this study were consulted. It seems important to first discover how the research was conducted and the reactions of those involved, before looking at the interpretations made by others. For the area of hemisphericity, it is Roger Sperry who seems to be responsible for the latest interest within the last decade, with his studies of split brain patients. Robert Ornstein, another primary source, studied normal patients and hemisphericity, using EEG readings. More recently, Jerre Levy has focused attention on more accurate descriptions of hemisphericity, in response to her work in the area of handedness. Herman Epstein is the source for the theory of brain growth periodization, with his correlation of data from previous autopsy studies. Of major interest when discussing the evolutionary pattern of the brain, is Paul MacLean, who established the concept of the triune brain. In the area of sex differences of the brain, several studies were consulted, including those of Doreen Kimura and Sandra Witelson. Without first becoming aware of the actual brain function research that is being discussed, it seems difficult to make any valid interpretations. In this study, the primary sources were consulted first, before looking at various critiques and interpretations.

In selecting the primary sources, the following criteria were established:

1. The brain function research is APPLICABLE TO EDUCATION. The rationale is that since the brain is the center for learning, efficient development of brain potential should increase learning potential. In selecting research to be included in this study, attention was focused upon research that discussed the probability of increased learning, or learning at a higher level than usual. Research which could not be applied to education was not included in this study.

2. The brain function research is PRACTICAL for the typical classroom. Given that procedures described in the research are feasible and readily understood by an accredited teacher, greater practicality is allowed in the selection of the research to be reviewed. Considerations in this area also included financial concerns, since many of today's classrooms have limited budgets, and cannot spend an excess of additional money for any trivial reason. Another consideration in this area was the ability to infuse these ideas easily into the already existing curriculum with a minimum of effort, since many teachers already work under severe time strains.

3. The research is RELIABLY ORGANIZED and VALIDLY ESTABLISHED. The studies included here have been published in major journals and have been referred to by others in several journals and publications. In 1978, the National Society for the Study of Education published the works of a committee on Education and the Brain. That publication also

supports many of the findings. Each of the major studies included seems to have been reliably organized and validly established, not only according to their peers in the medical or scientific field, but also from the point of view of the educational field, which has drawn implications from them.

4. The research exhibits GENERALIZABILITY. Each of the areas included can be applied to a variety of disciplines at varying levels of education. Not only can these concepts be included at early stages of schooling, but can also be infused into the curriculum at later levels. In addition to benefits which a self-contained classroom would seem to derive from the brain function research, each subject area discipline would also appear to be able to make use of the implications.

5. The research is CURRENT and UP TO DATE. Each of the studies has been widely written about within the last ten years. The research itself has been done within the last twenty years, at the longest, with much of the research being completed within the last fifteen years.

The secondary sources were consulted for each of the major areas of brain function research that were included in this study. An effort was made to incorporate those secondary sources that were directly involved with the primary sources, along with secondary sources which both agreed and disagreed with the original research. Those which were most directly involved with the primary sources of research included Conrad Toepher (who has written with Herman Epstein), Leslie Hart, (who has publicized Paul MacLean's concept of the triune brain), and Richard Restak, (who, in addition to relating his own research, has reviewed the research of others).

In selecting the secondary sources, the following criteria were established:

1. The opinions cited in the secondary sources are WELL-FOUNDED. One factor considered was that the bibliographic references included primary sources. It also seemed important that in relating the educational implications of the research, that the author appeared to incorporate basic knowledge of the educational field, including an understanding of the classroom of today.

2. The INTERPRETATION OF THE ORIGINAL RESEARCH IS VALID. It seemed important that the rationale was supported by original research. When the author of a secondary source was making a suggestion, it was considered in the reading whether or not the original intent of the implication of the research being discussed had been a part of the interpretation.

3. The views expressed are OPERATIVE IN THE TYPICAL CLASSROOM. It appears to be of primary concern that those ideas and suggestions are clear, logical and easily integrated into already existing curricula. Given the traditional classroom of today, there seems to be a need to make any new addition as easily infused as possible. This can be done by

considering what is already existing in the classroom and realizing that anything to be added, no matter the importance, must be made a part of the day with as little confusion as possible.

4. The opinions exhibit GENERALIZABILITY. It seems important that those opinions reviewed are applicable to as many classrooms as possible. This would include a wide range of disciplines, as well as many different levels.

5. The views of brain function research are CURRENT and UP TO DATE. An effort was made to use the most current articles available. These included journal articles and publications that have been written in the last ten years. These current articles reflected those areas that have been included in this study.

6. There is GENERAL AGREEMENT on any topic among secondary sources. The majority seemed to be in agreement on each topic discussed, prior to consideration for inclusion as a possible implication. With this general agreement of ideas, a more valid interpretation could be made of the concepts presented.

Once the literature on brain function research had been evaluated, using the criteria that have been listed above, general implications were considered. After reviewing the areas of hemisphericity, brain growth periodization, the triune brain and sex differences of the brain, the implications that were chosen for further study were thinking skills, problem solving, manipulatives, classroom management, time management, and collegiality. The criteria used to evaluate these areas included the same concepts that have been listed for brain function research, using primary and secondary sources. It was also considered important that both primary and secondary sources be evaluated for the areas of the implications of brain function research. These areas were concerned with practicality and applicability to education and the classroom. Generalizability and currency were also deemed important in considering articles for inclusion in this study.

B. Synthesis

The limitations of this study consider that neuroscience and education are on two different levels. It has been only recently that an attempt has been made to bring the two together. Journal articles and books have been limited to those from brain function research that have educational implications. Given that professional bias may be inherent to the findings, an attempt has been made to evaluate these findings objectively, using the criteria that have been previously established.

In order to synthesize the findings in a practical and applicable manner, consideration was given to the following. General agreement of the ideas from the literature gave strong support for certain concepts. Dissonance among what is presented and what actually takes place in education was another aspect. Also those gaps where further study is needed raised several questions. The information synthesized in terms of agreement, dissonance, and gaps will be presented in Chapter V.

SUMMARY

This chapter described methods used for this study. The literature from brain function research was used according to the criteria that had been previously established. Those criteria are described. The synthesis for practical application is also outlined. From this foundation, the findings are presented in the following chapter.

CHAPTER IV

FINDINGS

It seems important that brain function research be documented, so that its implications can be utilized. With more efficient use of the brain, learning may be greatly enhanced. From the literature that has already been reviewed, including hemisphericity, brain growth periodization, the triune brain, and sex differences, these areas are synthesized here, using the previously established criteria. Those suggestions for further implementation in the classroom that seemed to be most prevalent, are also discussed. Certain aspects seem to be inherent. A logical extension of these aspects on better use of the brain would include problem solving, thinking skills, and the use of manipulatives. The incorporation of these concepts into the classroom, indicates an improvement in staff development techniques. These could include classroom management, time management, and collegiality.

The findings that resulted from a critical evaluation of the literature from these areas, using established criteria, will be presented in this chapter. In synthesizing the results, some suggestions are made that could be applicable for the classroom, to further implement brain function research. Since the literature and the findings therefrom presented in this chapter represent more of a theoretical framework, the specification of more operational applications for the classroom will be discussed later in Chapter V. Chapter V will also contain tables of implications and applications.

A. Hemisphericity

The concept of hemisphericity describes the apparent specialization of each of the two halves of the brain in different skills. The right side is generally thought of as utilizing affective skills, while the left is more cognitive. The importance of understanding hemisphericity seems to be in bringing both sides of the brain together to function as a unified whole, to achieve higher levels of learning. Generally, our society favors the left side of the brain, and the thought patterns inherent in that side. Although it is largely agreed upon that both sides do differ in their functions of thought, it is preferable to use both sides together, and this may mean different things to different learners. For instance, learners may have an auditory or a visual learning preference, but each should be used to develop both sides of the brain.

One of the criteria established for primary sources for the area of hemisphericity is applicability to education. It is important for educators to consider both sides of the brain as reasonable. Roger Sperry (1975) suggests that our educational system discriminates against one side of the brain, giving little attention to the side favoring the non-verbal and the non-mathematical. There does seem to be an indication that utilizing the whole brain can provide a better balance in our curriculum, as Robert Ornstein discusses (1978). Levy (1983) further suggests that whole brain learning may mean different methods for different people.

The concept of hemisphericity can be practical for the typical classroom; another criterion. It requires a knowledge of the topic on the part of the teacher, not necessarily elaborate materials. As Ornstein (1978) suggests, the hemispheres are specialized for different types of thought, not different types of materials. In other words, depending on the type of story read and for what purpose, the right hemisphere can be used. Glassner (1980) reports that writing familiar information suggests left brain stimulation, and that writing to explore or discover suggests right brain stimulation.

The professional people who have contributed to the field of hemisphericity, with research that is reliably organized and validly established, are included in this study. Roger Sperry's work that seemed to have initiated the current interest in hemisphericity, is an example. Robert Ornstein later substantiated the concept through the use of EEG readings. Most recently, Jerre Levy has brought new light on the subject, by cautioning against some of the common misconceptions of hemisphericity.

Another criterion is that the use of hemisphericity can be generalized across the disciplines, and used at any level. The whole brain approach can aid in the learning of concepts for any age, and lends itself to a variety of subjects. For example, using drawings and words to describe the same topic, can be applied at different levels and subjects, while at the same time encouraging the use of the whole brain. It is also important for the research to be current. Sperry's work came from the mid-sixties, leading up to Levy, who is still contributing to the field.

In order to aid in the integration of the two hemispheres, both sides seem to need stimulation. Materials should be presented to both sides in different manners, for better comprehension. Involvement in the process of learning appears to be as important as the content itself. In applying the whole brain approach to learning, activities and materials should be provided that aid development of the right brain as well. Since the left brain type of thought is generally encouraged in the typical classroom, incorporating the right brain thought patterns should encourage more of a whole brain approach.

One of the criteria considered for the secondary sources was that it be well founded, through the use of primary source bibliographic references, and a knowledge of the educational field. It should be noted that the cautionary statement made by Fagan (1979), (where he suggests that the concept of brain hemispheres is no panacea for school crises), does not include any primary source bibliographic references. The other sources provided primary source bibliographic references, and exhibited an apparent knowledge of the educational field. Springer and Deutsch (1981), in critiquing the material, state that the evidence is not conclusive on what functions are present for which hemisphere, but that the educational system may be neglecting the development of talents from both sides of the brain.

