Title	A research study on learning styles: Its implications on teachers and teacher education
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Source	1st Asia-Pacific Conference on Teacher Education: New Directions for Changing World, 11 – 14 July 1988, Bangkok, Thailand

A RESEARCH STUDY ON LEARNING STYLES :

ITS IMPLICATIONS ON TEACHERS AND TEACHER EDUCATION

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NEW DIRECTIONS FOR A CHANGING WORLD
CHULALONGKORN UNIVERSITY
BANGKOK, THAILAND

JULY 11 - 14, 1988

A RESEARCH STUDY ON LEARNING STYLES: ITS IMPLICATIONS ON TEACHERS AND TEACHER EDUCATION

One of the main concerns of education has been on the individual differences of students. Recent interests have been on individual differences in terms of learning styles. Learning styles have been technically defined with varying ramification by advocates of learning style based education (Dunn, Dunn, and Price, 1985; Gregorc, 1979; Gordon, 1985; Keefe, 1982; Kolb, 1975; Hunt, 1979). Learning styles in this study refer to the five domains, namely, environmental, physical, emotional, sociological, and psychological under which an individual is most likely to learn, achieve, remember, and process information. However, the term is always defined in relation to the specific behavior on how individuals learn, remember, achieve, perceive, interact, conceptualize, respond, and process information.

The high attrition rates which include dropouts and school failures, the importance of being verbally and numerally literate, the great concern to fully develop any special talents in an individual, the need to find out why some students are not progressing, the urgency to determine a group or individual learning style patterns or characteristics, and the efforts to help students stretch to the limits of their academic abilities are some of the reasons that prompted the implementations of this research.

The emphasis of the paper is on the implications of the study on teachers and teacher education. However, I will begin by providing a

background to the study as the findings of the study have important implications for teachers and teacher education. The background of the study is as follows :

Title of Study: Learning styles of Singapore Secondary Two Students

Objectives

1) To identify the learning style patterns in terms of the environmental, physical, emotional, sociological, and psychological domains of fourteen year old Secondary Two students in the three achievement groups, namely, the Normal (low achievers), Express (average achievers), and Special (high achievers)

2) To determine which categories of learning style characteristics distinguished the learning styles of the fourteen year old Secondary Two students in the three achievement groups, namely, the Normal (low achievers), Express (average achievers) and Special (high achievers).

Domains of Learning Styles Investigated :

Five domains of learning styles were investigated. The domains and their respective elements were as follows :

- environmental (noise, light, temperature, and design elements),
- emotional (motivation, persistence, responsibility, and structure elements),
- sociological (learning alone, peer oriented, authority figures present, parent/parent figure motivation, and teacher motivation elements),
- physical (learning in several ways, auditory, visual, tactile, kinesthetic preferences, intake of food, functioning best in the morning, afternoon and evening, and mobility elements).
- psychological in relation to hemisphericity which refers to the tendency of a person to use one side of the brain to perceive and function more than the other.

Year study completed: October 1987

Student Sample :

The 284 students were from the three different achievement groups, namely, the Normal (low achievers), the Express (average achievers), and the Special (high achievers). The criterion for their placement into the respective groups was based on the achievement scores (T-scores) the students obtained from the national examination, the Primary School Leaving Examination (PSLE). 33.5% were low achievers, 33.5% were average achievers, and 33.1% were high achievers. students were examined on Mathematics, Science, English, and a second language. The majority of the students (86.5%) were from the lower income group. 56.7% were from Mandarin speaking homes. 49.6% were males, and 50.4% were females.

Instrumentation :

1) The environmental, physical, emotional, and sociological stimuli were measured by the Learning Style Inventory (Dunn, Dunn, and Price, 1985) a 104-item self report, machine scored inventory for students from grades 3 to 12. The Learning Style Inventory (LSI) measured 22 areas in the four categories of stimuli. They were noise, light, design, temperature (environmental stimuli); motivation, persistence, responsibility, structure (emotional stimuli); learning alone, peer oriented, authority figures present, parent/parent figure motivation, teacher motivation, learning in several ways (sociological stimuli); auditory, visual, tactile, kinesthetic preferences, intake of food, functioning best in the morning, afternoon/evening, mobility (physical stimuli).

2) The psychological domain, that of hemisphericity was measured by the Cognitive Laterality Battery (Gordon, 1986), a performance test in the slide/cassette media. It consisted of eight subtests, four of which measured the left brain dominant tasks (verbal abilities) and the other four measured the right brain dominant tasks (visuo-spatial abilities).

3) The Demographic Data Inventory (Yap, 1986), an 18-item paper and pencil questionnaire was used to identify the commonalities and differences of the 284 students in terms of the number of students in each achievement group, gender, language spoken and written, subjects preferred in school, handedness, and socio-economic status.

Design of the Study :

1) The independent variables consisted of two factors, namely,
   (a) the three achievement groups of student in the Normal (low achievers), Express (average achievers), and Special Courses (high achievers).
   (b) the left and the right brain lateralization tests

2) The dependent variables consisted of the two areas to be measured, namely,
   (a) the 22 elements in the environmental, sociological, emotional, and physical domains as measured by the Learning Style Inventory
   (b) the three areas in the psychological domain as measured by the Cognitive Laterality Battery. The three areas in the psychological domain were,

(i) the students' overall performances in the Cognitive Laterality Battery as measured by the Cognitive Performance Quotient (CPQ)

ii) the students' types of cognitive profiles, which is measured by the Cognitive Laterality Quotient (CLQ)

(iii) the students' performances of the left and the right brain dominant tasks. The performance scores obtained on tests of the right brain dominant tasks were labelled appositional (A). The performance scores obtained on tests of the left brain dominant tasks were labelled Prepositional (P).

The design to measure the interaction between the brain lateralization tests and the achievement groups was the 3x2 factorial design.

Statistical analysis :

The statistics used to analyze the data included :

(1) The One-Way Analysis of Variance (ANOVA)

(2) The Analysis of Covariance (ANCOVA)

(3) The Two-Way Analysis of Variance with Repeated Measures

A significant level of 5% was chosen.

Table 1 provides a summary on the hypotheses, and statistical analysis of the study.

