

**EFFECTIVENESS OF BRAIN-BASED LEARNING METHOD
AND CONVENTIONAL METHOD IN THE TEACHING OF
MATHEMATICS AT SECONDARY LEVEL IN PAKISTAN:
AN EXPERIMENTAL STUDY**



Name of Researcher : Aziz-ur-Rehman

Registration No. : 25 – SS/Ph.D(Edu)/03

**DEPARTMENT OF EDUCATION
FACULTY OF SOCIAL SCIENCES
INTERNATIONAL ISLAMIC UNIVERSITY
ISLAMABAD**

2011

**EFFECTIVENESS OF BRAIN-BASED LEARNING METHOD
AND CONVENTIONAL METHOD IN THE TEACHING OF
MATHEMATICS AT SECONDARY LEVEL IN PAKISTAN:
AN EXPERIMENTAL STUDY**

By

AZIZ-UR-REHMAN

25 – SS / Ph.D. (Edu) / 03

Submitted in partial fulfillment of the requirements for the
Degree of Doctor of Philosophy in Education at the Faculty
of Social Sciences, International Islamic University,
Islamabad

SUPERVISOR:

Dr. MAQSOOD ALAM BOKHARI

**DEPARTMENT OF EDUCATION
FACULTY OF SOCIAL SCIENCES
INTERNATIONAL ISLAMIC UNIVERSITY
ISLAMABAD**

2011

Approval Sheet

**EFFECTIVENESS OF BRAIN-BASED LEARNING METHOD
AND CONVENTIONAL METHOD IN THE TEACHING OF
MATHEMATICS AT SECONDARY LEVEL IN PAKISTAN:
AN EXPERIMENTAL STUDY**

By

AZIZ-UR-REHMAN

25-ss/PhD (Edu)/03

Accepted by the Department of Education, Faculty of Social Sciences, International Islamic University, Islamabad as partial fulfillment of the requirements for the award of degree “**DOCTOR OF PHILOSOPHY IN EDUCATION**”

Supervisor:

(Dr. Maqsood Alam Bokhari)

Internal Examiner :

(Dr. A.R. Saghir)

External Examiner 1:

(Dr. Tanveer-uz-Zaman)

External Examiner 2:

(Dr. Ayesha Akbar)

Head,

Department of Education,

International Islamic University,

Islamabad.

Dean,

Faculty of Social Sciences,

International Islamic University,

Islamabad.

DEDICATIONS

To my late father who is still a source
of inspiration for my family

&

To my deceased mother who died
suddenly during this research study

ACKNOWLEDGEMENTS

The researcher is profoundly thankful to Almighty Allah Whose bounties are countless and Who never places a burden, on anyone, greater than one can bear. Special favours of Almighty Allah for the researcher enabled him to avail HEC indigenous scholarship and move forward to the field of research.

The researcher considers it the best blessings of Allah in the form of sincere prayers of an adored mother who behaved consolingly with the researcher throughout her life. May Almighty Allah place her in eternal peace and rest always (ameen).

The researcher is extremely indebted to Dr. Maqsood Alam Bukhari whose ever-available guidance and technical support were frequently reflected by the researcher in the study.

The researcher is lucky enough to have such teachers, research fellows and relatives whose facilitating attitudes, corroborative supports and the best wishes respectively resulted in the accomplishment of the study work.

The researcher is very much thankful to the Principals, teachers, parents and students of FG boys model schools I-8/4 (Islamabad), I-9/4 (Islamabad) and Hummak Town (Sector Sihala) as well as to the Area Education Officer, sector Sihala, FDE Islamabad, whose nice cooperation made it possible to conduct experiments of the study smoothly.

The researcher is also grateful to HOD and all faculty members of department of education, PhD (scholar) fellows and the administrative staff for their supportive attitudes which helped researcher in completion of this study.

Aziz-ur-Rehman

ABSTRACT

Teachers have been teaching students through conventional teaching method since past many years. Everyone acknowledges that the conceptual understanding of the content is not possible under a threatening classroom environment wherein rote-learning is a common practice. The present day learner is a member of social media age which promotes availing the latest information and discarding the orthodox ideas. This study compares effectiveness of the conventional teaching method i.e. the lecture method with an innovative teaching method known as brain based learning (BBL) teaching method to teach Mathematics at secondary level.

