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Differences in Right and Left Brain Dominance and Creative Thinking

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Abstract

Education is a process of bringing desirable change into the behaviour of human beings and it is a dynamic force in the life of every individual, influencing one's physical, mental, emotional, social and ethical development. Thus education is the complete development of the individuality. So that one can make an original contribution to human life to one's best capacity. As Mathematics is the foundation of all the disciplines, improvement in Mathematics education is a necessity for a developing country like India. Mathematics equips pupils with a uniquely powerful set of tools to understand and change the world. These tools include logical, reasoning, problem solving skills and the ability to think in creative way. Recent research (Peverly 1991, Swanson 1990, Brown & Kave 1988) evaluating the role of strategies and knowledge utilization in problem solving indicates that successful problem solving requires the ability to competently efficient problem solving ability. Creativity is a wonderful ability and power which enables the human beings to make new inventions and helps them to give solutions to challenging problems and make life interesting and worth living. But our society is characterised by uncertainty and rapid change. Hence the ability to think creatively is becoming the key to success and satisfaction, both professionally and personally. For today's children, nothing is more important than learning to think creatively learning to come up with innovative solutions to the unexpected situations that will continuously arise in their lives. So it is necessary to conduct the training programmes in school so as to bring out the creativity of the students.

INTRODUCTION

DEFINITIONS OF CREATIVITY

Creativity is the capacity to confront a given problem in an original way. It is the capacity to look at a situation or problem from a different perspective or even from a variety of perspectives that are not derived directly from the problems definition". (Ronny Erez).

According to Guilford (1950) creative abilities together constitute Creative Thinking which is characterized by "originality", "flexibility" "fluency", and "elaboration". Guilford maintained that these abilities are somewhat general and can be applied to a variety of tasks.

Torrance (1969) defines Creative Thinking as the process, of "sensing gaps or disturbing or missing elements forming ideas or hypotheses concerning them testing these hypotheses and communicating the results possible modifying and retesting the hypothesis".

"Creative Thinking is one of the important aspects of "Giftedness". It is a complex talent made up of many abilities, such as ability to recognize problems, to be flexible in thinking, to invent and originate ideas or products; to find new uses for old objects and materials says De Haan and Havighurst (1961).

Good (1959) defines "Creative Thinking as a thinking that is inventive, that explores novel situations, or reaches new solutions to old problems, or that results in thoughts original with the thinker"

"Creative Thinking results in novel outcomes, it appears to be a product not only of intelligence, but also of flexibility, independence and training" remarks Mann (1972)

Creative means seeing or expressing new relationship among things or ideas. The amount of creativity and its dimensions vary from individual to individual. Thinking is one of the most remarkable of human achievements. It is dynamic, intense and highly personal activity. Creative Thinking must involve the exercise of both intellect and imagination.
Emphasizing on the process of thinking and creation. Don Fabum states, "What tomorrow's need are not masses of educated men-men educated to feel and to act as well to think and to create. These two verbalized words, "to think and to create" would indicate the process of Creative Thinking that is to think creatively for today and tomorrow. The creative ability increases through imagination, ingenuity and curiosity; Creative Thinking involves the same mental processes that are utilized in other form of thinking, which are experiences, association and expression.

COMPONENTS OF CREATIVITY

Creative ability comprises:
(i) Originality
(ii) Flexibility
(iii) Fluency
(iv) Elaboration

ORIGINALITY

It is the divergent thinking ability to make an original, rare or uncommon response revealing cleverness as well as spontaneously. Novelty is the expression of originality. According to Guilford, Originality is the primary trait of Creative Thinking.

FLEXIBILTY

It is the ability to produce ideas which differ in approach or thought trend. This is the divergent thinking ability to make diverse relevant responses to a single stimulus.

FLUENCY

Fluency is represented by the number of relevant and unrepeated ideas which the persons produce. It is defined as "the proliferation and ease with which ideas are generated and expresses".

ELABORATION

This means semantic elaboration, redefinition and sensitivity of thought process such ability enables one to furnish a good number of details beyond that is necessary to communicate a basic idea.

CHARACTERISTICS OF A CREATIVE PERSON

Once the fact that creative potential can be enhanced is established, it is necessary to find out what are the qualities, which make a man creative. It is a capacity to visualize concept and objects, which are intangible, or it is the capacity to see things in an unusual way? Is it sensitivity to problems or openness to experience uncertainly? Is it an independence of judgment or toleration of ambiguity? Is it a result of just one component or a combination of components, which encompass both his heredity and environment?

Guilford (1970) observed that "Creativity is not any one thing; it is many things and takes many forms". What are these "many things? These include many abilities, skills, process and qualities. Important among them are fluency, flexibility, originality, sensitivity, curiosity, elaboration, visualization and imagination, independence, tolerance or ambiguity, complexity, risk-taking, improvisation and openness.

Thus a creative person has the following characteristics:

1. Seeing things in unusual ways
2. Independence in judgment
3. Curiosity
4. Self-reliance
5. Sensitivity to problems
6. Motivation
7. Openness to experience uncertainty
8. Needing and assuming autonomy
9. Freedom from fear to failure
10. Tolerance of ambiguity
11. Persistence
12. Selectivity
13. Flexibility
14. Originality

Every person has some of these characteristics in him. It is for the teacher to present an environment in which these characteristics get highlighted. With this, this fact should also be kept in mind that the same environment and same training does not elicit the same response in all persons as there are individual difference in the abilities of people.

DETERMINANTS OF CREATIVITY

Determinants of creative behavior are the following according to some scholars.

1. The values and practices of the culture in which a person is brought up and live.
2. A person's biological constitution.
3. Nature of the organization or institution.
4. Genetic inheritance.
5. The orientation of the group.
6. The nature of the work the person does.

MEASURING CREATIVE THINKING

Creative people are an asset to society, as they lead to all-round Intellectual, Cultural and Industrial development. It is a fundamental duty of schools and other educational institutions to identify such people at an early age and provide them with the opportunity to be Creative, Idey (1986).

Torrance (1962) considers that a Creative Individual may be identified through measuring creative. Measurement of creative may be important because it enhances our

understanding of human mind and personality, is helpful in individual teaching, guides mental growth and gives an indication of mental health, provides clues for arranging remedial programmes, helps in the evaluation of programmes and the need for guides in future.