Table 1

Summary table on the hypothesis, the statistical analysis, the significant difference, and pairwise difference on the learning styles of Secondary Two students in Singapore

HYPOTHESIS	STATISTICAL ANALYSIS	SIGNIFICANT DIFFERENCE	PAIRWISE DIFFERENCE
HYPOTHESIS 1: There will be significant differences in the mean standard scores obtained in the 22 areas as measured by the Learning Style Inventory among the Secondary Two Singapore students in the Normal, Express, and Special Courses. Hypothesis 1 is accepted at the 0.05 level for six out of the 22 areas.	ANOVA	. NOISE LEVEL . LIGHT . MOTIVATION . LEARNING ALONE/ PEER ORIENTED . LEARNING IN SEVERAL WAYS . VISUAL	. NORMAL & EXPRESS . NORMAL & EXPRESS . NORMAL & SPECIAL . EXPRESS & SPECIAL . NORMAL & EXPRESS . NORMAL & SPECIAL . NORMAL & EXPRESS . NORMAL & SPECIAL . NORMAL & EXPRESS
Hypothesis 2: There will be significant differences in the overall performance on the Cognitive Laterality Battery as measured by the Cognitive Performance Quotient (CPQ) among the Secondary Two Singapore students in the Normal, Express, and Special Courses. Hypothesis 2 is accepted at th 0.05 level.	ANOVA	. Cognitive Performance Quotient (CPQ)	. NORMAL & SPECIAL . NORMAL & EXPRESS . EXPRESS & SPECIAL
Hypothesis 3: There will be significant differences in the cognitive profile as measured by the Cognitive Laterality Quotient (CLQ) in the Cognitive Laterality Battery among Secondary Two Singapore students in th Normal, Express, and Special Courses. Hypothesis 3 is accepted at the 0.05 level.	ANCOVA	. Cognitive Laterality Quotient (CLQ)	. NORMAL & EXPRESS . NORMAL & SPECIAL
Hypothesis 4: There will be significant differences between the performance of the left brain dominant tasks (P) and the right brain dominant tasks (A) among Secondary Two Singapore students. Hypothesis 4 is accepted at the 0.05 level.	ANOVA	. Left brain dominant tasks (P) . Right brain dominant tasks (A)	. NORMAL & EXPRESS . NORMAL & SPECIAL . EXPRESS & SPECIAL . NORMAL & EXPRESS . NORMAL & SPECIAL . EXPRESS & SPECIAL
Hypothesis 5: There will be interaction between the brain lateralization tests and the achievement groups of Singapore students. There was interaction.	Two-way analysis of variance with repeated measures	. Interaction	

Summary of the Findings :

The study on the 284 fourteen year old Singapore students related to the five domains of learning styles identified

1) a core of learning preferences that can positively or negatively affect the students' academic achievement.

2) the psychological domain in terms of cerebral dominance as the one domain of learning style that distinctly distinguished the low, average, and high achievers. The three achievement groups differed clearly in their performances of the left and the right brain dominant tasks, in the overall performances of the eight subtests in the Cognitive Laterality Battery (CLB), and in the cognitive profiles which determined the students' cerebral dominance.

First, the Learning Style Inventory measured 22 areas but only six areas were found to be significantly different between the achievement groups. The six significantly different areas were noise level, light, motivation, learning alone/peer oriented, learning in several ways, and visual. How were they different in these six areas? Table 2 summarized these differences.

Table 2: A summarized description of the six significantly different learning style elements.

COURSE OF STUDENTS (ACHIEVEMENT LEVEL)		NORMAL (LOW)	EXPRESS (AVERAGE)	SPECIAL (HIGH)	
Learning style category & element	$\bar{X}$	Description of Learning Style Preference			Pairwise difference
ENVIRONMENTAL					
1. Noise level	N 41.44 E 38.77 S 40.35	Have higher noise level tolerance	Have especially low noise tolerance	Have especially low noise tolerance	Normal & Express
2. Light	N 48.24 E 50.38 S 53.16	Are light sensitive	Are light sensitive	Are light needy	Normal & Special Normal & Express Express & Special
EMOTIONAL					
3. Motivation	N 65.87 E 68.76 S 69.07	Have high motivation	Have high motivation	Have high motivation	Normal & Express Normal & Special
SOCIOLOGICAL					
4. Learning alone/ peer oriented	N 46.56 E 43.18 S 42.27	Are peer oriented	Prefer studying alone	Prefer studying alone	Normal & Express Normal & Special
5. Learning in several ways	N 54.62 E 50.23 S 48.73	Prefer learning in several ways	Prefer minimum variation in learning patterns	Prefer minimum variation in learning patterns	Normal & Express Normal & Special
PHYSICAL					
6. Visual	N 54.95 E 58.06 S 57.13	Have Less visual preference	Have Visual preference	Have Visual preference	Normal & Express

Note: $\bar{X}$ = Mean N = Normal E = Express S = Special

Second, the difference in learning styles appeared to be at the two extreme ends of the achievement continuum. The significant differences between the groups were more often than not limited to differences between the Normal (low achievers) and the Special groups (high achievers) or between the Normal and the Express groups (average achievers). Light was the only instance where there was significant difference between the Express and the Special groups (Table 2).

Third, the low and high achievers did show similar strong and low preferences for certain learning style elements. All the three groups were highly motivated, self persistent, had kinesthetic preferences, were parent and teacher motivated. All the three groups disliked noise and heat. While the majority of the students in the three groups were similar in certain learning style preferences, there were also differences within each achievement group on the learning style elements that were significantly different.

From these observations the following questions can be asked: What is the factor or what are the other factors, that could make the three achievement groups perform differently? What category of learning style elements apart from the environmental, physical, emotional, and sociological stimuli, that distinguishes the three achievement groups in terms of their learning styles?

As the Learning Style Inventory did not measure the psychological domain of learning styles in terms of hemisphericity, the Cognitive Laterality Battery (CLB) was selected for use to measure the psycholo-

gical domain in terms of the students' hemisphericity. The psychological stimulus represents the way the students prefer to perceive, process, interpret, and judge the incoming information.