All the 9th class students studying the subject of Mathematics at secondary level in Pakistan were the population of the study. Two secondary schools were selected through purposive sampling for smooth conduct of the experiments of the study at rural and urban areas. The independent variable of teaching methodology was manipulated into BBL and conventional teaching methods for the experimental and control groups respectively. An overall sample of 120 students was taken from both of the selected schools. Sixty students each of 9th class were selected independently from each of the two selected schools through the normal distribution of their 8th class annual examination scores. These 60 students were divided equally into experimental and control groups through simple random sampling. Thereafter, 60 students each of experimental and control groups were further categorized equally as high achievers, average achievers and low achievers through systematic random sampling.

A 2×3 factorial design was followed to conduct the study because the study contained two factors, namely teaching methodology and academic achievement. Three

chapters of 9th class mathematics textbook, containing 15 subtopics altogether, were selected to teach the selected students. The researcher developed 38 lesson plans each in light of the principles of BBL teaching method as well as conventional teaching method to teach the students of experimental and control groups respectively. A standardized 16-item academic achievement test, based on five innate faculties of human brain was administered to each group as pre-test as well as post-test. The difference between post-test and pre-test scores of each selected student was taken as academic achievement of the concerning student.

The results of the study proved effectiveness of BBL teaching method as compared to the conventional teaching method for the students of the rural school ($F(1, 28) = 146.46, p < .005$) as well as for the students of urban school ($F(1, 28) = 78.73, p < .005$). It was observed that BBL teaching method was more effective than conventional teaching method for high achievers ($t(18) = 7.877, p < .005$) of the rural school. The same effectiveness of BBL teaching method was noted for the average achievers ($t(18) = 5.399, p < .005$) as well as for the low achievers ($t(18) = 8.918, p < .005$) studying in secondary school at the rural area. For urban school students, BBL teaching method, too, remained more effective than conventional teaching method for the high achievers ($t(18) = 3.485, p = .003$), for the average achievers ($t(18) = 6.913, p < .005$) and for the low achievers ($t(18) = 4.373, p < .005$). It is, therefore, concluded that BBL teaching method is significantly more effective than conventional teaching method to teach mathematics at secondary level. The performance of the students can be enhanced if a teacher manages to activate the innate faculties of human brain of the learners in accordance with its natural physiology.

SUPERVISOR’S CERTIFICATE

It is certified that the contents and form of the thesis entitled “**Effectiveness of Brain Based Learning and Conventional Method in the Teaching of Mathematics at Secondary Level in Pakistan: An Experimental Study**” submitted by **Mr. Aziz-ur-Rehman, Registration No. 25 S.S / PhD Edu. / (03)**, have been found satisfactory for the requirement of degree.

Date:/...../.....

Supervisor: _____

(Dr.Maqsood Alam Bokhari)

LIST OF CONTENT

Title	Page No
Title Page	ii
Approval Sheet	iii
Dedications	iv
Acknowledgements	v
Abstract	vi
Forwarding Sheet	viii
List of Content	ix
List of Tables	xiii
List of Figure	xx
Abbreviations	xxi
CHAPTER 1: INTRODUCTION	01
1.1 Introduction	01
1.2 Statement of the problem	07
1.3 Objectives of the study	07
1.4 Hypothesis of the Study	08
1.5 Conceptual Framework of the Study	12
1.6 Significance of the study	14
1.7 Delimitations of the study	15
1.7.1 Limitation of the Study	16
1.8 Procedure of the Study	16
1.8.1 Population	16
1.8.2 Sample	16
1.8.3 Research Tool	17
1.8.4 Data Collection and Analysis	17
CHAPTER 2: REVIEW OF RELATED LITERATURE	19
2.1 Historical Background of Brain based learning (BBL)	
Theory	20
2.2 Definitions of BBL	25