Torrance (1964) commented that of the different educational levels, the Higher Secondary School years have been the most neglected in creative research. Information accumulated concerning the pre-school and elementary school years because of interest in the 'Creative Imagination'. But educators appear to have had much less interest in the 'Creative Imagination' of the Higher Secondary School Students. Information is also accumulated concerning creative during the college years, because many outstanding creative scientists, Writers and Performers of many kinds began their productivity during these years and because it has been deemed appropriate for colleges to produce professionally trained people who make creative contributions exist for high Schools. In order to develop the creative thinking in the students, teacher should identify their Brain Hemispheric Dominance. It is accepted fact that creative thinking is seated in the Right Brain Hemisphere.

ACHIEVEMENT IN MATHEMATICS

In this modern age, achievement is considered as a key factor for Personal progress. Moreover, the whole system of education revolves around Achievement. Achievement of pupil in Mathematics indicates the level of attainment in various Mathematics activities planned as part of the Mathematics Curriculum.

Mathematics is the queen of Science. If we consider Science as a language, then Mathematics is its grammar. Achievement in Mathematics need special attention as it forms the basis for the successful performance in other studies. Achievement Mathematics in normally assessed by the student's ability to recall the mathematical concepts and his ability to apply the concepts and rules in mathematical problem solving.

Since Mathematics plays an important role in the school curriculum, the assessment of the subject is very essential. Mathematical Achievement contributes a great deal to the overall achievement.

1.4 FACTORS ASSOCIATED WITH THE PROBLEM SOLVERS

(a) Past Experience

The level of proficiency gained through some learning or training of one or other types of problems always works as a dealing factor for the problem solving in Mathematics.

(b) Motivational Level

The interest and motivation are known as the key factors or moving forces behind any activity carried out by the individual. These factors in terms of seeking the desired goals, motives, satisfaction of needs etc. induce him to find a solution to his problem.

(c) Role of Memory

One of the powerful strategies in solving problems is the efficient use of memory. Appropriate strategies depend on the level of material involved and the conditions under which the information must be remembered.

(d) Creativity

Creative Pupils are Sensitive to Problems. They also learn strategies needed to solve the Problems, they inevitably encounter. If one solution does not work, they immediately work for new combinations or new ways of attacking the Problem.

(e) Mind Set

Mind Set may be regarded as a way of perceiving things in the light of mental images already fixed in one's mind on Past Experiences. Consequently influenced by one's Mental Set, he/she tries to solve a Problem.

INFLUENCE OF SOME OTHER FACTORS ON BRAIN HEMISPHERICITY AND CREATIVE THINKING

Selected variable such as Gender, Socio Economic Status, and Region, Stream of Study and School Pattern could either enhance or constrain one's preference of Brain Hemisphericity in learning and thinking.

GENDER

Gender is a key parameter of recognition in all cultures. It is a focal point and an organizing man or woman, at the core of social values lives and our inner selves.

'Sex' is a biological term; 'Gender' a psychological and cultural one. They are merely two ways of looking at the same division. To be a Man or a woman, a boy or a girl, is as much a function of dress, gesture, occupation, social network and personality, as it possesses a particular set of genitals.

Anthropologists have reported wide variations in the way different cultures define gender. It is true that every society uses biological sex as a criterion for the aspiration of gender, but beyond that starting point, two cultures agree completely on what distinguishes one gender from the other. Every society believes that its own definition of gender-corresponds to the biological duality of sex. Culturally the same distinctions are found between males and females, co-existing with greater variations in gender roles.

Social shaping is utmost importance in children's acquisition of sex typed behavior. This acquisition is related to certain sex-linked biological pre-disposition also. Adults and other children have exception when conveyed to the child; influence his behavior through rewards, punishments and initiations of

adult models. Boys are encouraged to copy their fathers, girls and their mothers. Subsequently children find that modeling their behavior on the sex parent is rewarding in and of itself. As self-categorization occurs early in life and forms the basis upon which children order their experience it is nearly impossible to change the child's belief about his Gender after the age of three.

Gender difference in brain preference of learning and thinking have been explored extensively both in India and Abroad. It is a key parameter of recognition in all cultures. The differential treatment given to girls children by parents and society in India might reduce their motivation for learning.

MEDIUM OF INSTRUCTION

According to the dictionary meaning, Medium of Instruction refers to that by which instruction or teaching is expressed. The medium should enable the students to acquire knowledge with facility, to express them with clarity and to think with precision and vigour. The satisfaction of one's interests, the gaining of experience, and the development of the power to participate in higher terms of utilization of language.

India is a multi linguistic nation. It had assimilated various languages. Now we can hear a battle cry in the system of education about the Medium of Instruction of which medium is most preferable mother tongue or English.

It is agreed on all hands that the mother tongue is the best Medium of Instruction. Indian Education Commission (1964-66) recommended the use of mother tongue as the medium of Instruction up to the highest level of Education.

However, we cannot neglect the importance of English in to the modern technology world. It is rightly regarded as the key to the storehouse of knowledge books on all branches of knowledge through this medium.

TYPE OF SCHOOLS:

"The destiny of the nation is shaped in the class rooms," states the Report of Education Commission. The products of our schools are the future citizens in whose hands the destiny of the nation is entrusted. So in post independent period Indian evolved in own system of education, which suited to its cultural background and met its socio-economic man power and other needs. A national curricular framework is also introduced in all over the country under a new Education policy. From the point of view, the schools can be of different types. There are schools maintained by

a) Central Government
b) State Government
c) Municipal Corporation
d) Direct beneficiaries (student paying fees)
e) Religion and charitable institutions and
f) Internal agencies

Each of these different types of school has its own unique organizational problems and its own particular structural arrangements, which influence the management of the system, the effectiveness of teachers, students and growth competence elements.

i) RECOGNIZED SCHOOLS:

A recognized schools is one in which the course(s) of study followed is/are prescribed or recognized by the Government (central /state) or university or a board constituted by the central or any other agency authorized by the central or state government and which satisfies one or more of the authorities (i.e.) Directorate of Education, Municipal boards, Secondary Board with regard to its standard of efficiency. It runs Classes and sends candidates for public examination.

ii) GOVERNMENT SCHOOLS:

All schools run by the state or central government public undertakings and autonomous organizations completely financed by government will be treated as Government schools.

iii) AIDED SCHOOLS:

The private schools which are (partially) controlled and financed by Government are called Aided Schools.

iv) PRIVATE SCHOOLS

School set up, controlled administered and financed by private bodies come under private schools.