Fourth, there was significant difference in the students' overall performance on the Cognitive Laterality Battery (CLB) as measured by the Cognitive Performance Quotient (CPQ) among the Secondary Two students in the Normal, Express, and Special Courses. The higher the achievement level, the better was the students overall performance in the CLB. In short, the CPQ was related to the achievement level of the students (Figure 1).

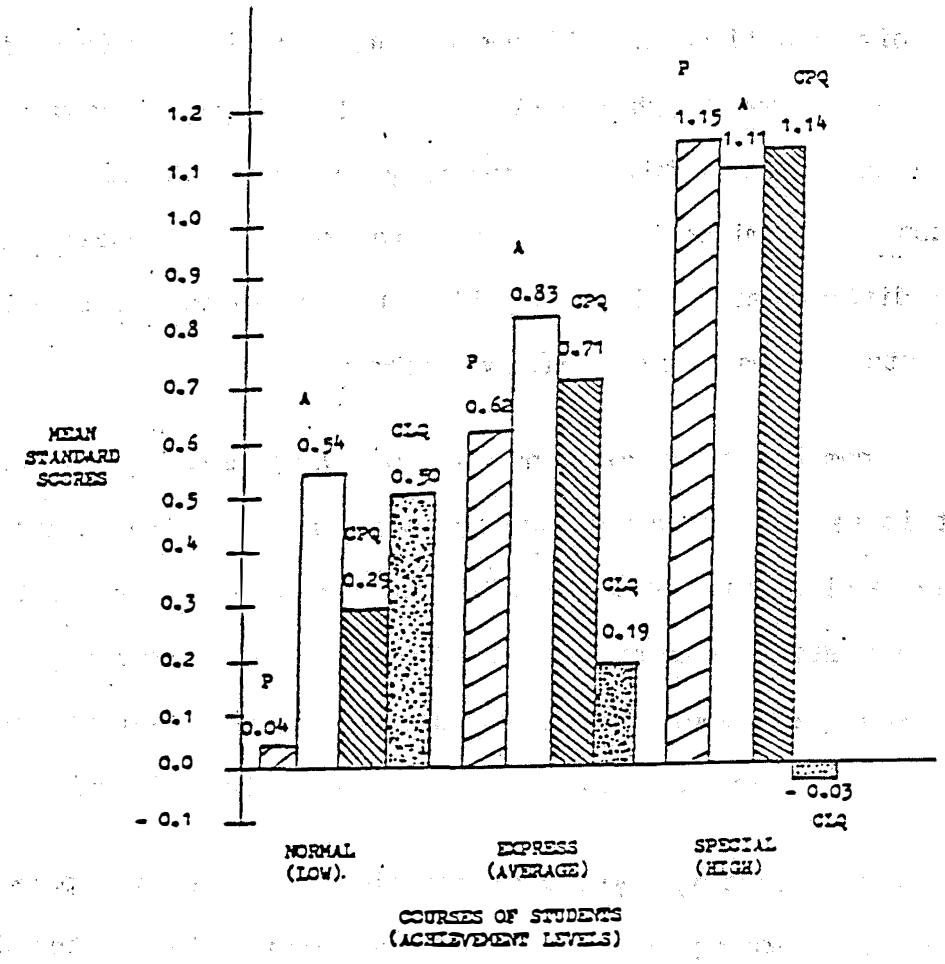

FIGURE 1 : COMPARION OF P, A, CPQ, AND CLQ

NOTE: P is for the performance of left brain dominant tasks.

A is for the performance of right brain dominant tasks.

CPQ is the Cognitive Performance Quotient, the overall performance on the Cognitive Laterality Battery.

CLQ is the Cognitive Laterality Quotient, the cognitive profile. A positive CLQ score indicates a right cognitive profile. A negative CLQ score indicates a left cognitive profile.

Fifth, there was significant difference in the students' cognitive profiles as measured by the Cognitive Laterality Quotient (CLQ) in the CLB. The cognitive profiles were to assess the relative level of functioning of the right and left hemispheres. It also referred to a tendency of a person to use one side of the brain to perceive and function more than the other. Instead of the traditional vertical dimension of who or what is better, or who or what is worse on a performance test, a horizontal dimension of the relative performance between the two information process tasks is available for comparison. As people do not process tasks in the same way, there is the need to recognize and accept the fact that there are two equally valid methods of acting upon, processing, perceiving, and storing information.

The Normal group (low achievers) had a positive cognitive profile, the Special group (high achievers) had a negative cognitive profile while the Express group (average achievers) also had a positive CLQ (Figure 1). A positive CLQ reflects a relatively better performance on tests of right hemisphere and a negative CLQ reflects a relatively better performance on tests of left hemisphere function. The high achievers were more dominant in their left hemisphere and the low achievers were more dominant in their right hemisphere. The right was dominant in the visuo-spatial tasks and processed information holistically. The left hemisphere was dominant in the verbal tasks and processed information sequentially.

Sixth, there was significant difference between the performance of the left brain dominant tasks (P) and the right brain dominant tasks (A) among the Secondary Two students (Figure 1).

Performances of the left brain dominant tasks (P) and the right brain dominant tasks (A) differed with each achievement group. The better achievers did exceptionally well for both the left (P) and the right brain dominant tasks (A), while the lower achievers continued to perform poorly for both P and A. The low achievers did better in their right brain dominant tasks compared to their left brain dominant tasks. In short, the higher the achievement level of the students, the better were the students' performances in both the tasks. The lower the achievement level of the students, the poorer were the students' performances in both the tasks

Seventh, there was interaction between the two independent variables or factors, namely the brain lateralization tests and the three achievement groups. The difference in the mean standard score between the performance of the left (P) and the right dominant tasks (A) was greater for the Normal group (low achievers). This difference narrowed when the achievement levels of the students increased. The difference in the performance of the left and the right brain dominant tasks narrowed to a very great extent for the high achievers in the Special group. The lower the achievement levels of the students, the more unbalance were their performances between the right and left brain dominant tasks (Figure 2).