2.3 Principles of BBL Theory and their Implications for Classroom	29
2.3.1 Application of Caine and Caine' 12 Principles of BBL Theory on Classroom	39
2.3.2.1 <i>Application of Principle 1 (P₁)</i>	40
2.3.2.2 <i>Application of Principle 2 (P₂)</i>	41
2.3.2.3 <i>Application of Principle 3 (P₃)</i>	41
2.3.2.4 <i>Application of Principle 4 (P₄)</i>	42
2.3.2.5 <i>Application of Principle 5 (P₅)</i>	43
2.3.2.6 <i>Application of Principle 6 (P₆)</i>	44
2.3.2.7 <i>Application of Principle 7 (P₇)</i>	44
2.3.2.8 <i>Application of Principle 8 (P₈)</i>	45
2.3.2.9 <i>Application of Principle 9 (P₉)</i>	45
2.3.2.10 <i>Application of Principle 10 (P₁₀)</i>	47
2.3.2.11 <i>Application of Principle 11 (P₁₁)</i>	49
2.3.2.12 <i>Application of Principle 12 (P₁₂)</i>	50
2.4 Teaching Techniques in BBL Teaching Method	51
2.4.1 Orchestrated Immersion (OI)	52
2.4.2 Relaxed Alertness (RA)	52
2.4.3 Active Processing (AP)	55
2.5 Application of BBL Theory in Developing Teaching Learning Materials	57
2.5.1. Integrated Thematic Instruction (ITI)	58
2.5.2. Power of Ten	58
2.5.3. The Five Finger Paragraph (FFP)	60
2.5.4. Science, Mathematics, Arts, Reading and Technology (S.M.A.R.T)	61
2.5.5. 4 MAT Cycle	61
2.5.6. Layered Curriculum Method of Instruction	63

2.6. BBL and Contemporary Concepts	66
2.6.1. Learning Styles	66
2.6.2. Multiple Intelligences	67
2.6.3. Peer Tutoring	68
2.6.4. Mastery Learning	68
2.6.5. Cooperative Learning	70
2.6.6. Emotional Intelligence	70
2.7. Criticism on BBL Theory	71
2.7.1 Logical Justification of BBL theory	75
2.8. Conventional Teaching Method	78
2.9. Difference Between Conventional and BBL Teaching Methods	80
2.10. Research Underpinnings for BBL and Conventional Teaching Methods	84

CHAPTER 3: RESEARCH METHODOLOGY **93**

3.1. Research Design of the Study	94
3.2. Population	95
3.3. Sample	96
3.3.1 Sampling of the Schools	96
3.3.2 Sampling of the Students	97
3.4. Formation and Equivalence of Groups	100
3.5. Selection of Text	102
3.6. Development and Validation of Lesson Plans	103
3.6.1 Lesson Plans for Control and Experimental Groups	104

3.6.1.1	<i>Classroom Layout and Grouping of Students</i>	105
3.6.1.2	<i>Instructional Objectives of Lesson Plan</i>	106
3.6.1.3	<i>Materials</i>	106
3.6.1.4	<i>Optimal Environment for Classrooms</i>	106
3.6.1.5	<i>Pre-Requisites for Brain-Compatible and Conventional Classrooms</i>	109
3.6.1.6	<i>Instructional Procedures</i>	110
3.6.1.7	<i>Product of Students</i>	111
3.7	Development of Tool of the Study	112
3.7.1	Preparation of Tables of Specification	112
3.7.2	Construction of Test Items	113
3.7.3	Validity of Test Items	115
3.7.4	Reliability of Test Items	116
3.7.5	Scoring Procedure of Test Items	117
3.8	Selection of Teachers	117
3.9	Description of Experiments of Study	117
3.9.1	Duration of Study	118
3.9.2	Teaching of Experimental and Control Groups	118
3.9.3	Equivalence of Academic Opportunities	120
3.9.4	Consent of Students and Parents	121
3.9.5	Physical Facilities Provided by the Concerning Schools	121