REGION

The Rural and Urban environment produces difference in learning ability. The difference in learning of Rural and Urban children is due to the range of situations available to them. In cities number of learning resources such as libraries, magazines, TV programmes, recreational and social activities are available to children, whereas children who live in Rural areas have very limited access to such sources of learning. This could considerably influence their thinking and performance.

STREAM OF STUDY

Mathematics is concerned with the activity of people in the world around us. It would be of most interesting to investigate the Brain Hemisphericity of pupils if Mathematics groups in relation to their achievement.

SOCIO – ECONOMIC STATUS

Socio – Economic status can be defined as "the individuals" relative position in the community (Chaplin, 1968). It is an indication of one's position of respect, prestige and influence in the social structure, which may either inhibit or enhance an individual's access to sources of information and his

willingness to deviate from great norms. Economic status stratifies modern population according to the amount and source of income, which is usually derived from a set of occupational activities, The Ownership of property or both.

NEED AND SIGNIFICANCE OF THE STUDY

Teacher Education is vital for the development of a country. The quality of education provided in a country depends to great extent on the quality of the teacher education programme. A nation is built by citizens, citizens are molded by teachers and teachers are made by teacher educators. NPE (1986**)** stated "No people can rise above the level of its teachers". (C.F.Educatracks, July 2003, P.16). So far the development of the country, it is very important to have teachers, and it can be produced only if we have good system of teacher education. The report of the UNESCO entitled "Learning: the treasure with in (1996)" elaborates the role of teachers of tomorrow and the possible strategies which may help then in discharging their professional and social functions and obligations.

Our educational system and modern society generally discriminates against one whole half of the Brain. In school education, the attention given to the minor hemisphere of the Brain in minimal compared with the training lavished on the Left or Right Hemisphere. Also the teaching methods, at all levels of education, tend to foster common intellectual skill: thinking the world to pieces. This skill is very essential but thinking the world to pieces is only half of understanding. The curriculum and learning materials adopted in the schools in the past and present are investigative to develop only one part of the Brain i.e., Left hemisphere and the other part of the Brain i.e., the Right Hemisphere is Left untouched.

The researches in Hemisphericity and learning, (Reynold and Torrance, 1978) have suggested that it is possible to modify a person's preferred style of learning and thinking and can train the individual to modify their information processing procedures to improve their performance. Therefore, it is important for teacher trainees to have knowledge of their own Brain Hemisphericity in order to identify advantages and disadvantages in their teaching techniques. In addition, knowledge of their own Brain Hemisphericity can assist them in becoming more flexible and effective in teaching in the class room.

According to our Prime Minister Rajiv Gandhi, "India had achieved tremendous progress in the field of science and technology since independence but the vast resource, namely the pupil, had remained undeveloped".

The main aim of education has always been the total development of the student's creativity. Our schools have been doing almost nothing to nourish the creative potential of children, which is the most important need of today.

The higher objectives of education is the all round development of the creativity of the child. The development of creativity is determined not only by heredity and environment.

Since the educational system today is very much result oriented, it is not important to nurture individuals who have a good creativity. It is only a child with a positive creativity and interest who shines in its academic and future career.

This investigation, it is hoped, will highlight intelligence as well as problem-solving ability of the high school students in relation to their Achievement in Mathematics. Hence, this study will have wider educational implications.

Further, this study is intended to generate thoughts and ideas among the teaching fraternity for effective and fruitful utilization of pupils' potentialities that have to be nurtured in consonance with academic achievement, to train them to face life and its problems successfully and courageously.

The relationship between Hemisphericity of creativities and their Achievement in Mathematics will help the teachers to modify the context and the teaching techniques. Based on this Idea, the investigator wanted to identify and find out the influence of Brain Hemisphericity on Mathematics Achievement. This has motivated the investigator to identify the problem of the study as follows.

THE TOPIC AND DEFINITIONS OF THE TERMS

Statement of the Problem

The Problem is entitled **"Brain Hemisphericity and Creative Thinking as related to Achievement in Mathematics among XI Standard Students".**

Operational Definitions of the Terms

The operational definitions of the important terms used in the present study are given below

Brain Hemisphericity

It refers to the score obtained by the students in the test "Style Of Learning And Thinking" (SOLAT) constructed by Venkataraman (1994).

Creative Thinking

It refers to the score obtained by the students in the test

1. Activity-I-Consequences Test-What will happen if…
2. Activity-II Un usual uses Test-Novel uses of things
3. Activity- III New relationships Test-Similarities
4. Activity-IV Just think why Test

Constructed by Dr.V.P.Sharma and Dr.J.P.Shukle (Rajpur)

(a) Mathematics Achievement

It refers to the marks in Mathematics scored by the students in their XI standard Quarterly Examination.

Gender: It refers to the sex of the student Male or Female.
Region: It refers to the area of the Rural and Urban.

Socio-Economic Status: It refers to educational qualification of Father and Mother, Occupation of Father and Mother, Monthly Income of Father and Mother.

School Type: It refers to Government, Aided and Private Schools considered in the present investigation.

Stream of Study: It refers to the Mathematics (Bio Mathematics and Computer Science Mathematics, Business Mathematics) group considered in the present investigation.