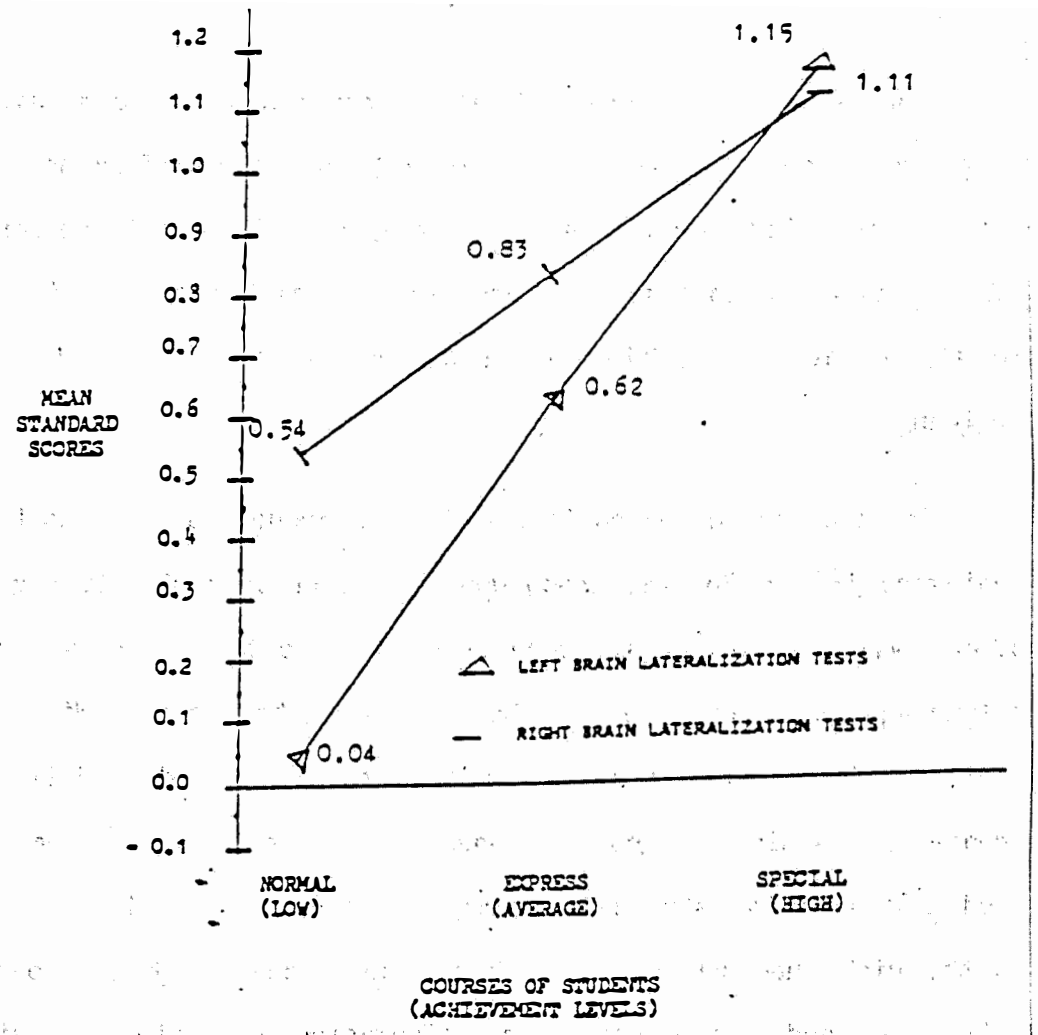

FIGURE 2: INTERACTION BETWEEN THE BRAIN LATERALIZATION TESTS AND THE THREE ACHIEVEMENT GROUPS

CONCLUSIONS OF FINDINGS :

The students' learning styles in terms of the environmental, physical, emotional, and sociological factors were different among the fourteen year old Secondary Two students in the three achievement groups. They varied in six out of 22 elements, namely, noise level, light, motivation, learning alone/peer oriented, learning in several ways and visual.

Not all the students process information in the same way. The three achievement groups differed clearly in their performances of the left and the right brain dominant tasks, in their overall performances of the eight subtests in the Cognitive Laterality Battery (CLB), and in the cognitive profiles which determined the students' cerebral dominance.

The average achievers in the Express group, but more so the high achievers in the Special group would do well academically regardless of the ways learning tasks were introduced to them as they were more balanced in the functioning of both sides of the brain. With the low achievers in the Normal group, there might be a need to deliberately create a learning environment where the teaching styles match the students' learning styles in terms of their cerebral dominance, that is the right hemisphere, which has a dominance in the visuo-spatial abilities, and which processes information holistically, simultaneously, and synthetically.

Table 3 provides a summarized description of all the significantly different learning style elements as measured by the Learning Style Inventory and the Cognitive Laterality Battery.

Table 3
A summarized description of the significantly different learning style elements as measured by the Learning Style Inventory and the Cognitive Laterality Battery

COURSE OF STUDENTS (ACHIEVEMENT LEVEL)		NORMAL (LOW)	EXPRESS (AVERAGE)	SPECIAL (HIGH)	
Learning style category & element	$\bar{X}$	Description of Learning Style Preference			Pairwise difference
ENVIRONMENTAL					
1. Noise level	N 41.44 E 38.77 S 40.35	Have higher noise level tolerance	Have especially low noise tolerance	Have especially low noise tolerance	Normal & Express
2. Light	N 48.24 E 50.38 S 53.18	Are light sensitive	Are light sensitive	Are light needy	Normal & Special Normal & Express Express & Special
EMOTIONAL					
3. Motivation	N 85.87 E 88.78 S 89.07	Have high motivation	Have high motivation	Have high motivation	Normal & Express Normal & Special
SOCIOLOGICAL					
4. Learning alone/ peer oriented	N 46.58 E 43.18 S 42 27	Are peer oriented	Prefer studying alone	Prefer studying alone	Normal & Express Normal & Special
5. Learning in several ways	N 54.82 E 50.23 S 48.73	Prefer learning in several ways	Prefer minimum variation in learning patterns	Prefer minimum variation in learning patterns	Normal & Express Normal & Special
PHYSICAL					
6. Visual	N 54.35 E 58.08 S 57.13	Have Less visual preference	Have visual preference	Have Visual preference	Normal & Express
PSYCHOLOGICAL					
7. Cognitive Performance Quotient, (CPQ)	N 0.29 E 0.71 S 1.14	Poor overall performance	Average overall performance	High overall performance	Normal & Express Normal & Special Express & Special
8. Cognitive Laterality Quotient, (CLQ)	N 0.50 E 0.19 S -0.03	Right cognitive profile	Right cognitive profile	Left cognitive profile	Normal & Express Normal & Special
9. Left brain lateralization tests	N 0.04 E 0.82 S 1.15	Low mean standard scores	Average mean standard scores	High mean standard scores	Normal & Express Normal & Special Express & Special
10. Right brain lateralization tests	N 0.54 E 0.83 S 1.11	Low mean standard scores, but much higher than those of the left	Average mean standard scores, but only slightly higher than those of the left	High mean standard scores & very little difference from the left	Normal & Express Normal & Special Express & Special
Difference between right & left		0.50	0.21	-0.04	