Among the secondary sources from the area of hemisphericity, the opinions presented generally seemed aware of the original research, and made interpretations that were valid, according to the majority of the sources. Good overviews of the original research were provided by both Andrews (1980), and Gray (1980). After considering the hemispheric research, they both concluded that more of an integration of the whole brain needs to be considered. For instance, attention should be given to the skills associated primarily with either the right brain or the left brain.

The views of the secondary sources needed to be operative in the typical classroom; another criterion. Many of the opinions expressed can be used with little or no preparation. Haglund (1981) suggests emphasis on process rather than on content, where if the subject matter is of importance, then teaching can involve learning by doing, mental imaging, conversational interaction, and field experience. Visualization and metaphorical teaching can be incorporated into the classroom, as suggested by Webb

(1983), Samples (1975), and Williams (1983). The encouragement of creativity and invention can also be included. There seems to be a concern for integrating the cognitive and the affective domains of learning, while at the same time creating a more holistic approach to learning, as Sonnier (1983) suggests. The student needs to be the focal point of the projects and the activities. In other words, the interests and abilities of the students should be of primary concern, when establishing learning methods.

Some impractical suggestions include the system combining hemispheric research and learning style theory, done by Bernice McCarthy (1985). It seems improbable that teachers will be able to take the time to classify learners into the four categories, and then proceed to teach each lesson in each of the four modes, while at the same time providing right and left brain activities for each. Another includes the use of biofeedback and yoga, as Yellin (1983) discusses. There is still controversy in these areas, as well as several negative connotations among skeptical educators.

The opinions that exhibit generalizability were another concern. As Gray (1980) discusses, schools stress the left side of the brain and practically ignore the right, where the concern is calculating, not conceptualizing, and mastery, not application. Techniques, such as visualization, metaphorical teaching, and fantasy, need to be integrated into the present curriculum, not added to it, as

Williams (1983) states. Blakeslee (1983) suggests that teaching intuitive thinking may encourage a right-brain orientation, but it needs to occur on a daily basis in all subjects taught.

General agreement among the sources was another criterion. The majority of writers appeared to concur on the whole brain approach, rather than the separation of the two hemispheres. As Andrews (1980) suggests, healthy individuals appear to function more effectively when the two sides of the brain are being integrated. In regards to currency, many of the journal articles and books used in this study were published in the last five years.

Suggestions made for encouraging the use of the right brain include restructuring environmental science to include right brain thought patterns, as Gilsdorf (1982) discusses. In this way students would be encouraged to perceive themselves as a small part of a larger system. The importance of art may provide hemispheric stimulation, as suggested by LeCompte and Rush (1981). Sinatra (1983) and Rico (1983) suggest that providing experiences that stimulate the right brain is important for language. Rico encourages writing in a non-linear fashion, such as clustering thoughts in a map according to themes, so that the right brain may function optimally. Buzan (1983) also encouarges note taking in a non-linear fashion.

Specific activities to encourage the whole brain are suggested by Staley (1980), who encourages providing real life problems to solve in the outdoors, where both sides of the brain can be activated naturally. Hunter (1976) suggests presenting information to both sides of the brain, perhaps using a different technique for each side. In a workshop designed for the whole brain, Barzakov (1982) uses sensory awareness, relaxation, and imaging. Integrated thinking is important, as Grady (1984) advocates, and suggests giving directions, both visually and verbally, in written and manipulative forms, allowing students the option of illustrating an idea, or expressing it in words, thus encouraging a variety of thinking skills to solve problems.

B. Brain Growth Periodization

Brain growth periodization develops the notion that the brain grows in spurts, and then plateaus before reaching another spurt. The spurts are the times that the most learning seems to take place. It is during the plateau periods that there can be a danger of providing too much new information at one time, resulting in frustration and failure. Girls show a larger increase in their brain growth earlier than boys, who apparently experience their largest growth a few years later.

The primary source in this area of brain growth periodization is Herman Epstein. That the work be reliably organized and validly established is a criterion. The original work is well presented and gives a logical interpretation of the findings of autopsy reports, explaining those periods of growth that seem to correlate with mental growth and the developmental stages of Piaget. Although this work has recently come under attack by McQueen (1984), Epstein has made a satisfactory response to the allegations, stating that the critique is mainly irrelevant and that the data do indeed support the notion of brain growth periodization. This work is current, and has come about in the last fifteen years.

In considering the criteria of being applicable to education, the area of brain growth periodization provides an interesting solution to several problems. In order for this to become the solution, more research is needed and that is presently being done, as Epstein (1984) has noted. In the meantime, those who work with students experiencing those plateau periods are well aware of inherent problems, including the difficulty of presenting new concepts, and many frustrated students turning off completely to education. Given the same considerations, this research is also practical for the classroom, and can be generalized to a large population, concerning various disciplines and different levels. For instance, the growth spurts and plateau periods refer to those of school age, from beginning school through high school.

Although there has been some controversy as to the credibility of this research, those who have worked closely with the age groups involved seem to accept more readily what has been described. The implications of brain growth periodization indicate further support for Piagetian theory.

Also there is an indication that during the plateau periods, concepts should be further developed and extended, rather than a lot of new information provided. This seems to support involving the learner in the application of the concepts learned, and manipulation of the environment to further develop those concepts.

That the secondary sources consulted should be aware of the original research, and seem to have made valid interpretations, is another criterion. Epstein's work is largely brought to the field of education by Conrad Toepfer, who has worked with him. The major critic of Epstein, Richard McQueen, does not refer to the primary source in his bibliographic references.

The suggestions that are operative in the classroom and generalizable, include an apparent substantiation of Piagetian theory, and a comparison of Epstein's biological basis for brain growth. It seems important to consider a student's stage of development before instructing in new skills, as Johnson (1982) discusses. During the sensory-motor stage of up to two years, maturation may depend upon proper environmental and social stimulation. The preoperational stage during ages two to seven, appears to show a rapid development of motor skills and language, implying a curriculum which provides an extensive language experience. From ages seven to eleven, the concrete operational stage shows an ability to organize and perform operations involving more than one variable, while using concrete objects.

The stage of formal operations from eleven to adult is now possible, if the previous stages have been developed. Otherwise failure and frustration may result. Some suggestions for utilization of brain growth periodization include the development of already existing skills, rather challenging on one's own level, instead of introducing a new concept before one is ready, agrees Cramer (1981), Horst and Johnson (1981), and Epstein and Toepfer (1978). It also seems important for students during plateau periods to be taught in an environment that is concerned with teaching to what has real meaning for them, such as something that has personal importance. This appears to provide for greater learning, as discussed by Epstein and Toepfer (1978), Cramer (1981), and Horst and Johnson (1981). The real meaning can come from experiences, practical skills, an emphasis on personal development, teaching from the known to the unknown, and manipulation of the environment.

More recent research has been done to support the findings of brain growth periodization, as Toepfer (1980) states. It seems clear that in students taught in terms of when they can be challenged and when they cannot, there appears to be greater achievement and maturation of thinking skills. On the other hand, Fischer and Lazerson (1984), in a review of the research of brain growth and Piagetian periods, conclude that changes do occur during the growth spurts, but these do not always appear to coincide precisely with Piagetian periods. Also there does not seem to be any support for the theory that new skills cannot be learned during the plateau periods. There clearly is a need for more research in the area of brain growth periodization, but in the meantime, the suggested implications seem worthy of consideration in the classroom.

C. Triune Brain

In considering the evolutionary pattern of the brain, the concept of the triune brain seems to be well authenticated. The older portions of our brain, according to the research, are still intact, although there is no language connected with them. The two older parts are mainly concerned with survival and emotions, and become the central focus of attention when activated. The newest part of the brain to evolve is the center of our rational thought, and functions best when the older portions of the brain are comfortable. If the older portions of the brain are active, then it appears that only very simple learning can take place.

The primary source in this area mainly involves the work of Paul MacLean. The research appears to be reliably organized and validly established, since the work not only involves anatomical work on animals, but also extensive observation of their behaviors as a result of anatomical surgery. This research is applicable and practical for education. Those in education are well aware of those circumstances where feelings and emotions can take over a situation. Some behaviors that MacLean (1978) discusses include preferences for routines, such as preferring the same seating arrangement. These parts of the brain need to be free from stress before higher level learning can take place. Now it is important to consider how they can be applied to education.

This research exhibits generalizability, since the concept that the rational part of the brain, as the center for reason and thought, can be applied to all disciplines and any age level, is another criterion. For instance, the concept of improving learning, and incorporating ways to make the learner more comfortable to learn, are of concern at different levels and disciplines. It seems important for all educators to consider this research, and how it can be applied to their situation. In regards to currency, the research and the opinions represent writings in the last ten years.

The educational implications of the triune brain are concerned mainly with the reduction of threat in the classroom. It seems to be important to reduce threat in as many ways as possible, in order for higher level learning to take place. For instance, an atmosphere can be created where the learners feel comfortable and not threatened. There also seems to be an indication that empathy must therefore be taught, and that if it is never developed, the concept of empathy may never come to exist in a learner's experience.

One secondary source of the triune brain is Leslie Hart, who has also written about other brain related areas. He seems to be well acquainted with the research and is able to make valid interpretations. In addition to explaining MacLean's research, Hart (1983) has also brought it closer to the classroom. Considering the criterion of being operational in the classroom, some suggestions made in this area include maintaining certain procedures, and minimizing emotions, so that the older portions of the brain are not as active, thus enabling the newer portion to operate more effectively in a less encumbered fashion. Another is providing risks, (but in secure and non-threatening settings) variety, and fresh information for the newer portion of the brain to operate at optimal levels, and to encourage higher thought.

The generalizability of these concepts to the classroom is apparent. Any discipline and any level can benefit from minimizing threat in the classroom, and from providing conditions where higher level thought can take place. If the two older brains are content, it seems that the newest brain involved in the higher thought processes can work optimally. Higher level thought can take place under conditions where threat is minimal and emotions are kept in place.

D. Sex Differences

According to the research, there does seem to be significant biological differences in the male and female brains. The male brain shows a relative preference for spatial thinking, and uses visual orientation as well as total body coordination. The female brain is more linguistically oriented, and prefers using an auditory approach, while perfecting fine motor coordination. The differences may help account for the widely observed superiority of academic skills among females in the elementary schools, and the observance of emergence among the males' relatively stronger academic skills in secondary mathematics and science classes. It seems important to note that there may be a connection with the brain growth periodization research, and the difference in the large amounts of growth in the female and male brain, respectively, at these times.