OBJECTIVES OF THE STUDY

The study aims at the followings objectives
To investigate the correlation between

- Right Brain Hemisphere
- Left Brain Hemisphere
- Creative Thinking
- Achievement in Mathematics

To examine the differences in Right & Left Brain

Dominance and Creative Thinking owing to the differences in

- Gender
- Region
- School Type
- Stream of Study
- Socio-Economic Status

To examine the differences in Mathematics

Achievement owing to the differences in

- Gender
- Region
- School Type
- Stream of Study
- Socio-Economic Status
- Brain Dominance
- Creative Thinking

To investigate the relationship between Right Brain Hemisphericity, Left Brain Hemisphericity, Creative Thinking and

- Gender
- Region
- School Type
- Stream of Study
- Socio-Economic Status

To investigate the relationship between Achievement in Mathematics and

- Gender
- Region
- School Type
- Stream of Study
- Socio-Economic Status
- Brain Dominance
- Creative Thinking

To examine the difference between the High and Low Achievers of Mathematics with reference to

- Right Brain Hemisphere
- Left Brain Hemisphere
- Creative Thinking

LIMITATIONS OF THE STUDY

- The study was limited only ten Schools in Chennai.
- The study included three Government Schools, three Aided Schools and four Private Schools only
- The samples selected from Rural and Urban areas.
- The sample was restricted in Chennai.
- The sample was limited in XI standard 635students were chosen for this study.(Boys-318&Girls-317)
- Standardized Test Materials alone were used in this investigation. The investigator did not develop any Psychological Tests for investigation purpose.

The discussion on "**Brain Hemisphericity and Creative Thinking as related to Achievement in Mathematics among XI Standard Students"** has been presented to high light the conceptual positions with which this study has been planned and conducted.

Research Design

Method of Study	Variables	Tools	Sample	Type of Analysis
Qualitative and Quantitative	Brain Hemisphericity	Style Of Learning And Thinking – Venkataraman (1994)	Total -635, Boys-318, girls-317	Descriptive Analysis, Inferential Analysis and Differential Analysis
	Creative Thinking	Scientific Creativity with Words- Dr.V.P.Sharma and J.P.Shukla (1985)		
	Achievement in Mathematics	Quarterly Examination Marks in Mathematics collected by School Mark Register.		
	Personal Variables	Personal Data Sheet		

DESIGN OF THE STUDY

Research design is a catalogue of the various phases relating to the formulation of a research effort. It is an arrangement of the essential conditions for collection and analysis of the data and forms the aims to combine relevance to research purpose with economy of procedure. The present study entitled "Brain Hemisphericity and Creative Thinking as related to Achievement in Mathematics among XI Standard Students" has been designed as a descriptive study**.** Best (1983) stated "Descriptive research deals with the relationship between variables, testing of hypotheses and development of generalization, principles or theories that have universal validity. (P.106) Hence the present study "Brain Hemisphericity and Creative Thinking as related to Achievement in Mathematics among XI Standard Students" has been designed as a descriptive study.

DESCRIPTION OF TOOLS

For the present investigation two standardized psychological tests were used to collect data.

(i) "Style Of Learning And Thinking" prepared and standardised by Venkataraman (1994)

(ii) The standardized test "Scientific Creativity with Words" by Dr.V.P.Sharma and J.P.Shukla (1985) was used to measure scientific creativity.

(iii) Quarterly Examination Marks in Mathematics collected by School Mark Register.

(iv) Personal Data Sheet prepared by the investigator to collect information on the selected Personal Variable.

TOOL- I - Style Of Learning And Thinking (SOLAT)

"Style Of Learning And Thinking" prepared by Venkataraman (1994) was used for finding the Brain Dominance of an individual. This tool has been designed to assess the preferred Brain Dominance of students.

The difference in preference of the two hemisphere for information processing have been referred to a Style of Learning and Thinking, Venkatraman (1994) and Torrance (1977) have developed the SOLAT tool based on the Hemisphericity functions of the Brain. It identifies hemisphere Dominance by way of studying the hemisphere functions. It indicates a student's learning strategy and Brain hemisphere performance.

The tool consists of fifty items designed to access the Brain Dominance of an Individual. For each item, there are two statements and four ways to respond. There is no time limit. But normally it takes thirty minutes for giving responses. Sample item is given below. (A copy of the tool in Appendix 'A').

Sample Items.

1. I understand clearly the information passed through by actions a□
2. I understand clearly the information passed through by words b□

Structure

The numbers of items in each dimension of learning the thinking styles are given in Table 3.2

Table 3.2 Dimensions of Learning and Thinking Styles

S.No	Dimensions	No of items and serial no of items
Learning Style		
1	Verbal	5 (1 to 5 items)
2	Content preference	5 (6 to 10 items)
3	Class preference	5 (11 to 15 items)
4	Learning preference	5 (16 to 20 items)
5	Interest	5 (21 to 25 items)
Thinking Style		
6	Logical/Factorial	5 (26 to 30 items)
7	Divergent/Convergent	5 (31 to 35 items)
8	Creative	5 (36 to 40 items)
9	Problem Solving	5 (41 to 45 items)
10	Imagination	5 (46 to 50 items)
Total No. of items		50

Reliability

The author of the tool measured the reliability of the tool by test-retest method. One month after the first test, retest was conducted to 635 students consists of 318 Boys and 317 Girls. The reliability co-efficient of correlation for the Right hemisphere function was found to 0.89. For the Left hemisphere functions, the co-efficient of correlation was found to be 0.65. The coefficient of correlation for integrated score was 0.71. These co-efficient suggests that SOLAT posses reliability to a significant level. The reliability coefficient as given in the manual as described above was accepted as the reliability of the tool.

Validity

The SOLAT tool was constructed and validated with the help of standardised SOLAT tool constructed by Paul Torrance. To find out the validity of the tool both the SOLAT tools (i.e., Tool prepared by Paul Torrance and tool prepared by Venkatraman) were administered to 635 subjects. The correlation between the two tests scores was 0.842 for the Right hemisphere part; 0.621 for the Left hemisphere part and 0.678 for integrated part. The correlation coefficient reveal that SOLAT tool possess high level of concurrent validity.

Scoring Procedure

Scoring was done as per the procedure and key given in the manual. There are 50 items in the tool. For each items, there are two statements and 4 ways to respond. Students are required to record their responses in the blank space on the test sheet. In the tool, against series number 1 to 50, checking of the first item indicates Right Hemispheric Dominance and checking of both the items indicates integrated hemisphere or whole Brain. The Hemisphericity Dominance was determined on the basis of the highest score in three categories.