Note: $\bar{X}$ = Mean N = Normal E = Express S = Special

DISCUSSION AND IMPLICATIONS FOR TEACHERS AND TEACHER EDUCATORS

The individual nature of students has great implications for all curricula. This has created a dilemma for teachers in trying to meet the needs of individual differences, while at the same time facing the reality of a large number of students in each class. Yet the success of education depends on adapting teaching to individual differences among the learners. Past research for a single educational strategy contradicted the generally accepted concept of individual differences. Some educational analysts had advocated the need for differentiated instructional approaches to enhance learning (Cody, 1985; Carbo, 1984; Friedman and Alley, 1984). The group and individual differences in learning styles as measured by the Learning Style Inventory and the Cognitive Laterality Battery have great implications to education for classroom teachers, administrators, curriculum designers, instructional designers, and teacher educators. The distinct group patterns of learning styles would warrant differentiated educational approaches in relation to the environmental, physical, emotional, sociological and psychological factors.

The conclusions drawn from the research have tremendous implications on teachers and teacher education. The research indicated the need for teacher educators to shift the emphasis of the pedagogical aspects of teachers and teacher educators to include the following dimensions of learning, namely :

(a) developing and matching differential instructional approaches according to the different learning styles;

(b) understanding the principles of information processing and recognizing the fact that there is a horizontal dimension to compare the relative performances of students;

(c) observing, identifying, diagnosing, measuring and analyzing students' learning preferences and profiles;

(d) reformulating assessment and evaluation formats for students who are deficient in capabilities related to the storage and organization of verbal or non-verbal materials;

(e) designing and developing specific learning activities and materials that can reinforce each learning modality.

A. DEVELOPMENT OF EDUCATIONAL APPROACHES ACCORDING TO THE ENVIRONMENTAL, PHYSICAL, EMOTIONAL AND SOCIOLOGICAL FACTORS

Students' ability to concentrate, absorb, and retain information are affected by four sets of stimuli, namely, the physical environment, the emotional framework, the sociological setting, and the physical being.

The Learning Style Inventory identified six significantly different elements in the learning styles of the Secondary Two students in the categories of environmental, emotional, physical, and sociological stimuli. They were noise level, light, motivation, learning alone/peer oriented, learning in several ways, and visual preferences. The environment has different effects on the students in terms of their pre-dispositions and internal structures. Historically, teachers tend to address each class as a whole and rarely vary their assignments, the requirements, the nature of the assessments, and the instructional methods to correspond to what the students are capable

of producing. Striving to provide alternatives for students in different ways could be an excellent move toward obtaining increased academic achievement.

For example, educational approaches need to be different for the unmotivated and the motivated students. Unmotivated students will probably benefit from frequent encouragement, positive, and frequent feedback on their performances. Short tasks that can be successfully accomplished in a limited time should be assigned. Uncomplicated assignments of the students' interests may be more effective to sustain their interests and attention.

Motivated students are usually persistent in their efforts to accomplish the assigned task. The students enjoy accomplishments and achievement. As they can work independently, they can also be relied upon to complete assignments with self-designed objectives, self-selected tasks, self-paced growth, self-scheduled activities, self-evaluation, and self instructional procedures. The very motivated and persistent students can achieve even if their preferences are at variance with the existing learning systems.

Some learners must experience visually. Learners whose perceptual strength is visual will be able to recall the information when it is presented to them as pictures, films, diagrams, drawings, books or magazines. For these learners, concepts and materials need to be explained through visuals. Some students learn well through lecture and discussions. Sometimes audio visual modalities can be complementary or reinforcing styles rather than the exclusive styles of the students.

Some students may find it hard to learn by 'look and see' method. They learn better by 'doing'. Kinesthetic preferences would include learning opportunities for real and active experiences like field trips, projects, role play, games, simulations, and mock-up activities. Multisensory approaches in teaching can overcome some of the perceptual problems in the traditional teaching of the chalk and talk method.

Some students prefer to study on their own, while others prefer to study with their peers. Some need to interact and discuss the materials to be learned. This group of students can function effectively inspite of surrounding sounds. Students who achieve through interaction may do as well in programs that are self instructional or teacher dominated.

Structure is another consideration. Students who need more structure may need precise instructions, direction and guidance. Objectives and procedures have to be clearly and simply stated, itemized, and listed without room for open interpretation. The nature of the tasks, the time requirements, and resources that are to be used have to be indicated clearly. For students that do not prefer structure, some allowance for flexibility can be encouraged. Within the clearly stated objectives, they can be permitted choices of resources, procedures, time line, reporting procedures, presentation format, and place of work. Such students feel inhibited with too much organization and 'how to' procedures.

The students in the three achievement groups did indicate a decided preference for learning in an environment that differs markedly from one another. For those who are not achieving, could

their learning be very well hampered by the usual formal and structured classroom environment that requires self motivation and auditory modalities? These characteristics will hinder the learning of some students who may prefer less structure, kinesthetic learning opportunities, and who to be more teacher motivated.

Teachers also need to be particularly sensitive to the energy highs of those who are not performing well. The more difficult concepts, newer information, more thought provoking activities, and memorization of complicated formulas should be introduced when the students are most mentally alert.