The primary sources in the area of sex differences of the brain seemed to be reliably organized and validly established. The major area of emphasis was from Richard Restak, who has not only done work of his own in this area, but also reliably reports that of others. To make his point clearly, he not only uses what he knows personally, but also sustantiates it from other points of view as well. The research in this area also includes observation of newborns, prior to any outside stimulation, so that a more accurate appraisal can be made of the abilities of males and females.

Since, to be sure, schools obviously are made up of male and female students, this area of research seems clearly to have a large amount of applicability and practicality to the classroom. It is important for educators to consider that males and females learn in different ways and have different preferences. Females tend to have a linguistic orientation to learning, and males are more spatially oriented. It also seems that this material is generalizable to different disciplines, and at different levels.

As with the implications for hemisphericity and providing both left and right brain activities, it seems important to provide both visual and auditory experiences, as well as both fine motor and total body coordination activities. By providing a combination of experiences, not only could whole brain thinking be encouraged, but also, it seems that sex differences could be minimized. In this way, boys may increase their improvement relatively in elementary school, and girls may improve more relatively in the mathematics and science areas in secondary school.

The secondary source was mainly Richard Restak, who was also mentioned as a primary source. There does seem to be a difference in abilities for the sexes and brain functions. However, it is cautioned that culture and stereotypes cannot be eliminated. It is unlikely, for instance, that U.S. public schools will revert to separate schools for boys and separate schools for girls (even though many societies do still segregate the sexes even today). It seems necessary for educators to consider what the research indicates and begin to make their own examinations. This research needs to be studied further for evidence that can be related, and not debated. The views expressed can be operative in the classroom, but need to be proven, for further application without a lot of controversy.

The research gives some suggestions to be considered. It seems that girls use a bilateral representation, while boys have greater hemisphere specialization, as Witelson (1976) discusses. It may be necessary to have different expectations for boys and girls, as Helfeldt (1983) suggests, regarding their abilities to perform certain tasks. Levy (1985) discusses that males seem to use language for thinking, while females use language for communication. She cautions against making right and left brain specialists.

There does seem to be general agreement, that there are sex differences in the brain, which is another criterion of this study; but as Springer and Deutsch (1981) caution, there is less agreement in their practical meaning. There is a great deal of overlap in abilities between males and females. On the average though, the groups do seem to possess different tendencies in cognitive approaches and abilities.

The areas of hemisphericity, brain growth periodization, the triune brain, and sex differences of the brain, seem to be among the most widely reviewed topics of brain function research currently under discussion as related to the field of education. As this study has reviewed and critiqued these areas separately, certain concepts seem apparent for the general utilization of the brain to increase learning and achievement. To improve thinking itself seems to be an implication throughout the various areas of brain function research. To search the idea of thinking further, the areas of thinking skills and problem solving were investigated. The use of manipulatives was also reviewed, as a means of increasing the learning process.

E. Thinking Skills

In order to make better use of the brain, it seems logical to consider ways to improve the teaching of thinking skills. More effective use of both sides of the brain could be enhanced from thinking skills that would encourage the use of the whole brain. The growth spurts would be developed, but the plateau periods would benefit from challenges on the appropriate levels. Greater use of the rational, thinking portion of the brain could be initiated, in considering the triune brain and providing safe learning environments minus extraneous threats. Sex differences could also be considered when teaching thinking skills, by keeping in mind the skills inherent in each and providing opportunities for gender to practice skills that might promote more equity in academic growth.

Thinking skills can be taught, as the research suggests, and incorporated throughout the various parts of the curriculum. The idea of improving thinking can become an integral part of any discipline at any level. Although teachers seem to agree that thinking skills are an important part of education, it appears that little is being done as yet to improve thinking upon which educators can confidently place reliance. It seems that by better utilizing thinking skills throughout the curriculum, by taking brain research findings into account, higher level learning might be more effectively encouraged.

Primary and secondary sources were consulted for the area of thinking skills. It seemed important to focus on the general area of thinking skills, rather than specific, in order to achieve generalizability. For instance, thinking skills can be infused into the curriculum and students can be given a systematic approach for thinking that can be applied to everyday processes. In order for this area to be practical and applicable to the classroom, it needs to be blended into the already existing curriculum. As Hansen (1982) suggests, thinking skills are basic and those thinking skills most germanely associated with each subject should be taught.

One of the suggestions made to make this point operative in the typical classroom, includes the idea that teachers need to develop their own thinking skills, so that they can better prepare their students. Developing teachers' thinking skills can be accomplished best perhaps by providing teachers with examples, and by showing them different ways in which to teach thinking skills, as Pendergrass and McDonough (1982) suggest. Also consideration should be given to providing an environment conducive to thinking, rather than an emphasis on memorization.

Learning to provide adequate time for thinking skills is another suggestion made by Costa (1981). This researcher might add that in addition to teaching teachers thinking skills, as recommended by Pendergrass and McDonough, teachers should also become knowledgeable about brain research findings per se, as well as become more familiar with the ways in which their own brains tend best to function.

F. Problem Solving

Extensive use of problem solving would appear to encourage more use of the brain. Since there are various types of problems for solving, the whole brain could be utilized. Problem solving could aid the growth spurts and be a good means of extending the levels achieved during the plateau periods, while at the same time presenting appropriate challenges. The higher level of thought utilized in the newest portion of the brain to develop would be enhanced with problem solving, but also considering the triune brain at the same time. Problems of various types and levels of difficulty could be presented to students to aid in minimizing sex differences and encouraging the development of the skills of each.

The concept of problem solving to improve learning can be important. Problem solving can be utilized throughout the curriculum, and various strategies can be taught. It seems important that learners have several different strategies available to them to solve problems, and that each strategy has a plan to follow. Activities designed for effective use in problem solving, and the necessary skills, should be an integral part of the curriculum. It also seems important that the solving of problems becomes an application of skills to situations that are of importance to the learner. In order to use problem solving to improve learning, it appears that the process needs to be stressed, rather than the answer.

The primary sources consulted for this area generally agree that problem solving can be taught, but that there is no one strategy for all problems, as Suydam (1982) discusses. For example, there seems to be a need for exposure to many and varied problems, along with different strategies for solving them.

The area of problem solving can be practical and applicable to the typical classroom with initial awareness on the part of the teacher. Suydam (1982) outlines the research wherein teachers expose learners to many varied problems, a variety of strategies, and provide problems at appropriate levels of difficulty.

The research is generalizable, since there is an indication that students involved in problem solving achieve more, and this can be applied at various levels, and for different disciplines. For instance, Yeotis and Hosticka (1980) suggest that good problem solvers show greater independence, more resonsibility, better organized thinking, and more creativity. These characteristics would be desirable at any level.

An effort was made to consider sources that discussed problem solving as a general topic, rather than as a specific topic, as indicated for example by the traditional notion of solving story problems in mathematics. An example of this general approach would include visualization, which can be applied in different areas, as discussed by Moses (1982). Illustrations of this approach to teaching thinking include seeing, imagining, and designing through drawings. Johnson, et al. (1980) discovered that those students involved in a cooperative situation while problem solving, achieved more than those working either by themselves, or competitively. Basically, it appears that problem solving abilities improve if one is exposed to situations that involve a wide variety of types of problem solving.

Several approaches are outlined for including problem solving in everyday situations. Kulm (1982) suggests approaches that include drawing, listing data, graphing, classifying objects, and using symbols. These approaches may lead to more familiarized methods, but in the meantime, the process itself is stressed, rather than obtaining the answer. Krockover (1979) and DeBruin and Gibney (1979) agree that students need to solve problems of their own. For example newspapers and magazines can be sources for locating everyday problems. Skills used to solve the problems may include writing, comparing, estimating, measuring and calculating.

G. Manipulatives

The use of manipulatives to further enhance a concept of learning, or to improve the abstraction of the idea, also appears to receive support from brain function research. Manipulatives would encourage more of the whole brain to be used, since the manipulation of objects calls forth uses of the right side of the brain, while specifying the purpose for the manipulation of the objects would encourage the left side. During the plateau periods when learners ought to be challenged on their own level, manipulatives would provide a means for extending various abstract concepts, such as those found in science and mathematics. In considering the triune brain, higher level learning could be encouraged, since manipulatives provide an opportunity to arrive at abstract concepts through hands-on use of concrete objects with which learners are familiar and with which they already feel safe. This is a more logical progression, rather than just introducing the concept in its abstract form. A typical example would be teaching that 2 + 3 = 5, but never using objects, such as Cuisenaire rods, to prove it. Sex differences could be minimized with the use of manipulatives. Boys, who prefer to manipulate their environment, would be encouraged, and girls, who have difficulty in mathematics and science, would be given an opportunity for better learning of these skills.

Primary and secondary sources for the area of manipulatives, were consulted in the fields of science and mathematics, since this is where the literature seems to be focused. It seems possible that the concepts developed here could be applied to other disciplines. Manipulatives have already been applied to various levels. Since generally the use of manipulatives is considered at the elementary level, Howden (1985) argues for the importance of their use at all levels, and reasons that they can be used at secondary levels as well as elementary levels.

There is general agreement in both science and mathematics that the use of manipulatives does produce higher achievement levels for the students involved, as discussed by Bredderman (1977) (1983), Shymansky, et al. (1983) and Suydam (1984). This improvement in achievement not only applies to the areas of science and mathematics, but seems to apply to reading as well. Using problem solving and developing thinking skills also seem to lead to improvement. Snyder (1978) cautions about generalizing the effectiveness of manipulative programs, since teachers and their behaviors should be considered. It should be noted that no primary sources were listed as bibliographic references for this disagreement.

Manipulatives can be practical for education, in that they seem to make abstract concepts more meaningful, which could improve learning. It is suggested by Reys (1971) that integrating the materials to be used is important, and that time also be considered, so that the development from the concrete level to the abstract may be sure to be completed. Fennema (1973) states that abstract concepts should be based on meaningful concrete experiences. For instance, manipulatives can provide the learner with better understanding of the symbols employed in abstract concepts. It seems important to consider and to develop through in-service training appropriate teacher behaviors and teacher awareness of the relationships among use of manipulatives, right brain - left brain operations, and the development of abstract concepts.