TOOL – II – Verbal Test of Scientific Creativity

The standardized test "Scientific Creativity with Words" by Dr. V.P. Sharma and J.P. Shukla (1985) was used to measure scientific creativity. The verbal test of scientific creativity includes four subtests, namely consequences test, unusual uses test, New relationship test and just think why test? These four subtests are groups under four "Activities". The four activities have three items each. Each activity measures fluency, flexibility and originality of students. (A copy of the Personal data sheet is given in Appendix 'B').

Sample Items

Task I: Consequences Test

1. What would happen if there is no land on the earth?
2. What would happen if there is no bone in human body?

Task II: Unusual Uses Test

1. Finger Nails-Utility
2. Water-Utility

Task III: New Relationship Test

1. Sugar and salt
2. Dog and Cat

Task IV: Just Think Why Test

1. Under what conditions population of heart shoots up?
2. Under what conditions a man cannot express himself?

Reliability

The author of the tool measured the reliability of the tool by test-retest method. Here the test battery was administered to 100 students in school twice with a gap of 10 days. The coefficient of correlation between the two sets of scores was found to be 0.82 indicating the high reliability of the test battery.

Validity

The square tool of the reliabilities coefficient is a measure of the validity of the tool (Garrett 1969). Therefore the validity of the test was found by computing the square root of the co-efficient of reliability and it was found to be 0.90 indicating the high validity of the test battery.

Administration and Scoring Procedure

After explaining the purpose of the test, clear instructions as to how the test item should be responded were given to the students. The total time required for the administering the test is 50 minutes in addition to the time necessary for giving instruction, passing out test booklets to students and getting them back. The students were allowed to write their response in Regional language and in English.

As there is no Right or wrong responses for the test, much care was exercised at the time of scoring while scoring the test on Creative Thinking, each item scored for fluency, flexibility and originality as per the directions given in the scoring guide. The procedure given in the scoring sheet, to summaries scores for fluency, flexibility and originality obtained by testing in different activities was followed. The composite creative scores could be computed after converting raw score into standard scores by the statistical procedure given in the scoring guide. To obtain the total score for Creative Thinking for each students, the sum of standard scores for originality, fluency and flexibility were taken. The score range from 101 to 265.

TOOL – III - Personal Data Sheet

To collect the information on selected Personal variables, Personal data sheet was prepared by the investigator and was distributed among the XI standard students. Ten minutes time was given to fill the Personal data sheet (A copy of the Personal data sheet is given in Appendix 'C').

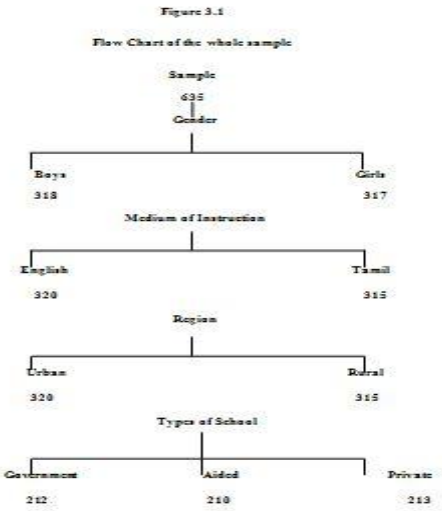
No separate tool was prepared by the investigator to measure the Achievement in Mathematics. The marks scored in Mathematics by the subjects in their quarterly examination conducted by the school as recorded in the school register was taken as the achievement scores in Mathematics.

SELECTION OF SAMPLE

The sample for the study was selected randomly. Representative sample of 635 students from XI standard were selected in Government school, Aided school and Private school in Rural and Urban areas.

A total number of samples 635 were selected of width 320from Urban and 315 from Rural. There are 212 Government Institutions, 210 Aided Institutions and 213 Private Institutions included in the Sample.

Figure 3.1 Flow Chart of the whole sample



The sample constituted of 635 XI Standard students drawn from ten schools from Rural and Urban areas. The institute wise distribution of sample is given in Table 3.3.

Table 3.3 School wise Distribution of Sample

S.No	Name of the School	Types of school	Sample		Total
			Boys	Girls	
1	Government Higher Secondary School, M.G.R Nagar.	Government	50	51	101
2	Government Higher Secondary School, Kundrathur.	Government	-	55	55
3	Government Higher Secondary School, Thirumalisai	Government	37	19	56
4	M.G.R Higher Secondary School, Kodambakkam.	Aided	50	21	71
5	Dr.K.K.Nirmala Girls Higher Secondary School, K.K.Nagar.	Aided	-	38	38
6	Sr Ramasamy Mudaliar Higher Secondary School, Ambattur,	Aided	53	48	101
7	St.Antony Matriculation Higher Secondary School, Kottivakkam.	Private	39	24	63
8	Amutha Matriculation higher Secondary School, Thirunindravur.	Private	29	18	47
9	Vidyaniketan Matriculation Higher Secondary School, Ashok Nagar.	Private	18	12	30
10	Velankanni Matriculation Higher Secondary School, Ashok Nagar.	Private	42	31	73
Total			318	317	635

Sample for the study has been selected following random sampling technique. The sample consisted of 317 Boys and 318 Girls. The distribution of the sample based on selected Personal variable is shown in Figure 3.1.

DISTRIBUTION OF SAMPLE ACCORDING TO THE SELECTED PERSONAL VARIABLES

The sample was classified on the basis of selected Personal variable and their sub divisions. The Table 3.4 represents the distribution of the sample according to the selected Personal variables.

Table 3.4 Distribution of Sample according to Selected Personal Variables

Variables	Sub-Categories	Size N	Percentage
Gender	Male	318	50.1
	Female	317	49.9
Region	Rural	315	49.6
	Urban	320	50.4
School/Management Type	Private	213	33.5
	Aided	210	33.1
	Government	212	33.4
Medium of Instruction	Tamil	315	49.6
	English	320	50.4
Socio-Economic Status	Low	167	26.3
	Average	315	49.6
	High	153	24.1

The sample was classified on the basis of selected Personal variable and their sub divisions. The Figure 3.2 represents the distribution of the sample according to the selected Personal Variables.

COLLECTION OF DATA

The "Thinking Creatively with Words" was administered first. After highlighting the purpose of the test, clear instructions and directions as to how the items in the test should be responded were given. After completion, the response sheets were collected back.