Students' learning styles can be used to group the students for instructional purposes. This provides an alternative to the traditional grouping of students by abilities, IQ, and achievement scores. While there are group differences in learning styles, there are also individual differences within a group or a class. Prior to grouping the students by their learning styles, it will be necessary for teachers to identify the learning styles, understand them, and compare the students' individual profiles with the demands of the programs. Students can be grouped for instruction according to their cerebral dominance or according to their preferred learning style elements. A group summary of learning styles can be used to identify which individuals have similar preferences. A subscale summary can be used to determine which of the subscales, areas, or elements are of major or of least importance to the group to the class.

Learning style elements like motivation or persistent level, parent or teacher motivation, energy curves of the students, and the

perceptual modalities have important implications for improving instruction because research has strongly suggested that, when students were taught through their individual styles, academic achievement toward learning improved significantly (Carbo, 1980; Doyle and Rutherford, 1984; Griggs and Dunn, 1984; Jarsonbeck, 1984).

In order to capitalize on the students' characteristics and the appropriate types of learning preferences, students' individual learning profiles, their sub-scale and group summaries should be matched with the program's requirements and demands.

B. DEVELOPMENT OF EDUCATIONAL APPROACHES ACCORDING TO THE CEREBRAL DOMINANCE OF THE STUDENTS

The Secondary Two students in the Normal, Express and the Special Courses were different in six of the 22 areas of learning styles measured by the Learning Style Inventory. But their differences in the mean standard scores were small. In fact, the three achievement groups indicated similar strong and low preferences. The more obvious difference among the students was evident in the psychological domain in terms of the groups' hemispheric preference, which is a differential efficiency of the two hemispheres. The students were differnt in their cerebral dominance. They all use both hemispheres to process the information, think, reason, and to achieve academically but they were different in their cerebral dominance. The incoming information arouses the two hemispheres differently. Each hemisphere has its own perspective, its own domain of activity and functions that will be aroused according to the nature of the tasks to be performed. "A Right preferenced person would appear to be more efficient at those tasks for which the right hemisphere is specialized. They tend to

think 'in pictures' and would prefer deductive reasoning. 'A' Left preferenced person should be more efficient at left hemisphere specialization and would tend to think 'in words', and would prefer inductive reasoning." (Dunn, Cavanaugh, Eberle, and Zenhausern, 1982, p. 291).

A close investigation of some subjects in the school curriculum 'll show the presence of interhemispheric processing of information in these subjects. It will also dispute the prevailing belief that the school curriculum is biased in favor of the left hemisphere. This misconception could be derived from the way the subjects are instructed. School subjects like literature, reading, mathematics, music, and art are all equally dependent on both hemispheres. The need to develop differentiated educational approaches for language, mathematics, literature, art and music was very well illustrated by Levy (1982). According to Levy, to educate a student is to provide him/her with a full and rich understanding of meanings and concepts derived from a deep synthesis of the differing perspectives. The full and rich meaning of a word is derived from the integration of both sides of the brain. For example, when one hears a word one does not merely derive the dictionary definition of the word. Instead, one generates images and visualizes the word or object in different color, expressions, postures, positions, activities, and emotions.

An example related to the integrative activity of the two hemispheres is in the appreciation of literature. Levy (1982) illustrated this socialized process by saying that,

> "The child's appreciation of literature depends on his or her ability to synthesize into words, words into sentences into meaning and thought. It depends on the ability to apprehend and respond to the rhythm of language, imagine and feel the scenes and moods, empathize with characters, understand their emotions, values and personalities, and to integrate all these into rich and full meaning with structure, configuration and detail. Such a process cannot be accomplished by either side of the brain alone, but represents so intimate an integrative activity that, in the end, we cannot say which side of the brain contributed what (p. 175)."

According to Levy, reading involves learning to read through phonics with the eventual mastery of fluent skills in sight reading. Similarly, a student who has learnt the whole word method should eventually develop excellent skills at phonetic analysis in order to decode new words. Geometric reasoning, involving viewing an opened-up drawing of an unfolded shape, and mentally turning three dimensional objects in the space, is the superiority of the right hemisphere. The learning of mathematics is not limited to only geometric relationships. It also involves verbal skills, symbolic equations, and problem solving. Art is no more a right hemisphere process than it is a left hemisphere process with the left to provide the details and the right to provide for its overall form.

The gap between the functioning of the left and the right brain dominance has to be narrowed as both hemispheres evidently contribute to the processing operation. Each hemisphere is restricted to a set of competencies and dominant functions. The Cognitive Laterality Battery data from the present study indicated a very narrow gap between the performances of the right and the left dominant tasks in the Special group (high achievers). It would mean that academic achievement with students in the Special group may be less affected by the types of learning tasks associated with the hemispheric dominance of

the students. This is because the students in the Special group are more balanced in their functioning of both sides of the brain. This could not be said for students in the Normal group (low achievers). There is a big gap between their functioning of the left and right brain dominant tasks. The gap between the performances of the brain lateralization tests widen when the achievement levels of the students become lower. It appear that for such students, there is a need to deliberately incorporate teaching elements associated with the students' cerebral dominance.

No data support the idea that normal people function like split brain patients who use only one hemisphere at a time. The individual differences in hemisphericity is to the extent that one hemisphere is more differently aroused than the other. There is no one best way to teach a group of students. Neither is dominance in one hemisphere better than the other. Hemisphericity is a relative efficiency rather than an absolute difference.

These differences suggest that whole brain learning may be better accomplished by different people with different methods. Levy (1982) defined learning style as the method of introducing materials. Jarsonbeck (1984) established the need to determine hemispheric preference of students and to initially present new information, difficult concepts and skills through the format that could be best assimilated by the preferred hemisphere, prior to bridging those experiences which required the interaction with the less preferred hemisphere. The stronger the preference, the greater the need to present initial learning experiences through the dominant hemisphere.

Partridge (1983) similarly believed in neurological symmetry or hemispheric teamwork for academic achievement and optimum performance.