In order to incorporate the ideas mentioned above into the typical classroom, it seems that consideration needs to be given to staff development techniques that might assist in bringing brain function research into the curriculum. Since wide arrays of activities already normally occur in today's classes and much is expected of the teachers, it seems important to consider improvement of what already exists. The areas of classroom management and time management were considered as feasible means to better include brain function research into the classroom. Because of wide spread existence of stress-related situations, collegiality was considered as a means to help reduce those feelings of stress, and also to assist in encouraging teachers to continue in the maintenance of the concepts developed.

H. Classroom Management

The teacher needs to be an effective manager of the classroom. The implication from brain function research from the area of the triune brain includes the idea of reducing threat. With an effectively managed classroom, in which low levels of threat obtain, an atmosphere conducive to higher learning levels can be created. This atmosphere may include deliberate use of cooperation, sharing, and rules for appropriate behavior. From the area of hemisphericity, an effectively managed classroom would encourage more consistent use of the whole brain. Sex differences could be provided for by providing opportunities for males to practice cognitive skills which come easily to females, and vice versa. The needs of the individual should be considered, while at the same time providing opportunities for cooperative efforts.

The primary and secondary sources in this area were consulted with an awareness of general application rather than specifics for greater generalizability. Brophy (1983) discusses that effective classroom managers keep the group alert and accountable, while providing variety and challenge. Some suggestions made include: maintaining respect for the individual, relying on instruction and persuasion, seeking full understanding of individual students, and utilizing humanistic values.

Beasley (1983), Sanford (1984), and Nelson (1980) agree that high levels of student involvement are important, and that this involvement can best be accomplished in small groups.

It seems important that certain general aspects of effective classroom management would allow for greater applicability to the typical classroom. An example of this would be providing a cooperative atmosphere in the classroom, as Humphrey, et al. (1982) studied. The cooperative learning included working together, decisions by consensus, and completing assignments together. This is a concept that can be applied to various disciplines at different levels. Also important is students sharing in their own learning, as Metzger (1981) discusses, where students accept responsibilities for their own learning.

I. <u>Time Management</u>

The area of time management includes the effective use of time by both the teacher and the students. It appears that this can be taught and readily incorporated within the regular curriculum. Apparently more time is generally spent in routine learning situations than is needed. With more effective use of time, it seems that then more could be incorporated into the classroom day. This could include the concepts from brain function research, such as activities to encourage the whole brain, including problem solving and thinking skills. The use of manipulatives can be better incorporated into the classroom with more effective use of time.

The primary and secondary sources consulted in this area involved the use of managing time more effectively, so that more could be included in the instruction. This is

gener
Stude
time
cont
pote

clas
conc
(198
impo
the
be
qual
that
case
acti

J. <u>C</u>

impro
ment
estab
bette
and *i*
to *nee*
one's
of *col*

generalizable to the different disciplines and at any level. Students and teachers can learn to make better use of their time. Some techniques suggested by Kozoll (1982) include controlled intensity, focusing, pacing, and controlling potentially stressful situations.

Managing time is also applicable and practical to the classroom. Teacher awareness seems to be the initial concern in developing this concept. Wang (1979), Gettinger (1984) and Gettinger and Lyon (1983) agree that it is important to spend adequate time in learning, relative to the amount of time needed to maximize achievement. This can be done by reducing the time needed, while increasing the quality of instruction. Wang (1979) and Moyer (1983) agree that students can learn to use time better, such as in the case of their predicting the amount of time needed for an activity.

J. Collegiality

Collegiality can provide a means of support while improving learning situations in the classroom. A commitment of continuous improvement seems to first need to be established. The idea that everyone can improve and do better, would appear to encourage better use of the brain and incorporation of brain function research. This appears to need an atmosphere of positive attitudes and support from one's peers, which can be accommodated through the concept of collegiality.

The primary sources consulted seemed to indicate improvement in both instruction and attitude where there was an atmosphere of support, as studied by Freeman, et al. (1980), and McFaul and Cooper (1983). Teachers can and will help each other in carrying out the tasks of their job better, as Roper, et al. (1976) studied. This is practical and applicable to education at any level and for different disciplines. The concept also is generalizable for the disciplines and levels.

Teacher awareness needs to be considered for further applicability to the typical classroom. Little (1982) found that staff development was most successful where there was a norm of collegiality, and the concept of continuous improvement was shared by the school. In several studies, Holdaway and Millikan (1980) found that time needs to be provided to allow teachers to work with others -- time for trust to develop, such as the triune brain suggests.

SUMMARY

By synthesizing the popular areas of brain function research related to education, certain implications seem to arise that would encourage the practical implementation into the classroom. Minimizing threat and sex differences may lead to higher learning, as well as providing activities and materials that encourage optimal functioning of both sides of the brain. In addition, it seems that thinking skills and problem solving need to be incorporated within various elements of the curriculum. The use of manipulatives wherever feasible, can also encourage better use of the brain. These and other concepts and related implications of brain function research need to be presented to educators in such a way that is practical for them and at the same time can be applicable to the average classroom. It appears that this is possible from the findings that have been presented as a result of a critical review of brain function research using previously established criteria. More specific applications will be explored in the next chapter.

CHAPTER V

APPLICATIONS

The purpose of this chapter is to consider the synthesis of brain function research from the last chapter and how specifically these concepts can be applied to the typical classroom. Particular concern will be given to keeping these suggestions practical for the typical classroom teacher, and generalizable to various levels and different disciplines. The chapter concludes with figures containing summary lists of chief recommendations for educational practice.

A. Hemisphericity

In considering the applications of hemisphericity, it seems important to consider the whole brain, rather than separating the classroom into the right brain learners and the left brain learners. There is still much controversy concerning exactly which skills are right-brained and which are left-brained. However, the whole brain approach refers to the idea of teaching to both sides of the brain. By teaching to both the right and the left hemispheres, the promise is that greater development of higher level thinking may be achieved.

Providing opportunities for reporting information is a process which appears to utilize more of the whole brain. For example, describing an event in words, pictures, or both, encourages the use of different thought patterns. By giving the right hemisphere a high input in the form of pictures, puzzles, graphs, and diagrams, in addition to the input the left brain receives through words, it would appear that the whole brain can thus be developed.

Clustering, or making a brain map, is another example for encouraging the use of the whole brain. Everything that can be triggered by the main topic selected for study is put into a cluster or a map, in relation to the ideas where there are connections. The left brain tends to be linear in its thinking. This clustering gives the right side of the brain a better chance to become a functioning part of the thinking process.

Teaching should be concerned with both the right and the left brain. Instructions might be presented, not only verbally, but also in a visual manner, whether it be by demonstration or through diagrams. Materials to be learned should also be presented in this manner, thus to encourage consistently the use of both sides of the brain.

Since most of what is currently done in most classrooms is left-brained, in order to redress a healthy balance, it would appear to be equally as important to present equal portions of right-brained activities to encourage development of that side. These represent mostly those activities that the students perceive as enjoyable and the teacher perceives as a waste of time. With a little planning, though, these activities can develop a purpose for learning, and also be enjoyed. For instance, rather than having students write a summary to the story that was read, have them draw a picture of the most exciting part.

Creating cartoons is another example of utilizing the whole brain. The thought process involved in the creation uses both sides of the brain to draw the picture and incorporate the words that will complete the cartoon. Cartoons are characteristically metaphoric in their meaning. Newspaper cartoons can be studied as examples of this model. This employment of cartoons as metaphors can be used in different disciplines at different levels. Also high-level thinking skills are utilized in the making of original cartoons.

There are already published materials available that encourage the use of the whole brain. Studies have already been cited that student achievement improves through implementation of materials of these sorts. Some of these include "Developing Mathematical Processes" (DMP), "Science Curriculum Improvement Study" (SCIS), and "Interaction Language Arts" (Moffet series). These materials are designed to utilize those skills that encourage both sides of the brain.

B. Brain Growth Periodization

The theory of brain growth periodization refers to the brain growing in spurts, rather than on a linear continuum. Implications indicate that the higher input of new material can best be made during a growth spurt. During a plateau period, however, the material presented should be challenging but generally on the same level, and aimed at expanding and confirming the learner's grasp of concepts acquired during a growth spurt learning period. Since there is an apparent correlation between brain growth periodization and Piagetian development theory, one application would be to utilize the concepts of Piaget. (e.g. more disequilibration during growth spurts, more equilibration during periods of plateauing)

Studying various topics by themes is a concept which can be fruitfully used for responding to what the learners are themselves interested in studying. This method is particularly helpful during plateau periods. Once a topic is decided upon, activities are developed, with student input, that can be accomplished to learn more about the initial topic. It is particularly desirable to include all of the educational disciplines - reading, writing, social studies, science, and mathematics - on an interdisciplinary "problem solving" basis.

An interdisciplinary curriculum appears to enable more learning to be accomplished at one time, and to allow greater input to be absorbed during the growth spurts, while providing appropriate challenges, yet on the same level, during plateau periods. Learning tasks might optimally be of a practical nature, allowing students to have an opportunity to manipulate the environment around them. Within a planned interdisciplinary curriculum, multiple levels and types of learnings can be provided for the students. This framework would allow for greater extension of ideas within the learner group and, at the same time, provide a system that is also meaningful, while incorporating the disciplines.

C. Triune Brain

The theory of the triune brain takes into account the evolutionary pattern of the brain. The two parts of the brain that deal with survival and emotion, react to threat and stressful situations, respectively. These parts can have overriding influence over the third part of the brain even to the extent of impeding higher learning to occur and the neocortex to function optimally, the two older portions of the brain need to be relatively quiet or calm.

Threats in the classroom therefore need to be reduced to minimum levels. This reduction can then make way for an atmosphere of cooperation and supportive working with others. Grading can be minimized, while encouraging learning for the sake of learning. Discipline can take the form of logical consequences, such that results of misbehavior are seen as relevant by the learners. For instance, simply have students throw out the gum, rather than miss recess for a week.

A learning community can be established to provide an optimum atmosphere for the maximum amount of brain development. Here, positive attitude would be stressed, along with helping, and working with, others. A mutual respect between the teacher and the students would encourage cooperation toward the ultimate goal of learning. Another vehicle for helping make students comfortable so that higher level learning can take place, lies in involving them in educational goals. Students need to feel some responsibility for their own learning. It then becomes more important to them. For those teachers who may be uncomfortable with this concept, even giving students two assignments and allowing them the option for choosing which one to do first, can be a beginning.