3.9.6	Teaching Method for Control Groups	122
3.9.7	Teaching Method for Experimental Groups	123
	3.9.7.1 <i>Generation of Enriched Environment</i>	124
	3.9.7.2 <i>Brain-Friendly Teaching Learning</i>	
	<i>Activities</i>	127
3.9.8.	Execution of Experiments	129
	3.9.8.1 <i>Orientation of the Selected</i>	
	<i>Students of Experimental Group</i>	129
	3.9.8.2 <i>Statistical Equivalence of Experimental</i>	
	<i>and Control Groups</i>	129
	3.9.8.3 <i>Administration of Pre-Test</i>	130
	3.9.8.4 <i>Teaching Learning Sessions</i>	130
	3.9.8.5 <i>Control of Variables of the Study</i>	130
	3.9.8.6 <i>Administration of Post-Test</i>	135
3.10	Analyses of Data	135
CHAPTER 4: PRESENTATION AND ANALYSIS OF DATA		138
CHAPTER 5: SUMMARY, FINDINGS, CONCLUSIONS		
AND RECOMMENDATIONS		183
BIBLIOGRAPHY AND REFERRANCES		201

LIST OF APPENDICES

APPENDIX A : The 9 th Class Students Selected as Sample from FGBMS I-8/4 (Urban Area)	209
APPENDIX B : The 9 th Class Students Selected as Sample from FGBMS Hummak (Rural Area)	210
APPENDIX C: Pre Test, Post Test and Achievement Scores of the Selected Students of FGBMS I-8/4 (Urban Area)	211
APPENDIX D : Pre Test, Post Test And Achievement Scores of the Selected Students of FGBMS Hummak Town (Rural Area)	212
APPENDIX E Research Tool of the Study	213
APPENDIX F Rubrics for Pre/Post Test (Tool of Study)	222
APPENDIX G List of Experts	223
APPENDIX H A Lesson Plan in the Perspective of Brain-Based Learning (BBL) Teaching Method	224
APPENDIX I A Lesson Plan in the Perspective of Conventional Teaching Method	239
APPENDIX J Summary of the Statistical Measurements Performed	245
APPENDIX K Plot of Comparison of the Achievement Scores of High Achievers in the Urban School	246

APPENDIX L Plot of Comparison of the Achievement Scores of Average Achievers in the Urban School	247
APPENDIX M Plot of Comparison of the Achievement Scores of Low Achievers in the Urban School	248
APPENDIX N Plot of Comparison of the Achievement Scores of High Achievers in the Rural School	249
APPENDIX O Plot of Comparison of the Achievement Scores of Average Achievers in the Rural School	250
APPENDIX P Plot of Comparison of the Achievement Scores of Low Achievers in the Rural School	251
APPENDIX Q Summary of Descriptive Statistics on Pre-Test Scores for the Selected Students of Rural and Urban Areas	252
APPENDIX R Summary of Descriptive Statistics on Achievement Scores for the Selected Students of Rural and Urban Areas	253
APPENDIX S Interaction between Teaching Methodology and the Levels of Achievement for the Selected Students at the Urban School	254
APPENDIX T Interaction between Teaching Methodology and the Levels of Achievement for the Selected Students at the Rural School	255

LIST OF TABLES

Table No.	Title	Page No
1.	Difference between BBL and conventional teaching methods	82
2.	Difference between BBL and conventional teaching methods	83
3.	Research Design of the Study	95
4.	Normal Distribution of the Students on AES	98
4.A	Selection of students as sample of the study from Urban and rural localities	100
5.	Formation of Experimental and Control Groups	101
6.	Summary of correlation between pre test scores and AES for the students of experimental group in urban school	140
7.	Summary of correlation between pre test scores and AES of experimental group in rural school	140
8.	Summary of correlation between pre test scores and AES of control group for urban school	141
9.	Summary of correlation between pre test scores and AES of control group for rural school	141
10.	Summary of correlation between pre test scores and AES of high achievers (HAs) of urban school	142
11.	Summary of correlation between pre test scores and AES of HAs at rural school	143
12.	Summary of correlation between pre test scores and AES of Average achievers (AAs) of urban school	143
13.	Summary of correlation between pre test scores and AES of AAs of rural School	144
14.	Summary of correlation between pre test scores and AES of Low achievers (LAs) of urban school	144