The differentiated educational approaches are to cope with the varied existing learning styles of individuals or groups of students. Curriculum designers have recommended and adopted different approaches like direct matches of instructional and learning styles, or direct matches of instructional methods with learner characteristics. The former approach is too dependent upon the staff availability. The matching approach limits the students' exposure to a single style of teaching and learning as other styles may be required outside the school setting.

Copenhaver (1980) indicated that students did not purposefully change their learning styles as they moved from one subject to another. Students did not seem to recognize the need to use a particular learning style to attain success in a particular subject area nor did they know when or how to change their preferred style of learning. Torrance (1978) thought otherwise. He found that modifications in preferred modes of thinking and learning (hemisphericity) were possible with short term intense training programs of about six to 12 weeks, employing either direct training in specific styles or indirect training through exposure to a variety of styles and experiences.

Several studies have evidenced significantly higher test scores when students were taught in ways that responded to their unique learning characteristics (Brennam, 1984; Cafferty, 1980; Douglas, 1979; Jarsonbeck, 1984; Spires, 1983; Zenhausern, 1983). Improving the quality of insruction may be closely associated to the increase of a

variety of instructional techniques used in the classrooms. Learning style assessment can help teachers direct their attention to strategies that are most effective with either an individual or a group of students. The instructional methodology by which the teachers introduce the materials can be determined by the individual students' learning style profiles which would indicate the particular way a student process information.

Yet it may not be enough to learn only through the students' preferred styles. Students may need to diversify their style preferences by adopting "style flex" which may be essential and useful in a complex and demanding society that warrants learning through the visual, auditory, and tactile modalities. It may help to vary instruction to match a student's particular approach to adapting, absorbing, and assimilating the incoming information.

Modern technology places increasing value on the students' abilities to read and write well, to reason in numerals, to manipulate the computer keyboard, to think critically, and to solve problems. Teachers need to develop and utilize classroom activities which will assist students develop flexible learning styles to cope with the multi-dimensional tasks.

C TEACHER EDUCATION

The presence of the teachers and the roles they play in the classrooms are important variables in influencing educational outcomes. Their main concern is how to improve the levels of learning and performances in the classrooms. Teachers may be able to recognize individual differences in the characteristic way students process their

information, but they may not understand the basis of this difference. Preservice and inservice teachers' may need to understand the principles involved in information processing in order to move to a higher level of understanding about students' information process to enable the teachers to utilize the acquired knowledge. They could be taught how to effectively diagnose, identify, be sensitive to the learning styles of their students, how to identify their own preferred teaching styles, how to develop and utilize a variety of instructional strategies to match the learning styles of the students in the classroom, and how to develop and create lessons, presentations, and evaluations based on these principles.

Hunt (cited in Copenhaer, 1980) advocated such a teacher education program. He believed that one of the goals of teacher education should be process goals (that is, how to process the information), as well as product goals (that is, what is to be learnt from the process). Consequently, he believed that preservice and inservice teachers be prepared to teach their students the process to attain the products.

Lyons and Languis (1985) recommended five phases of such a teacher education program. They proposed the following :

Phase one was a basic course on the brain, mind, behavior, and the fundamental principles underlying brain organization, structure, and function. This focus on the brain and its function in human learning is termed neuroscience.

Phase two concentrated on self awareness and the analysis of learning patterns. It would also include an awareness of the characteristic patterns in the teachers' own learning styles.

Phase three consisted of teaching style patterns which included an introductory course on models of teaching and alternative teaching approaches. This phase would provide teachers with the opportunities to investigate, evaluate, and experiment with a variety of teaching strategies.

Phase four included adapting teaching styles to learning styles or preferences. Prospective teachers would be required to observe, identify, and diagnosis cognitive, affective, and physiological patterns of learning behavior in the students they were instructing. They may need to design instructional strategies to meet individual learning styles, and adapt their teaching methodologies to accommodate these learning needs.

Phase five was internship where teacher trainees would receive guidance, direction, and feedback in applying cognitive science and learning style research.

The above preservice teacher education program was designed and experimentally implemented at The Ohio State University (Lyons, 1983).

A deliberate effort to educate teachers and teacher trainees on their own learning styles and the styles of others can have positive and long term benefits. An awareness of one's own learning styles can be a prerequisite to the understanding of the varied learning styles in the students. Such realization may enable them to identify and be sensitive to the learning styles of others. This will avoid the conscious or unconscious attempts of the teachers to impose their own teaching styles on the students. Instead, they may support oppor-

tunities, develop, and utilize activities that will broaden the students' learning styles. They can also be sensitive to the effects that certain tasks can have on the arousal of the two hemispheres of the brain.

D EVALUATION

Studies on hemisphericity, including the present study, have indicated very strongly the existence of two different ways of storing information, namely, verbal and non-verbal, though the latter form of storage is hardly emphasized as a form of evaluation for what the students are capable. Most achievement tests give more credit to performances related to the left brain dominant tasks of verbal abilities. The traditional method of evaluation appears to be heavily biased on the logical and verbal responses. Traditional evaluation hardly provides for students who cannot put learning or understanding into words. Yet the right brain involvement in learning appears to be especially important for those who are deficient in capabilities related to the storage and organization of verbal materials.

The present study showed that while the Normal group (low achievers) did poorly in the left brain dominant tasks, they were much better in their performances of the right brain dominant tasks. Their strength was in visuo-spatial abilities. Gwany's study (1985) on Nigerian students included the study on the students' preferred test format, namely, objective, essay, or practical forms and their cognitive profiles. Essay and objective tests required verbal and analytic-logical abilities. Practical tests required mainly visuo-spatial and tactile processes which required a lot of right hemisphere functions.

He found a significant difference on right brain dominant tests between those who preferred essay tests and those who preferred objective and practical type tests. There were significant correlations between essay tests and performance on left brain tests (P). Those who preferred practical format types of tests had significantly higher mean scores on the performance of the right brain tests (A). Gwany's findings could prove to be very relevant to the Singapore context because of a similar educational system based on a historical and a colonial past.