D. Sex Differences

Research has shown that the male and female brains in some ways do function differently on a biological level. In the early years, schools favor girls who tend to excel relatively in fine motor and auditory skills, while boys tend to develop relatively better gross motor and visual skills. The boys tend to do better in mathematics and science in the later years.

Gross motor activities are particularly important at the elementary level, to give boys a chance to excel. Many kinds of activities, from using the chalkboard to making large murals, can be considered. In the later years, consideration needs to be given to developing linguistic skills in areas of mathematics and science, so that more girls do well in those areas which tend culturally to be denied them.

Using brainstorming can aid in minimizing sex differences in the classroom, since if the teacher takes care both boys and girls may have equal opportunity to participate, and benefit from each other's ideas. This involves everyone in the class having an opportunity for equal input to an idea, and each idea is added to the whole. It should be remembered that while brainstorming, all ideas are accepted, and no evaluation is made until the process has been completed. For example, a new unit of study could be brainstormed for possible directions, or the brainstorming could be used at the end of a unit of study, to ascertain what has been learned. This effective technique will also aid the neocortex in achieving higher thinking, while minimizing conflicts from the older parts of the brain.

In addition to providing both visual and auditory experiences to utilize the whole brain, the visual and auditory experiences will aid in minimizing the differences between the way males and females learn. In order to determine which activities are best suited to either gender, give the students choices among several types of activities. For instance, the boys may select activities where there are pictures and diagrams, while the girls may select the ones with words that they can read to each other. Alternative experiences can be set up in which the girls get chances to deal with pictures and diagrams and the boys get to deal with words. These activities are generally male oriented and female oriented and do not apply to everyone.

Synthesizing the literature on brain function research, makes certain implications seem promising. The concepts include encouraging thinking skills, incorporating problem solving, and use of manipulatives in teaching. These arenas have been investigated and discussed in this study. In addition, there appeared to be a need for looking at structural teaching components, so that the promises of brain function research could be more easily implemented. The literature read and examined on teaching structures covered classroom management, time management, and collegiality. More specific suggestions for their use in relation to brain function research, and its implementation, will be discussed in the following sections.

E. Thinking Skills

Teachers need to examine what they are teaching, and how thinking skills can be incorporated into their curriculum. Often subjects are taught at very low levels of thought, concerned only with rote memory and basic recall. Thinking skills at higher levels, however, can be incorporated into what is already being taught. For instance, after reading about the first Thanksgiving, rather than asking ten comprehensive questions, have students imagine themselves as a part of the action, and tell what happened to them. In this way, more thoughts of different sorts, especially involving right brained functions may go into the activity, and the teacher can still assess whether the subject material has been absorbed.

The teacher can make whole brain thinking skills become a part of the classroom, by providing challenges, puzzles, and brain teasers for the students. This can involve spare time activities, for students waiting for their next class, or for individuals who have completed their assignments. For instance, ask students to discover how an egg can be dropped three feet without breaking it.

If we were to strive for teaching higher level thinking skills a framework could be used to organize questioning techniques as learning activities. Bloom's Taxonomy of Educational Objectives: Cognitive Domain (1956) seems to offer such a framework. By striving for more than the literal comprehension of knowledge, greater thinking may be achieved. Of particular importance in this process, brain function research suggests, appears to be making application of knowledge. For instance, being able to find a use for what has just been learned, and then applying it.

F. Problem Solving

Brain research suggests that when skills of problem solving become part of the classroom, they should incorporate different types of problems, and require the employment of varied strategies for solving them. Some of these involve thinking aloud, listing alternatives, visualization, and diagramming. Other activities can be provided to promote problem solving skills, such as simulations, games, debates, and brainstorming.

Another fruitful aspect of effective use of problem solving is to involve students in experiences that are relevant to them. These could come from varied sources, including newspapers and television, as well as the students' own daily lives. Student generated problems may involve something as simple as determining the favorite television program of the school, or could involve more complex situations, such as raising funds for a class trip.

G. Manipulatives

Manipulatives are most often currently used in the areas of science and mathematics, but it seems logical that this teaching vehicle could be fruitfully applied to other areas. When a student is asked to manipulate the environment in some way, brain research suggests that the concepts to be learned can be more readily acquired. For instance, making a three dimensional scene, to incorporate what has been learned, and for the purpose of teaching others about that learning, can also be considered a use of "manipulatives".

There are materials designed specifically for manipulation in the classroom. These include programs in mathematics and science. Examples would include "Developing Mathematical Processes" and "Science Curriculum Improvement

Study". The programs involve students in the actual use of concrete objects to learn abstract concepts. For instance, using blocks to understand the concept of area and volume, rather than only reading about it.

H. Classroom Management

In order to implement the concepts that have been suggested from brain function research, teachers need to become effective managers. Involving students working in groups and interacting, while doing activities, requires a system that both the students and the teacher can be comfortable doing. For instance, initially, this may mean doing one structured activity a week, and setting down several ground rules, until both students and teacher are ready to implement more. Eventually, students might grow to be able to become involved with the planning and implementation of managing the classroom.

Involving students in classroom management aims at their accepting responsibility for their own learning. They can help establish rules for self discipline. If students are seated in groups of four, then each group can set up rules and appoint a leader. It seems important to let them be a part of the process and provide input. This will vary with the age of the student and the classroom situation. It requires asking the students what they can do and how they can become involved. The teachers need to adjust to this sort of control, by giving up some of their customary power. This may require re-assessing the goals established by the teacher for each learning situation. For instance, determining which skills are to be obtained from a particular activity, rather than how much can be memorized from the textbook.

I. Time Management

Implementation of activities to encourage better use of the brain, requires effective use of time. Teachers need to learn to manage their own time and to educate students to use their time effectively, too. This can be done by assessing how much time is actually required for an activity, and then working toward that goal. In addition, one needs to establish priorities. By doing the most important activities first, students can be taught to make better use of their time. For example, a list can be kept of what needs to be completed. Extra incentive can be provided by allowing the students to choose assignments of their own to do after the required assignments have been completed. Students should also be encouraged to determine the time needed, and to strive for completion of the activity in the designated time. At present, in many classrooms, more time is often allowed for activities than is really required, and often these portions of time are spent on routine, trivial, or low level tasks, so far as developing brain use capacity is concerned. By keeping track of the time used and planning for the extra time, this problem can be reduced.

J. Collegiality

It appears important for teachers to have significant support from someone, before attempting to implement the promising concepts into the classroom deriving from brain function research. This could be as simple as having one other person to confide in and to offer suggestions. On the other hand, this may involve an entire school, and a support system can become part of the implementation plan. This support system could allow for released time for one or more teachers to plan further activities and discuss problems. The principal could and probably should also provide additional support, by becoming a part of the implementation program.

Summary Figures of Chief Implications

Suggestions have been made above for implementing each of the areas from brain function research, and those other topics that have been discussed as being implicated. In order for brain function research to be further implemented into the average classroom, an outline of teacher behavior, activities, and materials is presented below. In this way, a summary portrait may emerge of the implications of brain function research and how they can be incorporated into each classroom at different levels and in different disciplines, according to the needs and ability levels of the individual students and individual teachers. It seems important to provide an open-ended, generalized plan, so that individuals can make application of the suggestions according to each situation. An improvement plan for better use of the brain need not be a step by step plan where all of the elements must be followed. Instead certain aspects can be applied gradually and comfortably.

The teacher behaviors that have been suggested in this study, include teaching to the whole brain, utilizing Piagetian theory, reducing threat, and building a learning community. These approaches would appear optimally to require a humanistic attitude toward the students. Teachers should also become effective classroom managers and make more effective use of time. Most important seems to be the idea of developing collegiality and gaining support from one's peers.

Activities suggested include right-brained projects, clustering on brain maps, theming topics, and brainstorming. Visual and auditory experiences should be provided, as well as fine motor and gross motor activities. Thinking skills and problem solving should be incorporated, while introducing challenges and puzzles.

Materials that can be implemented should include manipulatives. There are complete programs where these are incorporated, such as in the areas of science and mathematics. Also manipulatives can be used to expand and deepen individual concepts, as in separate activities. Additionally, curriculum materials should be used that encourage the use of the whole brain. Textbooks need to be used as resource materials, and not as the entire content of the curriculum.

The following figures include:

Figure I - Hemispheric Characteristics Suggestive of Curricular Goals and Practices - contrasts characteristics which literature portrays of right and left brain

Figure II - Contrasting Practices - comparison of educational practices antithetical and consonant with current brain research implications

Figure III - Chief Curricular Recommendations in Brain Research Literature - includes compilation of ideas presented from areas discussed

These figures have been developed by culling through the research reviewed earlier and consolidating the many different implications and applications contained therein into collated interrelationships which may be useful for teachers.

For instance, it is hoped that teachers might find Figure I useful in giving a clearer portrayal of right and left brain types of thought. Figure II may be useful to point out what is being done and how changes can be implemented. The recommendations in Figure III provide an outline for teachers to begin to apply the implications presented.