15. Summary of correlation between pre test scores and AES of LAs of rural school	145
16. Result of independent sample t test on pre-test scores of experimental and control groups in urban school	146
17. Result of independent sample t test on pre-test scores of experimental and control groups in rural school	147
18. Summary of result of independent sample t test on pretest scores of HAs of urban school	148
19. Summary of result of independent sample t test on pretest scores of HAs of rural school	149
20. Summary of result of independent sample t test on pretest scores of AAs of urban school	150
21. Summary of result of independent sample t test on pretest scores of AAs of rural school	151
22. Result of independent sample t test on pre-test scores of LAs of urban school	152
23. Result of independent sample t test on pre-test scores of LAs of rural school	153
24. Result of independent sample t test on achievement scores of experimental and control groups in urban school	154
25. Result of independent sample t test on achievement scores of experimental and control groups in rural school	155
26. Group statistics of achievement scores of HAs of urban school	156
27. Significance of difference on mean achievement scores for HAs of urban school	157
28. Group statistics of mean achievement scores of HAs of rural school	158
29. Significance of difference on mean achievement scores for HAs of rural school	159

30. Group statistics of mean achievement scores of AAs of urban school	160
31. Significance of difference on mean achievement scores for AAs of urban school	161
32. Group statistics of mean achievement scores of AAs of rural school	162
33. Significance of difference on mean achievement score for AAs of rural school	163
34. Group statistics of mean achievement scores of LAs of urban school	164
35. Significance of difference on mean achievement scores for LAs of urban school	165
36. Group statistics of mean achievement scores of LAs of rural school	166
37. Significance of difference on mean achievement scores for LAs of rural school	167
38. Group statistics for students of experimental and control groups of urban school	168
39. Results of ANOVA for students of experimental and control groups selected from the urban school	170
40. Results of Post Hoc Tests for Multiple Comparisons of mean differences among three levels of achievement by Tukey HSD in urban school	173
41. Group statistics for students of experimental and control groups of rural school	174
42. Results of ANOVA for students of experimental and control groups in rural school	175
43. Results of Post Hoc Tests for Multiple Comparisons of mean differences among three levels of achievement by Tukey HSD in rural area	178

LIST OF FIGURE

Figure No.	Title	Page
1	Skills of the Four Learning Styles	63

ABBREVIATIONS

AES	Annual examination score
ANOVA	Analysis of variance
AP	Active Processing
ASCD	Association for Supervision and Curriculum Development
AAs	Average Achievers
BBL	Brain-Based Learning
BCL	Brain Compatible Learning
CAT or CT	Computerized Axial Tomography
CBBC	Concept-Based Brain Compatible
df	Degree of freedom
EEG	Electroencephalography
FDE	Federal Directorate of Education
FG	Federal Government
FGBMS	Federal Government Boys Model School
fMRI	Functional Magnetic Resonance Imaging
GRE	Graduate Record Examinations
HAs	High Achievers
LAs	Low Achievers

M	Mean
MRI	Magnetic Resonance Imaging
N	Number of students in a particular group
OI	Orchestrated Immersion
P ₁	Principle No. 1 of BBL Theory
P ₂	Principle No. 2 of BBL Theory
P ₃	Principle No. 3 of BBL Theory
P ₄	Principle No. 4 of BBL Theory
P ₅	Principle No. 5 of BBL Theory
P ₆	Principle No. 6 of BBL Theory
P ₇	Principle No. 7 of BBL Theory
P ₈	Principle No. 8 of BBL Theory
P ₉	Principle No. 9 of BBL Theory
P ₁₀	Principle No. 10 of BBL Theory
P ₁₁	Principle No. 11 of BBL Theory
P ₁₂	Principle No. 12 of BBL Theory
PAC	Perception, Analysis, Choice
PET or PETT	Positron Emission Transaxial Tomography
RA	Relaxed Alertness

SD	Standard Deviation
SE _M	Standard Error of Mean
SL	Significance level
SPSS	Statistical Package for Social Sciences
SSM	Symbol Selection and Manipulation
TOS	Table of Specification
USA	United States of America