The "Style Of Learning And Thinking" was administered immediately after the administrations of "Thinking Creatively with Words" clear instructions were given to the XI standard students as to how the response sheet of SOLAT. After completion, the response sheets were collected back and the Quarterly marks collected from class teacher Mark Register.

To collect data for the present study, the investigator visited 10 higher Secondary School. After obtaining the permission from the heads of the Institution and ensuring the cooperation of the teaching faculty the investigator administered the tools to the students.

To collect the information on selected Personal variables namely Gender, Medium of Instruction, School Management Type, Socio-Economic Status, the Personal data sheets were distributed among the students. Ten minutes time was given to fill the Personal data sheet.

CRITERIA FOR CLASSIFICATION OF DATA

Criteria for classifying the sample as per their levels of Mathematical Achievement, Creative Thinking and Socio-Economic Status of the Parents were fixed. The criteria were arrived at by computing quartile deviation and it is presented in the Table 3.5.

Table 3.5 Criteria for Classification of Data according to varying levels of Mathematical Achievement, Creative Thinking and Socio Economic Status

Variable	Levels	Criteria	Range
Mathematical Achievement	High	>Q3	>63
	Average	Between Q1 & Q3	Between 48 - 63
	Low	< Q1	<48
Creative Thinking	High	>Q1	>195
	Average	Between Q1 & Q3	Between 169 - 195
	Low	>Q1	<169
Socio Economic Status	High	>Q3	>18
	Average	Between Q1 & Q3	Between 11 -18
	Low	<Q1	<11

STATISTICAL TREATMENT OF DATA

The major functional variables for analysis and interpretation of data include Mathematical Achievement, Creative Thinking & Brain Hemisphericity and Personal Variables include Gender, Region, School type, Medium of instruction, Socio Economic Status.

The following statistical techniques were used for analysis and interpretation of data.

(i) Descriptive Analysis

In the initial analysis of the data, the XI standard students were classified into various groups and subgroups on the basis of different selected variables. Mean and standard deviations were calculated for the whole sample as well as for the sub sample.

(ii) Critical Ratio
(iii) One-way Analysis
(iv) Chi-Square Analysis
(v) Correlation Analysis
(vi) Regression Analysis
(vii) Discriminate Analysis

Discriminate Function Analysis was selected for discriminating between high and low Creative Thinking of students.

ANALYSIS AND INTERPRETATION

"Analysis of the data is an important as any other components of the research process. Regardless of how well the study is conducted, in appropriate analysis can lead to in appropriate conclusions,"

According to Mouly (1964), "Research data become meaningful in the process of being analyzed and interpreted". Francis Rummel (1972) has said, "The analysis and interpretation of data involve the objective material in the possession of the researches and his subjective reactions and desires to derive from the data the inherent meanings in their relation to the problem", however valid, reliable and adequate the data may be, it does not serve any worthwhile purpose unless it is carefully edited, systematically classified and tabulated, scientifically analyzed, intelligently interpreted and rationally concluded.

This chapter deals with the statistical analysis of the data with reference to the hypothesis that were formulated. Interpretations are also made to account for the results. The choice of statistical techniques for data analysis is largely determined by the research hypotheses to be tested. Statistical analysis of the data was done using SPSS package.

DESCRIPTIVE ANALYSIS OF THE DATA

Six hundred and thirty five students drawn from the IX-standard, selected from Government, Aided and Private School of Rural and Urban area in Tamilnadu constituted the sample. The variables studied in the present investigation are Brain Hemisphericity, Creative Thinking and Achievement in Mathematics with reference to some selected variables namely Gender, Medium of Instruction, Types of School, Region and Socio-Economic Status.

After the data was collected, it was classified according to the various levels of Creative Thinking and Mathematical Achievement. Mean and Standard Deviation of the scores for the variables namely Creative Thinking and Mathematical Achievement were computed for the whole sample as well as the sub sample classified on the basis of the selected Personal variables and Brain Hemisphericity.

Table 4.1.1 Classification of whole sample according to varying levels of Mathematical Achievement and Creative Thinking

Variables	Levels	Frequency	Percentage
Mathematical Achievement	High	163	**26.1**
	Average	297	48.9
	Low	175	25
Creative Thinking	High	159	25.7
	Average	310	46.8
	Low	166	27.6
Total		635	100.0

Table 4.1 reveals that out of 635 students 297 students fall under average Mathematical Achievement category and 163 students fall under high Mathematical Achievement category. It is also seen that 310 students possess average Creative Thinking and 159 students possess high Creative Thinking.

Table 4.1.2 Classification of whole sample according to Brain Hemisphericity

Level of Brain Hemisphericity	Frequency	Percentage
Right Brain	304	47.9
Left Brain	331	52.1
Total	635	100.0

Table 4.1.2 reveals that out of 635 students 331 students having Left Hemispheric Dominance and 304 students having Right Hemispheric Dominance.

Table-4.2.2 Category wise Mean and Standard Deviation of Creative Thinking

S. No	Variables	Category	N	Mean	SD
1.	Gender	Boys	318	61.87	17.69
		Girls	317	63.48	18.44
2.	Region	Urban	320	61.57	17.58
		Rural	315	63.80	18.52
3.	Types of School	Government	212	65.23	19.05
		Aided	210	64.02	17.33
		Private	213	58.79	17.21
4.	Medium of Instruction	English	320	60.93	18.11
		Tamil	315	64.44	17.89
5.	Socio-Economic Status	High	153	58.44	17.00
		Average	315	63.40	17.95
		Low	167	65.19	18.70
6	Brain Hemisphericity	Right Brain	304	64.30	17.86
		Left Brain	331	61.18	18.164

Mean and Standard Deviation presented in Table 4.2.2 indicate that Mean of Creative Thinking are not equal for students classified on the basis of various selected variables and other sub-categories.

The analysis of Mean values presented in Table 4.2.2 reveals slight difference in the values of Creative Thinking for Boys (63.48) and Girls (61.87). Mean score of Girls is slightly greater than that of Boys.

The Mean of the sub samples classified on the basis of Region shows that the Rural students have higher Creative Thinking mean score than those Urban students.

The Mean of the sub samples classified on the basis of School Management Type shows that Government School (65.23) students have the higher Creative Thinking mean score in comparison with that of Aided (64.02) and Private (58.79) School students. Thus, the School Management Type appears to affect the Creative Thinking.