FIGURE I

HEMISPHERIC CHARACTERISTICS SUGGESTIVE OF CURRICULAR GOALS AND PRACTICES

LEFT BRAIN	RIGHT BRAIN
Intellectual	Intuitive
Names	Faces
Verbal Instructions	Demonstrations
Problem Solving	Problem Solving
(breaking into parts)	(looking at whole)
use logic	use hunches
Objective	Subjective
Planned and Structured	Fluid and Spontaneous
Analytic Reader	Synthesizing Reader
Prefers Talking and Writing	Prefers Drawing & Manipulating
Multiple Choice Tests	Open-Ended Questions
Controlled Feelings	More Free with Feelings
Auditory, Visual Stimuli	Kinesthetic Stimuli
Relies on Language in Thinking	Relies on Images in Thinking
Response to Environment	Essentially Self-Initiating
Single Variable Research	Multi Variable Research
Independent, Separate, Atomistic	Interdependent, Continuous
Precise	Approximate
Deductive	Inductive
Decision Making-Right or Wrong	Multiple Consequences of Decisions
Logical	Creative
Pictures Abstract	Visual - Pictures
Reading, Speaking, Writing	Body Language/Gestures/Facial
Computation	Geometry
Definitions	Functions
Linear Time	Cyclical Time
Rhythm	Melody

Sources: Haglund (1981), Johnson (1982), Springer (1981)

FIGURE II

CONTRASTING PRACTICES

Educational Practices Antithetical to Current Brain Research Implicators	Educational Practices Apparently Consonant With Current Brain Research Implicators
Little mention of brain	Teach about brain and how it works
Threats inherent in classroom	Build confidence and self esteem and sense of trust and safety
Silent - teacher directed	Talking - student activated
Representations of reality maps, pictures	Real objects, actual problems, concrete materials
Testing for grading	Testing for what is already known - what needs to be known
Teacher talks	Two way communication
Emphasis on analytical, linear, left brain	Whole brain - includes holistic, nonlinear, intuitive
Concern with norms	Concern with individual performance in terms of potential
Reliance on theoretical, abstract	Inclusion of experiment and experience
Room designed for efficiency, convenience	Room designed to meet needs for privacy, needs for interpersonal and interaction
Convergent thinking	Divergent thinking
Grades include letters, percentages	Evaluations include qualitative descriptors, records of interviews, anecdotal observations
Teaching/training based on authority, written forms	Present information in visual, tactile, kinesthetic forms
Knowledge separated into categories and subjects	Emphasize connections, use metaphors
Fine motor, auditory	Include gross motor, visual

Sources: Hart (1975), Ferguson (1980), Grady (1983)

FIGURE III

CHIEF CURRICULAR RECOMMENDATIONS IN BRAIN RESEARCH LITERATURE

HEMISPHERICITY

-- Make mind maps (Rico, 1983; Buzan, 1983)

-- Present material visually and verbally in written and manipulative forms (Grady, 1983)

-- Allow option of illustrating or writing (Grady, 1983)

-- Use metaphorical teaching (Samples, 1975; Williams, 1983)

-- Create visualization experiences (Webb, 1983; Williams, 1983)

-- Use direct experiences, such as simulation, concrete objects, role playing (Haglund, 1981; Staley, 1980)

-- Read same story with a right brain purpose and left brain purpose (Ornstein, 1978)

-- Incorporate art activities (LeCompte and Rush, 1981)

-- Use graphic representation, such as charts, diagrams, graphs (Grady, 1983)

-- Teach parts to the whole, such as species within world that needs to value other species (Gilsdorf, 1982)

BRAIN GROWTH PERIODIZATION

-- Consider learner's stage of development (Johnson, 1982)

-- Present new material during growth spurts (Epstein and Toepfer, 1978)

-- Challenge on own level during plateau periods (Cramer, 1981; Epstein and Toepfer, 1978)

-- Allow manipulation of environment (Horst and Johnson, 1981)

FIGURE III (continued)

TRIUNE BRAIN

-- Reduce threat (MacLean, 1978; Hart, 1983)

-- Teach empathy (MacLean, 1978)

-- Provide risk, variety and new information (Hart, 1983)

SEX DIFFERENCES

-- Provide visual and auditory experiences (Restak, 1979)

-- Provide fine motor and gross motor activities (Restak, 1979)

-- Consider different expectations for boys and girls (Helfeldt, 1983)

THINKING SKILLS

-- Incorporate thinking skills into the subject areas (Hansen, 1982)

-- Provide time for thinking skills (Costa, 1981)

-- Help teachers develop their own thinking skills (Pendergrass and McDonough, 1981)

PROBLEM SOLVING

-- Use many and varied problems (Suydam, 1982)

-- Teach different strategies to solve problems (Suydam, 1982)

-- Include everyday situations for problem solving (Kulm, 1982)

-- Allow students to solve problems of their own making (Krockover, 1979; DeBruin and Gibney, 1979)

FIGURE III (continued)

MANIPULATIVES

-- Use manipulatives at secondary level (Howden, 1985)

-- Allow enough time for development of abstract concept (Fennema, 1973)

-- Integrate the materials to be used (Reys, 1971)

STAFF DEVELOPMENT TECHNIQUES

-- Become an effective classroom manager (Brophy, 1983)

-- Learn to use time more effectively (Kozoll, 1982; Wang, 1979)

-- Develop a norm of collegiality (Little, 1982; Roper, 1976)

SUMMARY

This chapter has discussed specific means of implementing brain function research into the typical classroom. Each of the areas, including hemisphericity, brain growth periodization, the triune brain, and sex differences, has been described. Additionally, the arenas of implication have been detailed; thinking skills, problem solving, manipulatives, classroom management, time management, and collegiality. A set of summary figures is included listing chief implications of current brain function research for classroom practices.

CHAPTER VI

SUMMARY, CONCLUSIONS, AND REFLECTIONS

The brain seems to be capable of so much that educators ought to look more carefully at brain function research as a way to increase the efficacy of their teaching and curriculum and increase the learning capacity of students. Minimizing threatening situations, for instance, appears likely to allow for greater use of the brain. Introducing and reinforcing materials by different modes of instruction may activate more of the whole brain, while learners should be actively involved in their own learning. Boys and girls could be taught differently in order to achieve a greater equality between them. With an awareness of these findings on brain function research, an attempt can be made to increase learning and improve education.

Hemisphericity discusses the seemingly separate thought patterns of the right and left brain. The left side is generally sequential and analytical, while the right side specializes in emotion and appreciates intrinsic forces. The difficulty arises in making a separation between the two sides of the brain, and determining what is right sided and what is left sided. The brain seems to use both sides in functioning, but uses each side in varying degrees. It appears important to consider the whole brain. Present school practices rely very heavily -- probably too much so -- on left-brained functions.

The concept of hemisphericity can be practical and applicable to the classroom. Both sides can be stimulated, using materials and methods that appeal to different thought patterns, affective and cognitive. A whole brain approach appears to be encouraged by the majority of writers. Since most of the classrooms today are directed only to the left brain, the incorporation of the activities to use more of the right brain may encourage increased usage of the whole brain. Implementing uses of visualization, metaphors, and invention should aid in the development of whole brain thought patterns.

Brain growth periodization refers to the brain growing in spurts and then plateauing prior to another growth spurt. During a growth spurt, it seems that the most new learning can optimally take place, while the plateau periods are times for expanding on existing information, rather than risking the input of new information, whence frustration and failure could result. Although these conclusions have been criticized, the implications seem to be important enough for educators to consider, in order that further study can be implemented.

The implications of brain growth periodization research indicate apparent support for a Piagetian developmental theory. The plateau periods seem to be of primary concern.

This should be a time for developing and applying the concepts learned, while also manipulating the environment to further enhance that development. For instance, this enhancement can be accomplished by incorporating the concepts into activities that have meaning for the learners.

The triune brain is the evolutionary concept of the brain's having added the neocortex for rational thought, while keeping the earlier portions, concentrating on survival and emotions. In order for higher level thought to take place, the older portions seem to need to be comfortable and relatively quiescent. Under threat or emotional stress, it appears difficult for any higher level learning to occur.

Educational implications of the triune brain research seem to be mostly concerned with the reduction of threat in the classroom. In addition, emotions need to be minimized. For instance, maintaining certain procedures, and developing a routine, appear to be helpful. Also, providing risks, variety, and increased input, may aid in higher level learning if general conditions of the classroom allow the learners to feel safe and secure.

Sex differences of the brain indicate that there are biological differences between male and female brains. The male brain prefers spatial thinking, relatively speaking, and utilizes more visual orientations, as well as focusing total body coordination. The female brain is more linguistically oriented, and prefers auditory learning, incorporated with fine motor coordination. The elementary schools favor the female skills, while the male skills become increasingly encouraged in secondary school, especially in mathematics and science classes.

The implications of sex differences of the brain would appear to encourage the provision of both visual and auditory experiences. In addition, both fine motor and total body coordination activities should be encouraged. This may develop those skills necessary for boys to improve in elementary school and for girls to improve in the areas of mathematics and science at the secondary level.

To anchor the implication of brain function research in current realities of education, certain areas from curricular practice were chosen for the purposes of this study to indicate how current curricular practices might be altered and improved. It appeared necessary to consider the improvement of thinking itself, for more increased learning. The various arenas considered included thinking skills, problem solving, and the use of manipulative materials.

Higher level thinking skills appear to be teachable, while at the same time being capable of being incorporated into current curricula. Although it is largely agreed that thinking skills are important, it seems that little is being done to improve thinking in very many classrooms. Teachers need first consciously to develop their own abilities for thinking, so that they can better prepare their students. Developing an environment for thinking, rather than relying mainly on rote learning and memorization, also seems to be important. In addition, adequate time should be provided for higher level thinking skills. At present, it appears that in many classrooms too much precious time is spent on trivial activities.

Problem solving may assist in utilizing more of the brain and in increasing learning. Several strategies for solving problems, along with a variety of different types of problems, should be presented to the learner. Problems can become parts of the existing curriculum in various subjects, rather than becoming additional subjects. Instead of finding the correct answer, the process of solving problems should be stressed. Problem solving abilities can improve, as the learner is exposed to various situations, including those with personal relevance.

Manipulatives seem to utilize the concepts of brain function research, since the use of concrete objects for the abstraction of an idea can increase learning, and improve achievement. This process incorporates right brain activities for more whole brain learning, and might help increase spatial reasoning skills for female brain's types of thought patterns. During plateau periods of brain growth among middle schoolers, manipulatives may assist in expanding known concepts, while challenging expansions of concepts but at the same level. At present, manipulatives are generally used in the areas of science and mathematics, but it seems probable the process could be incorporated fruitfully into other disciplines for further implementation. Additionally, the use of manipulatives seems to improve thinking skills, as well as problem solving abilities.

To implement the ideas suggested in this study, certain areas of staff development were considered, for further facilitating the incorporation of the implications of brain function research into the typical classroom. Since the primary focus has been means of infusing the concepts into the curriculum, rather than adding something more, it seemed feasible that classroom management, and time management be included. Collegiality was also reviewed, in order to maintain continued development of the ideas presented.

Classroom management concerns the idea that the teacher should become an effective manager. In order to provide an atmosphere that is conducive to higher level learning, as has been suggested, the classroom should include cooperation, sharing, and rules for appropriate behavior. The needs of the individual learner should also be considered, while additionally providing opportunities for cooperation with others. The classroom should be a safe place for learners.

Time management, in this study, is concerned with the effective use of time, by both the teacher and the learners. This concept can be taught and included, throughout the curriculum. More time seems to be spent currently on various low level situations than is apparently required.

Reassessment of the skills to be learned and the amount of time needed for them, would allow increased time for inclusion of the concepts from the areas of brain function research. Managing time more effectively can be practical, and applicable, to various aspects of education.