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

People learn through different ways at different rates by virtue of multifaceted factors of heredity and upbringing. Such individual differences result in a variety of learning styles because visual, auditory and kinesthetic learners digest information in contrasting styles. There are generally two types of learners i.e. ‘concrete and abstract perceivers’ and ‘active and reflective processors’ (www.funderstanding.com/v2/educators/learning-styles-3/). Concrete perceivers are those learners who absorb information by doing, acting, sensing and feeling through direct experiences whereas abstract perceivers are those learners who take in information through analysis, observation and thinking. Active processors are the learners who make sense of an experience by immediately using the fresh information while the learners, named as reflective processors make sense of an experience by reflecting on and thinking about it. (www.funderstanding.com, 1998-2001). The teaching and learning materials and methodologies must be consistent with such varieties so that a successful learning task can be accomplished in the perspective of concrete experience, reflective observation, abstract conceptualization and active experimentation of Kolb’s (1984) learning cycle.

Teacher is the vital agent in creating an effective teaching learning environment through his behavior as well as specific teaching principles and methods which make a difference in academic achievement of the students (Lunenburg and Ornstein, 2004). A significant difference in learning occurs with the expertise of teachers who develop

solutions for common classroom problems and their knowledge of teaching content is extensive and well organized (Woolfolk, 2005).

The teacher must be able to direct or guide learning, motivate pupils to learn, help pupils develop desirable attitudes, improve teaching techniques, and recognize and achieve those personal qualities which are conducive to successful teaching (Crow and Crow, 1999). All the efforts of teachers and enrichment of environment facilitate the learners to whet their enthusiasm for acquisition of different concepts. For this purpose, human brain plays a pivotal role because it is the center of thinking, memory and emotions.

The process of learning cannot be kept aloof from thinking, memory and emotions of an individual. Human brain has been attracting philosophers, psychologists, physiologists and even laymen since centuries ago. They have presented different ideas such as Descartes' idea of Cartesian dualism proposing the separation between mind and body, the Empiricism of John Locke (1689) and his contemporaries viewing that all knowledge coming through five senses, Introspection by Wundt, James and Ebbinghaus, the Gestaltian school of thought, Piaget's intellectual development and the cognitive psychology during 1950s to 1980s revolved around the role of brain in learning (Hayes, 1999).

These considerations initiated brain studies and analysis of different parts of the brain and their functions. The study of dead brains, mainly through autopsy, had been a common practice in neurological sciences till 1970s which failed to answer about functions of the various parts of mysterious brain. During 1970s, left and right brain theory and Paul McClean's concept of the triune brain opened new pathways for

researchers. The latest techniques like Magnetic Resonance Imaging (MRI), Functional Magnetic Resonance Imaging (fMRI), Computerized Axial Tomography (CAT or CT) scan, Electroencephalography (EEG) and Positron Emission Transaxial Tomography (PET or PETT) scan disclosed the mysteries of brain to the neurologists and the revolutionary research period of exploration of brain widened new pathways of thinking for the cognitive psychologists.

The study of a live human brain is possible with the help of above-mentioned techniques. On July 3, 1977, the first MRI examination was performed on a human being, which took almost five hours to produce one image of brain (Gould, 2007). Earlier, Hart proposed the Proster Theory in 1975, declaring learning as the formation of programs (called as prosters) and control of the brain on muscles and sense organs. He proposed two types of thinking such as SSM (symbol selection and manipulation) thinking which is conscious and step-by-step, and PAC (perception, analysis, choice) thinking which is intuitive or natural (Reifschneider, 1983). Later on, Hart refined his ideas by arguing that a glove to be used by human hands cannot be designed without considering the structure of hands and termed it non-sense to organize learning without considering the natural functioning of brain (Robertson, 2008).

Hart's ideas attracted many intellectuals to ponder over the brain and its functions. Consequent upon findings about various functions of live brain through CT scans, MRI etc., the revolutionary period about brain research started pragmatically. That's why 1990-1999 was declared a decade of brain by U.S. President George Bush with the remarks that during this period, brain research enhanced public awareness of the benefits to be derived from it (Wikipedia, 2007). The zeitgeist of brain has been

prevailing since 1990 (Conte, 2003) and the 21st century is being called as the century of brain (Lee, 2003). In this century of brain, one should avail the wonderful findings of functions of various parts of brain.