The Mean of the sub samples classified on the basis of Medium of Instruction reveals slight difference in the values Creative Thinking for Tamil and English medium students.

Mean score of Tamil Medium is slightly greater than that of English Medium.

The study of the Mean of Creative Thinking of the sub samples classified on the basis of the Socio-Economic Status of their parents' shows that there is only slight variations in the of varying groups of the students.

The Mean of the sub samples classified on the basis of Brain Hemisphericity shows slight difference in the values of Creative Thinking for Right and Left Hemispheric Dominance. Mean score of f Creative Thinking for Right Hemispheric Dominant is slightly greater than that of Left Hemispheric Dominant students. The value of Standard Deviation shows homogeneity of the two groups.

Table 4.3.3't' ratio for differences in Creative Thinking owing to differences in Selected Variables

Variables	Category	N	Mean	SD	Critical ratio	LOS
Gender	Boys	318	92.18	37.142	3.789	0.01
	Girls	317	103.56	38.561		
Region	Urban	320	91.11	39.852	4.553	0.01
	Rural	315	104.72	35.320		
Medium Of Instruction	English	320	97.82	38.064	0.031	NS
	Tamil	315	97.91	38.506		
Brain Hemisphericity	Left Brain	331	99.46	36.143	1.097	NS
	Right Brain	**304**	**96.13**	**40.415**		

Since the calculated value of't' (3.789) is greater than the table value (2.58) at 0.05 level of significance for degree of freedom 633, the null hypothesis is not accepted. Thus there is significant difference between Boys and Girls in their Creative Thinking.

Since the calculated value of't' (4.553) is greater than the table value (2.58) at 0.05 level of significance for degree of freedom 633, the null hypothesis is not accepted. Thus there is significant difference between Urban and Rural in their Creative Thinking.

Since the calculated value of't' (0.031) is less than the table value (1.96) at 0.05 level of significance for degree of freedom 633, the null hypothesis is accepted. Thus there is no significant difference between English and Tamil Medium Students in their Creative Thinking.

Since the calculated value of't' (1.097) is less than the table value (1.96) at 0.05 level of significance for degree of freedom 633, the null hypothesis is accepted. Thus there is no significant difference between Right Brain and Left Brain in their Creative Thinking.

To study the differences in Creative Thinking of students owing to differences in School Management Type and Socio-Economic Status. Analysis of Variance was carried out and the results are presented in Table 4.3.4.

Table 4.3.4 One-way ANOVA showing the differences in Creative Thinking of students owing to differences in School Management Type and Socio-Economic Status

Variable	Category	N	Mean	SD	F Value	LOS
School Management Type	Government	212	92.15	39.634	3.781	0.05
	Aided	210	99.56	37.635		
	Private	213	101.88	36.941		
Socio-Economic Status	High(>13)	153	104.29	35.945	4.303	0.05
	Average(10-13)	315	97.96	37.936		
	Low(<13)	167	91.80	40.106		

Since the calculated value of 'F' (3.781) is greater than the table value of 'F' (3.01) at 0.05 level of significance for degrees of freedom 634, the null hypotheses is not accepted. Hence, there is significant difference between Mathematics Achievement and Types of School.

Since the calculated value of 'F' (4.303) is greater than the table value of 'F' (3.01) at 0.05 level of significance for degrees of freedom 634, the null hypotheses is not accepted. Hence, there is significant difference between Mathematics Achievement and Socio-Economic Status.

The 'F' ratio presented in Table 4.3.4 indicates that there is no significant difference in Creative Thinking of students owing to differences in School Management Type and Socio-Economic Status.

H4. There is no significant association between Mathematical Achievement and all selected Personal Variables namely Gender, Region, Medium of Instruction, School Management Type, Socio-Economic Status and Brain Hemisphericity.

There is no significant association between Creative Thinking and Gender.

Table 4.3.11 Chi-Square Table showing the Association between Creative Thinking and Gender

Sex	Level of Creative Thinking			Total	Chi-Square Value	LOS
	Low	Average	High			
Boys	92	162	64	318	13.260	**0.01**
	(28.9)	(50.9)	(20.1)			
	[579]	[52.3]	[38.6			
Girls	86	144	87	317		
	(211)	(46.7)	(32.2)			
	[42.1]	[47.7]	[61.4]			
Total	159	310	166	635		

Note: 1. The value within ( ) refer to Row Percentage**.**
Note: 2. The value within [ ] refer to Column Percentage**.**

Since the calculated value of Chi-Square (13.260) is greater than the tabulated value of Chi-Square (5.991) at 0.01 level of significance for degrees of freedom 2, the null hypothesis is not accepted. Thus there is significant association between Creative Thinking and Gender.

There is no significant association between Creative Thinking and Region.

Table 4.3.12 Chi-Square Table showing the Association between Creative Thinking and Region

Region	Level of Creative Thinking			Total	Chi-Square Value	LOS
	Low	Average	High			
Urban	101	151	68	320	17.219	**0.01**
	(31.6)	(47.2)	(21.3)			
	[63.5]	[48.7]	[41.0]			
Rural	58	159	98	315		
	(18.4)	(50.5)	(31.1)			
	[36.5]	[51.3]	[59.0]			
Total	**159**	**310**	**166**	**635**		

Note: 1. The value within ( ) refer to Row Percentage**.**
Note: 2. The value within [ ] refer to Column Percentage**.**

Since the calculated value of Chi-Square (17.219) is greater than the tabulated value of Chi-Square (9.210) at 0.01 level of significance for degrees of freedom 2, the null hypothesis is not accepted. Thus there is significant association between Creative Thinking and Region.

There is no significant association between Creative Thinking and Medium of Instructions.