Collegiality can provide a means of support, so that increased learning situations can be enhanced. When committing to change, certain new experiences can provide stressful situations. It seems that where there is an atmosphere of support, both attitude and instruction can improve. The concept of collegiality may better assist teachers in implementing the concepts presented from brain function research in order to improve learning.

It has not been the purpose of this study to identify additional practices for the already full classroom schedule. Rather, suggestions have been made to provide a more productive learning experience. If it is a waste of time to present new concepts during the plateau periods of brain growth, then further consideration can be given to developing already existing concepts. If classroom discipline provides a stricter, more threatening environment, then learning capacities are being wasted and attention can be directed to providing an atmosphere for higher level thinking. If the movement of emphasizing the basics and increasing homework does not raise levels of knowledge, initiative to create whole brain activities may result in a solution. To implement the suggestions presented, teachers may need to consider techniques for better managing the classrooms while making more effective use of their time. It is possible that through better use of the brain in the classroom, that learning, as is presently conceived, may change drastically.

With a rapidly changing society engrossed in high technology and information systems, it seems important to begin implementing the suggestions presented for higher level learning immediately. Many of the ideas can be infused into the present curricula with minimal preparation. Others may require teacher training and continued support from staff and administration. The implications from brain function research for this study seem to be practical and applicable for the typical classroom. Additionally, further research and study appears to be indicated for several areas of concern. Changes may need to be considered for the preparation of new teachers. Administrators need to be alerted to the potential for increased learning and developing techniques necessary for staff improvement. Parents should be trained and then encouraged to provide improved educational experiences for their children. These areas and further research to substantiate the implications indicated may provide opportunities for others to study.

No matter what particular type of research on how the brain functions is discussed, it is apparent that educators are only just beginning to understand how best to utilize the potentials of the brain. Professionals should be concerned with extending thinking skills by incorporating the educational implications of brain function research. Additionally, there should be concern for minimizing threatening situations and for seeking equity between the sexes to increase learning. Activities and materials should be presented, to encourage the whole brain to function at more optimal levels. Using manipulatives, wherever possible, may also improve thinking. These and other related implications from brain function research, need to be presented to educators in a practical and applicable manner. Thus, a critical and objective analysis of the research will provide a framework that should enhance the quality of education through more efficient use of the brain.

BIBLIOGRAPHY

Andrews, Michael F. "Consonance Between Right Brain and Affective, Subconscious and Multi-Sensory Functions," Journal of Creative Behavior, Vol. 14, No. 2, 1980, 77-87.

Barzakov, Ivan. Quoted in "Brain-Mind Bulletin," April 19, 1982.

Beasley, Warren. "Teacher Management Behaviors and Pupil Task Involvement During Small Group Laboratory Activities," Journal of Research in Science Teaching, Vol. 20, No. 8, 1984, 713-719.

Bereiter, Carl. "How to Keep Thinking Skills from Going the Way of All Frills," Educational Leadership, September 1984, 75-77.

Berman, Barbara. "How Children Learn Mathematics: Rediscovering Manipulatives," Curriculum Review, May 1982, 193-96.

Beyer, Barry K. "Improving Thinking Skills -- Defining the Problem," Phi Delta Kappan, March 1984, 486-490.

Blakeslee, Thomas R. The Right Brain: A New Understanding of the Unconscious Mind and Its Creative Powers, New York: Berkley Books, 1983.

Bondy, Elizabeth. "Thinking About Thinking," Childhood Education, March/April 1984, 234-238.

Bredderman, Ted. "Adoption of Science Programs -- Another Look," Elementary School Journal, May 1977, 364-83.

Bredderman, Ted. "Effects of Activity-based Elementary Science on Student Outcomes: A Quantitative Synthesis," Review of Educational Research, Winter 1983, 499-518.

Brophy, Jere. "Classroom Organization and Management," Elementary School Journal, Vol. 83, No. 4, 1983, 265-284.

Buzan, Tony. Use Both Sides of Your Brain, New York: E.P. Dutton, Inc., 1983.

Capie, William and Kenneth Tobin. "Pupil Engagement in Learning Tasks: A Fertile Area for Research in Science Teaching," Journal of Research in Science Teaching, Vol. 18, No. 5, 1981, 409-417.

Costa, Arthur L. "Teaching for Intelligent Behavior," Educational Leadership, October 1981, 29-32.

Cramer, Jerome. "Latest Research on Brain Growth Might Spark More Learning in Your Schools," American School Board Journal, August 1981, 17-20.

DeBruin, Jerome and Thomas Gibney. "Solving Everyday Problems Using Mathematics and Science Process Skills," School Science and Mathematics, November 1979, 613-617.

DeWald-Link, Margaret and Sharon Wallace. "Help Students Face Tomorrow: Use Problem Solving Approaches in Your Classroom Today," Clearing House, January 1983, 214-217.

Edwards, Betty. Drawing on the Right Side of the Brain, Boston: Houghton Mifflin, 1979.

Epstein, Herman T. "Growth Spurts During Brain Development: Implications for Educational Policy and Practice," Education and the Brain, The Seventy-Seventh Yearbook of the National Society for the Study of Education, 1978, 343-70.

Epstein, Herman T. "Brain Growth and Cognitive Development: A Response to Richard McQueen," Educational Leadership, February 1984, 72-75.

Epstein, Herman T. and Conrad F. Toepfer, Jr. "A Neuroscience Basis for Reorganizing Middle Grades Education," Educational Leadership, May 1978, 656-8+

Fagan, Edward R. "Brain Hemispheres: Panacea 2001?," The Clearing House, May 1979, 407-410.

Fennema, Elizabeth. "Manipulatives in the Classroom," Arithmetic Teacher, May 1973, 350-352.

Ferguson, Marilyn. The Aquarian Conspiracy: Personal and Social Transformation in the 1980's, Los Angeles: Tarcher, 1980.

Fischer, Kurt and Arlyne Lazerson. "Research: Brain Spurts and Piagetian Periods," Educational Leadership, February 1984, 70.

Freeman, Gary, Roberta Palmer and Ann Ferren. "Team Building for Supervisory Support," Educational Leadership, January 1980, 356-358.

Gettinger, Maribeth. "Achievement as a Function of Time Spent in Learning and Time Needed for Learning," American Educational Research Journal, Fall 1984, 617-628.

Gettinger, Maribeth and Mark Lyon. "Predictors of Discrepancy Between Time Needed and Time Spent in Learning Among Boys Exhibiting Behavior Problems," Journal of Educational Psychology, Vol. 75, No. 4, 1983, 491-499.

Gilsdorf, Sister Marita. "The Natural Balance," Science Teacher, September 1982, 34-38.

Glassner, Benjamin M. "Preliminary Report: Hemispheric Relationships in Composing," Journal of Education, Vol. 162, 2, 74-95.

Grady, Michael P. Teaching and Brain Research, New York: Longman, 1984.

Gray, Esther Cappon. "Brain Hemispheres and Thinking Styles," Clearing House, November 1980, 127-32.

Haglund, Elaine. "Closer Look at the Brain as Related to Teachers and Educators," Peabody Journal of Education, July 1981, 225-34.

Hamburg, David. Quoted in "Brain-Mind Bulletin," June 17, 1985.

Hansen, J. Merrill. "Thinking Skills in the Classroom: A Needed Basic in Education," Clearing House, October 1982, 60-63.

Hart, Leslie. "Brain, Language, and the New Concepts of Learning," Educational Leadership, March 1981, 443-5.

Hart, Leslie. "The Three Brain Concept and the Classroom," Phi Delta Kappan, March 1981, 504-6.

Hart, Leslie. "Programs, Patterns, and Downshifting in Learning to Read," Reading Teacher, October 1983, 5-11.

Helfeldt, John P. "Sex-linked Characteristics of Brain Functioning: Why Jimmy Reads Differently," Reading World, March 1983, 190-195.

Herrmann, Ned. "The Creative Brain," NASSP Bulletin, September 1982, 31-46.

Holdaway, Edward A. and Ross H. Millikan. "Educational Consultation: A Summary of Four Alberta Studies," Alberta Journal of Educational Research, September 1980, 194-210.

Horst, Bill and Rebecca Kelch Johnson. "Brain Growth Periodization and Its Implications for Language Arts," English School Journal, September 1980, 74-5.

Howden, Hilda. "Manipulatives in Secondary Math?," paper presented at the National Council of Teachers of Mathematics Regional Conference, Parsippany, New Jersey, March 1985.

Humphreys, Barbara, Roger Johnson and David Johnson. "Effects of Cooperative, Competitive, and Individualistic Learning on Students' Achievement in Science Class," Journal of Research in Science Teaching, Vol. 19, No. 5. 1982, 351-356.

Hunter, Madeline. "Right-Brained Kids in Left-Brained Schools," Today's Education, November 1976, 8-10.

Jackson, Robert L. and Gussie Phillips. "Instructional Aids in Mathematics," National Council of Teachers of Mathematics Yearbook, 1973, 299-344.

Johnson, David, Linda Skon and Roger Johnson. "Effects of Cooperative, Competitive, and Individualistic Conditions on Children's Problem Solving Performance," American Educational Research Journal, Spring 1980, 83-93.

Johnson, Virginia R. "Myelin and Maturation: A Fresh Look at Piaget," Science Teacher, March 1982, 41-44.

Johnson, Virginia R. "Concentrating on the Brain," Science Teacher, March 1985, 33-36.

Kimura, Doreen. "The Asymmetry of the Human Brain," Scientific American, March 1973, 70-78.

Kozoll, Charles. "Time Management for Educators," Phi Delta Kappan Fastback 175, 1982, 7-34.

Krockover, Gerald. "Solving Everyday Problems by Applying Science and Mathematics Principles," School Science and Mathematics, November 1979, 607-611.

Kulm, Gerald. "The Development of Mathematics Problem Solving Ability in Early Adolescence," School Science and Mathematics, December 1982, 666-672.

LeCompte, Nancy and Jean Rush. "The Jack Sprat Syndrome: Can Split-Brain Theory Improve Education by Including the Arts?," Journal of Education, Vol. 163, 4, 335-343.

Levy, Jerre. "Research Synthesis on Right and Left Hemispheres: We Think With Both Sides of the Brain," Educational Leadership, January 1983, 66-71.

Levy, Jerre. Interview by Jo Durden Smith and Diane deSimone, Omni, February 1985, 69-70, 97-102.