There is a crucial role of brain behind human emotions, memory, thinking and learning. These four elements have significant impact on the performance of humans in different spheres of life. Proper management of emotions, memory and thinking results in human development that is used as a tool of success in different fields of life. Education is the essence of any human society, which cannot keep itself detached from advancements in any field and any part of the world. These advancements added new knowledge in the process of human learning.

The brain researches have significant findings for teaching learning process so that the present day learner, who belongs to an era of a social media, may not be deprived of advancements occurring elsewhere in the world. Educationists are considering such findings about brain to actualize them in teaching learning process. So teaching learning strategies may be based on the application of findings of brain to the classroom teaching situations with the spirit of how the brain learns. The set of such strategies is called Brain Based Learning (BBL) or Brain Compatible Learning (BCL) teaching method (Caine and Caine, 1999 and Jensen, 2005).

BBL teaching method is based on functioning of brain. It steps away from the conventional teaching method, which focuses on the rote memorization of facts (www.funderstanding.com, 1998-2001). Instead, BBL emphasizes contextual learning and engages learners in decision-making, forming cooperative groups and applying the knowledge (www.funderstanding.com.1998-2001). Caine and Caine (1999) described

that active uncertainty or the tolerance for ambiguity, problem solving, questioning and patterning by drawing relationships through the use of metaphors, similes and demonstrations are some of the features of BBL teaching method. The BBL theory suggests many choices for activities and projects to be given to the students. It resembles to what Hayes (1999) says 'Aha! Experience' that is a student's experience of enlightenment, in which the solution of a problem is perceived very rapidly.

BBL teaching method, based on principles of BBL theory, is warmly adopted in U.S.A, Europe, Australia, Japan and Turkey etc during 1990s and onward. It is a blend of various concepts like multiple intelligences, cooperative learning, experiential learning, learning styles, peer tutoring, mastery learning, right brain-left brain theory, triune theory of brain etc. These concepts are compatible with the prevailing teaching method for different fields of knowledge which include languages, social sciences, natural sciences etc. Among these fields, mathematics demands comparatively a lot of mental discipline and intellectual skills for understanding and application of its particular concepts. Teaching of mathematics is more effective through inductive reasoning (generalization on the basis of observations), deductive reasoning (conclusion based on generalization) and problem solving reasoning (mental process of finding and shaping a problem) (www.cde.ca.gov/be/st/ss/documents/mathstandards.doc).

Logical-mathematical intelligence was one of the multiple intelligences reported by Gardner (1983). The inductive, deductive and problem solving reasoning are linked with teaching method of BBL theory.

The ongoing discussion shows that the teaching method based on BBL theory is pragmatic for teaching learning process which establishes a link between theory and practice. This theory has been applied in different contexts, on many disciplines and at different levels. Mathematics is a discipline which develops the logic of a concept among the learners provided the concept is presented in a meaningful way. The learners may construct different mathematical concepts deeply if teachers organize brain-friendly teaching learning activities for them. In our country, unluckily, students are exposed to rote-learning, textbook-based examination and the threatening environment which are all brain-antagonistic ways. The clarity of thinking, deep understanding of mathematical ideas, inter-connection between resembling mathematical concepts and inculcation of fresh mathematical knowledge are some of the areas which are poorly addressed by the teachers of mathematics in our perspective. BBL teaching method encourages learners to act and react in accordance with the natural functioning of their brains. Contrary to conventional teaching method, this innovative method promotes concept-based mathematical ideas, presentation of meaningful content, threat-free enriched environment and acceptance of ambiguities in the perspective of natural functioning of human brain. It may be investigated whether the innovative teaching method, as compared to conventional method, is more beneficial for the learners of mathematics at secondary level or not. The students of secondary schools located in rural or urban areas, sometimes, do not have equal opportunities with respect to academic inputs, physical facilities and co-curricular activities. It may be investigated whether change in location casts influence on the comparative effectiveness of BBL and conventional teaching methods or not. This study is, therefore, designed to compare effectiveness of

conventional teaching method and BBL teaching method at secondary level in the subject of mathematics at rural and urban localities.