Table 4.3.13 Chi-Square Table showing the Association between Creative Thinking and Medium of Instructions

Medium of Instructions	Level of Creative Thinking			Total	Chi-Square Value	LOS
	Low	Average	High			
English	84	150	86	320	1.010	**NS**
	(26.3)	(46.9)	(26.9)			
	[52.8]	[48.4]	[51.8]			
Tamil	75	160	80	315		
	(23.8)	(50.8)	(25.4)			
	[47.2]	[51.6]	[48.2]			
Total	**159**	**310**	**166**	**635**		

Note: 1. The value within ( ) refer to Row Percentage**.**
Note: 2. The value within [ ] refer to Column Percentage**.**

Since the calculated value of Chi-Square (1.010) is less than the tabulated value of Chi-Square (5.991) at 0.05 level of significance for degrees of freedom 2, the null hypothesis is accepted. Thus there is no significant association between Creative Thinking and Medium of Instructions

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There is no significant association between Creative Thinking and Types of School.

Table 4.3.14Chi-Square Table showing the Association between Creative Thinking and Types of School

Types of school	Level of Creative Thinking			Total	Chi-Square Value	LOS
	Low	Average	High			
Government	64	102	46	212	6.131	**NS**
	(30.2)	(48.1)	(21.7)			
	[40.3]	[32.9]	[27.7]			
Aided	48	105	57	210		
	(22.9)	(50.0)	(27.1)			
	[30.2]	[33.9]	[34.3]			
Private	47	103	63	213		
	(22.1)	(48.4)	(29.6)			
	[29.6]	[33.2]	[38.0]			
Total	**159**	**310**	**166**	**635**		

Note: 1. The value within ( ) refer to Row Percentage**.**
Note: 2. The value within [ ] refer to Column Percentage**.**

Since, the calculated Chi-Square value (6.131) is less than the value of Chi-Square value (13.277) at 0.05 level of significance for degrees of freedom 4, the null hypotheses is accepted. Hence, there is no significant association between Creative Thinking and Types of School.

There is no significant association between Creative Thinking and Socio-Economic Status.

Table 4.3.15Chi-Square Table showing the Association between Creative Thinking and Socio-Economic Status of the Parents

SES	Level of Creative Thinking			Total	Chi-Square Value	LOS
	Low	Average	High			
Low	51	82	34	167	8.097	0.05
	(30.5)	(49.1)	(20.4)			
	[32.1]	[26.5]	[20.5]			
Average	79	152	84	315		
	(25.1)	(48.3)	(26.7)			
	[49.7]	[49.0]	[50.6]			
High	29	76	48	153		
	(19.0)	(49.7)	(31.4)			
	[18.2]	[24.5]	[28.9]			
Total	159	310	166	635		

Note: 1. The value within ( ) refer to Row Percentage.
Note: 2. The value within [ ] refer to Column Percentage**.**

Since, the calculated Chi-Square value (8.097) is less than the value of Chi-Square value (13.277) at the 0.05 level of significance for degrees of freedom 4, the null hypotheses is not accepted. Hence, there is significant association between Creative Thinking and Socio-Economic Status of the Parents.

DISCUSSION OF RESULTS

In the present study it is found that there is no significant Gender difference in Mathematical Achievement of students. This finding is in conformity with the finding of D' Zurella et al (2001) and Nagalakshmi (1995) who reported that there was no significant difference between Boys and Girls in their Achievement in Mathematics. The study reveals that there is no significant difference in Mathematical Achievement for students of varying Socio-Economic Status, Rural and Urban area students and types of schools. The Chi-Square analysis also confirmed all the above findings as there is no significant association in Mathematical Achievement among students of varying Gender and Region. The study reveals that there is significant difference between the Tamil medium and English medium students, favoring Tamil medium students better than Achievement in Mathematics in English medium students. The study also shows no significant difference in Mathematical Achievement among students of Left and Right Brain Dominance. There is significant association in Mathematical Achievement among students of varying Medium of Instructions, School Management Type, Socio-Economic Status and Brain Hemisphericity.

In the present study it is found that there is significant Gender difference in Creative Thinking of students. This finding is in conformity with the finding of Upadhyaya (2008), Devi (2002) and Naik (2002) who reported that there was significant difference between Boys and Girls in their Creative Thinking. The study reveals that there is significant difference in Creative Thinking for students of varying Socio-Economic Status, Rural and Urban area students and School Management Type. The Chi-Square analysis also confirmed all the above findings as there is significant association in Creative Thinking among students of varying Gender, Medium of Instructions and Socio-Economic Status.

The study reveals that there is no significant difference between the Tamil medium and English medium students, favoring Tamil medium students better than Creative Thinking in English medium students. The study also shows no significant difference in Creative Thinking among students of Left and Right Brain Dominance. There is no significant association in Creative Thinking among students of varying Region, School Management Type and Brain Hemisphericity.

Creative Thinking focuses explainer ideas, generating possibilities, looking for many Right answers rather than just one. This is vital to successful working life. On activity like problem solving, this kind of thinking is important as it helps to choose and implement the best solution and valuables the effectiveness of the solution.

Everyone has substantial creative abilities. In adults, creativity has too often keen suppressed by various constraints but it is still there and can be reawakened. Often all that's need to be creative is to make a commitment to creative and to take the time for it. Thus the student's curriculum must be developed such that it brings out the Creative Thinking in the students.

The present study reveals that there is no significant difference in Creative Thinking of the students owing to the selected Personal variables except for Gender. It is also seen from the study that there exists a significant relation between Right Brain Hemisphericity and Creative Thinking and also negative but negligible relation between Left and Creative Thinking. So along with the curriculum focusing the development problem solving skill, development of Creative Thinking also is given importance. Creativity is original divergent thinking towards solving problem is more flexible way. It enables human beings to make inventions and helps them to find solution to challenging problems. Hence it is important to develop creativity in students

RECOMMENDATIONS FOR FURTHER RESEARCH

The following are some specific areas to which attention of further research may be undertaken:

(a) This study can be extending by consideration more independent variable like Intelligence and Problem Solving Ability in State Comparison.
(b) For the present study specified random sampling has done, it can be done utilizing other methods of sampling too.
(c) Research studies can be carried out to explore how for the problem solving skills developed in Mathematics classroom are helpful to solve life problems.
(d) Research can be carried out to explore the components of the Creative Thinking.
(e) This research can also be done with the help of other tools developed for Creative Thinking and Brain Hemisphericity can be developed by investigator itself.

CONCLUSION

This study on Mathematical Achievement, Creative Thinking and Brain Hemispheric of students indicated significant relationship among the variables. It is also seen that this study is of great relevant in these field of Mathematics Education

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