Little, Judith Warren. "Norms of Collegiality and Experimentation: Workplace Conditions of School Success," American Educational Research Journal, Fall 1982, 325-340.

Lochhead, Jack. "Research Synthesis on Problem Solving," Educational Leadership, October 1981, 68-70.

Lord, Thomas R. "Responsibilities of the Left and Right Neural Hemispheres," paper presented at the 1985 National Science Teachers Association: Cincinnati, Ohio, April 1985.

MacLean, Paul D. "A Mind of Three Minds: Educating the Triune Brain," Education and the Brain, The Seventy-Seventh Yearbook of the National Society for the Study of Education, 1978, 308-42.

McCarthy, Bernice. "What 4Mat Training Teaches Us About Staff Development," Educational Leadership, April 1985, 62-68.

McFaul, Shirley A. and James M. Cooper. "Peer Clinical Supervision in an Urban Elementary School," Journal of Teacher Education, September/October 1983, 34-38.

McQueen, Richard. "Spurts and Plateaus in Brain Growth: A Critique of the Claims of Herman Epstein," Educational Leadership, February 1984, 67-71.

Manning, Patricia. "Creating Science Inquiry Centers," Science and Children, April 1980, 37.

Mechling, Kenneth R. "The Importance of Hands-on Science Activities in K-12 Education," Keynote Address, 1984 Curriculum Conference, New Jersey Science Teachers Association.

Metzger, Devon. "Including the Student in Classroom Management," Clearing House, February 1981, 272-275.

Moses, Barbara. "Visualization: A Different Approach to Problem Solving," School Science and Mathematics, February 1982, 141-147.

Moyer, Margaret. "Let's Teach Time-Using as Well as Time-Telling," Academic Therapy, March 1983, 453-456.

Myers, John. "Hemisphericity Research: An Overview with Some Implications for Problem Solving," Journal of Creative Behavior, Third Quarter 1982, 197-211.

Nelson, Charles. "Reorganizing Classroom Leadership: A Future Approach to Higher Student Achievement," Contemporary Education, Summer 1980, 218-219.

Ornstein, Robert. "The Split Brain and the Whole Brain," Human Nature, May 1978, 76-83.

Pendergrass, R.A. and A. Maureen McDonough. "Teaching Thinking Skills: Helping Teachers Meet a Growing Demand," Education, Winter 1982, 186-189.

Restak, Richard M. "Other Differences Between Boys and Girls," Educational Leadership, December 1979, 232-5.

Restak, Richard M. The Brain: The Last Frontier, New York: Warner, 1979.

Reys, Robert. "Considerations for Teachers Using Manipulative Materials," Arithmetic Teacher, December 1971, 551-558.

Rico, Gabriele L. Writing the Natural Way, Boston: Houghton Mifflin, 1983.

Roper, Susan Stavert, Terrence E. Deal and Sanford Dornbusch. "Collegial Evaluation of Classroom Teaching: Does It Work?," Educational Research Quarterly, Spring 1976, 56-66.

Ross, Elliot. Quoted in "Brain-Mind Bulletin," February 15, 1982.

Russell, Peter. The Brain Book, New York: Hawthorn, 1979.

Safer, Martin A. "Sex and Hemisphere Differences in Access to Codes for Processing Emotional Expressions and Faces," Journal of Experimental Psychology, Vol. 110, 1, 86-100.

Sagan, Carl. The Dragon's of Eden: Speculations on the Evolution of Human Intelligence, New York: Ballantine, 1977.

Samples, Robert. "The Intuitive Mode: Completing the Educational Process," Media and Methods, September 1975, 25-27.

Sanford, Julie. "Management and Organization in Science Classrooms," Journal of Research in Science Teaching, Vol. 21, No. 6, 1984, 575-587.

Scandura, Joseph. "Problem Solving in Schools and Beyond: Transitions from the Naive to the Neophyte to the Master," Educational Psychologist, Vol 16, No. 3, 1981, 139-149.

Shaw, Terry. "The Effect of a Process-Oriented Science Curriculum upon Problem Solving Ability," Science Education, Vol. 67, No. 5, 1983, 615-623.

Shucard, David. "Linking Sex with Learning," Science Digest, March 1982, 99.

Shymansky, James A., William C. Kyle, Jr. and Jennifer M. Alport. "The Effects of New Science Curricula on Student Performance," Journal of Research in Science Teaching, Vol. 20, No. 5, 983, 387-404.

Sinatra, Richard. "Brain Research Sheds Light on Language Learning," Educational Leadership, May 1983, 9-12.

Snyder, Linda. "How Effective Are Our Teaching Practices?," Science and Children, September 1978, 31-3.

Sonnier, Isadore L. "Holistic Education: Teaching in the Affective Domain," Education, Vol. 103, 1, 11-14.

Sperry, Roger W. "The Great Cerebral Commissure," Scientific American, January 1964, 42-52.

Sperry, Roger W. "Left-Brain, Right-Brain," Saturday Review, August 9, 1975, 30-33.

Springer, Sally and Georg Deutsch. Left Brain, Right Brain, New York: W.H. Freeman and Company, 1981.

Staley, Frederick A. "Hemispheric Brain Research for Outdoor Education," Journal of Physical Education and Recreation, April 1980, 28-30.

Suydam, Marilyn. "Update on Research on Problem Solving: Implications for Classroom Teaching," Arithmetic Teacher, February 1982, 56-60.

Suydam, Marilyn. "Manipulative Materials," Arithmetic Teacher, January 1984, 27.

Toepfer, Conrad F., Jr. "Brain Growth Periodization - A New Dogma for Education," Middle School Journal, August 1979.

Toepfer, Conrad F., Jr. Interview by Richard Miller, The School Administrator, September 1980, 1,26-28.

Van de Walle, John and Charles Thompson. "Fitting Problem Solving into Every Classroom," School Science and Mathematics, April 1981, 289-297.

Wang, Margaret. "Maximizing the Effective Use of School Time by Teachers and Students," Contemporary Educational Psychology, July 1979, 187-201.

Wang, Margaret. "Implications for Effective Use of Instruction and Learning Time," Educational Horizons, Summer 1979, 169-174.

Wasserman, Selma. "Promoting Thinking in Your Classroom II," Childhood Education, March/April 1984, 229-233.

Webb, Gertrude M. "Left/Right Brains, Teammates in Learning," Exceptional Children, April 1983, 508-15.

Williams, Linda Verlee. Teaching for the Two-Sided Mind, Englewood Cliffs, New Jersey: Prentice-Hall, 1983.

Witelson, Sandra F. "Sex and the Single Hemisphere: Specialization of the Right Hemisphere for Spatial Processing," Science, July 1976, 425-427.

Yellin, David. "Left Brain, Right Brain, Super Brain: The Holistic Model," Reading World, October 1983, 36-44.

Yeotis, Catherine and Alice Hosticka. "Promoting the Transition to Formal Thought Through the Development of Problem Solving Skills in Middle School Mathematics and Science Curriculum," School Science and Mathematics, November 1980, 557-565.

Zakariya, Sally Banks. "His Brain/Her Brain: A Conversation with Richard M. Restak," Principal, May 1981, 46-51.

GENERAL REFERENCES

Begley, Sharon, et al. "How the Brain Works," Newsweek, February 7, 1983, 40-47.

Bloom, Benjamin S., Editor. Taxonomy of Educational Objectives Handbook I: Cognitive Domain, New York: David McKay Company, Inc., 1956.

Brown-Parker, Judi. "Classroom Behavior of Dominantly Left and Dominantly Right Cerebral Hemisphere Teachers in Australian Third Grade Classrooms," Summary of a Research Study.

Grady, Michael P. and Emily A. Luecke. "Education and the Brain," Phi Delta Kappan Fastback 108, 1978.

Hart, Leslie. How The Brain Works, New York: Basic, 1975.

Hart, Leslie. "Three Cheers for Smaller Failures?," Phi Delta Kappan, January 1983, 303-307.

Johnson, Virginia R. "Brain Functioning and Formal Reasoning: Learner's Choice," paper presented at the National Science Teachers Conference, Boston, Massachusetts, April 1984.

Levy, Jerre. "Right Brain, Left Brain: Fact and Fiction," Psychology Today, May 1985, 38-44.

McCarthy, Bernice. The 4Mat System - Teaching to Learning Styles with Right/Left Mode Techniques, Oak Brook, Illinois: Excel, Inc., 1981.

McKean, Kevin. "Of Two Minds: Selling the Right Brain," Discover, April 1985, 30-41.

Maranto, Gina. "The Mind Within the Brain," Discover, May 1984, 34-37.

Moffett, James, Senior Editor. Interaction: A Student-Centered Language Arts and Reading Program, Boston: Houghton Mifflin, 1973.

Ostrander, Sheila and Lynn Schroeder. Superlearning, New York: Dell, 1979.

Paldy, L.G., L.L. Amburgey, F. Collea, R. Cooper, D. Maxwell and J.W. Riley. Science Curriculum Improvement Study II, Nashua, New Hampshire: Delta Education, 1985.

Peterson, Rita W. "Great Expectations: Collaboration Between the Brain Sciences and Education," American Biology Teacher, February 1984, 74-80.

Pribram, Karl. Interviewed by Daniel Goleman, "Holographic Memory," Psychology Today, February 1979, 70-2+.

Roberg, T.A., J.G. Harvey, J.M. Moser and M.E. Montgomery. Developing Mathematical Processes, Chicago: Rand McNally, 1974.

Russell, Peter. The Global Brain, Boston: Houghton Mifflin, 1983.

Sibatani, Atuhiro, "The Japanese Brain," Science 80, December 1980, 24-27.

Springer, Judy. "Brain/Mind and Human Development Resources," Training and Development Journal, August 1981, 43-49.

Sylvester, Robert, et al. "Symposium: Educational Implications of Recent Brain Research," Educational Leadership, October 1981, 6-17.

Toffler, Alvin, Editor. Learning for Tomorrow, New York: Vintage, 1974.

Wenger, Win. "Creative Creativity: Some Strategies for Developing Specific Areas of the Brain and for Working Both Sides Together," Journal of Creative Behavior, Vol. 15, No. 2, 1981, 77-89.

Wittrock, M.C. "Education and the Cognitive Processes of the Brain," Education and the Brain, The Seventy-seventh Yearbook of the National Society for the Study of Education, 1978, 61-102.

Wonder, Jacquelyn and Priscilla Donovan. "Mind Openers," Self, March 1984, 160-164.