E CURRICULUM DESIGN

Traditional patterns of education may appear inadequate because they concentrate almost exclusively on the left hemisphere which emphasizes the power of linguistic and numeral reasoning, and tend to neglect the right hemisphere which controls conceptual, sensory, musical, and intuitive abilities. There may be a need to develop formal curriculum, teaching strategies, and school experiences to accelerate the development of neurological symmetry of individual students and to also provide for the diversified learning styles of the individuals within a group. This may mean the development of new materials in areas where existing materials are not appropriate or do not exist. There is also the necessity to evaluate existing or commercially available materials to determine their strengths and weaknesses when used with students. Where commercial materials are found to be lacking in certain aspects, teachers may have to use self developed materials and activities.

The roles of the teachers become very important, as they can develop specific learning activities and instructional materials that can reinforce each modality or style. The degree to which teachers are able to develop such activities, teaching materials, and curriculum may be crucial to the ultimate success of the learning style movement. Teachers may not have the time to juggle classes of 40 and more students, while simultaneously paying attention to 20 or more style preferences for each individual student. A more workable method is to delineate ways whereby teachers can focus upon selected basic style preferences of their students and be able to utilize these learning activities to support those styles. These basic style preference can be derived from the group summary or the subscale summary of the Learning Style Inventory.

Jarsonbeck (1984) realized the handicap of the right brain students being taught traditional mathematics concepts in a left brain manner. The question was whether the right brain students would do better if they were taught using a curriculum designed for the rights. The study showed that left dominant students did better using the curriculum that was designed for paper and pencil activities which were characteristic of left brain dominant tasks. The experimental group used hands on manipulation, kinesthetic activities, and each skill was introduced at the concrete level, then the pictorial level. All the lessons in the experimental program used games and learnng centers to reinforce each skill. Students who were identified to be right brain dominant did better in the experimental group.

Findings from studies on the brain do not suggest substituting the current and predominantly left brain dominant curriculum in the schools with a new right brain dominant curriculum. What the findings suggest are an integrative or a balanced curriculum approach. The curriculum content, objectives, methods, learning experiences, and evaluation may reflect a shift in the hemisphere mode to provide a more balanced curriculum to cater for individual or group differences in cerebral dominance.

CONCLUSION :

The learning styles of Secondary 2 students in the Normal, Express, and Special groups are different. They are different in the environmental, sociological, emotional, physical, and psychological domains as measured by the Learning Style Inventory and the Cognitive Laterality Battery.

The concept of learning styles is not new, but research findings related to learning styles have revived a re-look into another dimension of individualized instruction. Learning styles measurement provides for student's learning style profile to alert the teacher to the student's learning styles that may motivate or inhibit his/her learning. The profile also provides insights into how the student reasons, draws conclusions, formulates concepts, and processes information.

The present study draws certain conclusions on certain variables of learning styles, but the psychological element related to information processing habits appears to distinguish the Secondary 2 students' level of academic achievement. Though the present study together with research findings of other studies provide a substantive framework for educators to appreciate learning styles as a non traditional approach of looking at learning and instruction, the investigator of this study would respond to the findings with some caution. She has the following personal opinion.

First, she believes that prior to any change to the traditional or current practices of determining instruction, teachers, educators, and administrators may need to first appreciate and have a full understanding of learning styles as a new way of looking at learning and instruction. There is also a need for them to be re-directed into recognizing and accepting the fact that there are two equally valid methods of acting upon, processing, perceiving, and storing information. Instead of the traditional vertical dimension of who or what is better, or who or what is worse on a performance test, horizontal dimension of the relative performance between the two information process tasks need to be accepted for comparison. They need to regard learning styles as possibilities of motivating or demotivating a learner. They may need to be convinced that a learner can achieve better when taught in their preferred ways of learning. Only then can there be adequate assurance that instruction should begin with the diagnosis of a student's learning style.

Second, she also believes that the main stumbling block to the widespread practices of learning style diagnosis could be in the identification of a valid and reliable instrument or instruments that will be practical for use. Many specialized instruments are currently available commercially. Each probes and measures different domains of learning behavior. The use of them has significantly contributed to the development of a research base. Their findings have also resulted in educators taking a new look at classroom activities in the light of the student's learning characteristics.

The absence of a single instrument that embodies the environmental, affective, emotional, physical, and psychological factors has constituted a major obstacle to the widespread application of learning style diagnosis in the school setting. Anderson and Bruce (1982, p.85) listed six desirable criteria for such instrument that can be adopted for widespread use. They recommended that the instrument,

(a) be developed on a firm research basis,
(b) be relatively inexpensive for widespread application,
(c) be usable for group administration,
(d) be relatively simple and quick to administer and analyze,
(e) have appropriate reliability and validity,
(f) can provide for stylistic differentiation along a continuum.

Third, she recommends further research and application of the research findings in the school setting. Doubting the feasibility and practicality of learning style diagnosis can be expected, as there is insufficient data at the application level to provide adequate

assurances and guidance to teachers. Results of research have not been very consistent. This can be attributed to a number of reasons. There are too many varied instruments, each measuring a different aspect of learning style. The scope of the studies has been too diversified. It also appears that one instrument that embodies all the environmental, affective, and psychological factors is not available. Students have also been grouped by different criteria for diagnosis purposes.

Inspite of the above caution and the investigator's awareness of some possible but realistic problems that may be encountered, the findings of the present research does provide a substantive framework for educators to appreciate learning styles as a non traditional approach of looking at learning, instruction, and classroom activities related to learners' characteristics. The findings can be utilized in terms of

(a) attempting to identify sets of variables in terms of environmental, sociological, emotional, physical, and psychological factors that may determine whether the students find a lesson exciting or boring,

(b) placing students in their preferred learning environment,

(c) removing obstacles that may inhibit or demotive the learners,

(d) develop matching methodologies and curriculum that will support, reinforce, and complement the students' learning style preferences,

(e) recognizing and realizing the fact that there is a horizontal dimension instead of the traditional vertical dimension to compare the relative performances of students.

Learning style is not another educational quest or movement. Rather it is a potential key to educational improvement in that it provides teachers, educators, and educational administrators with a 'new look' at another dimension of individual differences, individualized instruction, and at classroom activities in the light of an individual student's learning characteristics and learning style preferences.

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D1550/R.STUDY