1.2. STATEMENT OF THE PROBLEM

The text-book based teaching and learning process in a conventional teaching method may habituate the students to learn through verbatim reproduction of the content. The BBL teaching method may replace verbatim reproduction of content with the meaningful understanding through concept-based teaching and learning process. The purpose of the study was to compare the effectiveness of conventional teaching method with the BBL teaching method to teach mathematics at secondary level in Pakistan. The comparative effectiveness of the two teaching methods was also investigated for high, average and low achievers. For the purpose, an experimental research was designed to observe the effectiveness between BBL and conventional teaching methods. The effectiveness of the both teaching methods was compared through statistical tests on the academic achievement of the selected students.

1.3 OBJECTIVES OF THE STUDY

The objectives of this study were to measure

- i. the effectiveness of BBL (brain based learning) teaching method versus conventional teaching method of the learners belonging to experimental and control groups respectively.

- ii. the effectiveness of BBL (brain based learning) teaching method versus conventional teaching method of the high achievers belonging to experimental and control groups respectively.
- iii. the effectiveness of BBL (brain based learning) teaching method versus conventional teaching method of the average achievers belonging to experimental and control groups respectively.
- iv. the effectiveness of BBL (brain based learning) teaching method versus conventional teaching method of the low achievers belonging to experimental and control groups respectively.

1.4 HYPOTHESES OF THE STUDY

In the light of objectives of the study, 14 null hypotheses (H₀ 1 to H₀ 14) as well as 14 alternative or research hypotheses (H₁ 1 to H₁ 14) were formulated to achieve the objectives. First eight hypotheses were formulated to investigate the significant difference between any of the two groups taken out of high, average or low achievers in the rural as well as urban areas. Since a 2×3 factorial design was used as research design of the study, so ANOVA was applied on the data of the study. For the purpose, six more hypotheses were formulated. Thus H₀ 9 to H₀ 14 were formulated to observe the main effects of 1st factor, i.e. teaching methodology; 2nd factor, i.e. academic achievement; and the interaction between these two factors in the rural as well as urban areas. In this way, following null as well as their respective alternative hypotheses were formulated:

- H₀ 1: There is no significant difference between the performance of the students of urban school taught through BBL and conventional teaching methods.
- H₁ 1: There is a significant difference between the performance of the students of urban school taught through BBL and conventional teaching methods.
- H₀ 2: There is no significant difference between the performance of the students of rural school taught through BBL and conventional teaching methods.
- H₁ 2: There is a significant difference between the performance of the students of rural school taught through BBL and conventional teaching methods.
- H₀ 3: There is no significant difference between the performance of the high achievers (HAs) of urban school taught through BBL and conventional teaching methods.
- H₁ 3: There is a significant difference between the performance of the high achievers (HAs) of urban school taught through BBL and conventional teaching methods.
- H₀ 4: There is no significant difference between the performance of the high achievers (HAs) of rural school taught through BBL and conventional teaching methods.
- H₁ 4: There is a significant difference between the performance of the high achievers (HAs) of rural school taught through BBL and conventional teaching methods.
- H₀ 5: There is no significant difference between the performance of the average achievers (AAs) of urban school taught through BBL and conventional teaching methods.
- H₁ 5: There is a significant difference between the performance of the average achievers (AAs) of urban school taught through BBL and conventional teaching methods.
- H₀ 6: There is no significant difference between the performance of the average achievers (AAs) of rural school taught through BBL and conventional teaching methods.

H₁ 6: There is a significant difference between the performance of the average achievers (AAs) of rural school taught through BBL and conventional teaching methods.

H₀ 7: There is no significant difference between the performance of the low achievers (LAs) of urban school taught through BBL and conventional teaching methods.

H₁ 7: There is a significant difference between the performance of the low achievers (LAs) of urban school taught through BBL and conventional teaching methods.

H₀ 8: There is no significant difference between the performance of the low achievers (LAs) of rural school taught through BBL and conventional teaching methods.

H₁ 8: There is a significant difference between the performance of the low achievers (LAs) of rural school taught through BBL and conventional teaching methods.

Following null as well as research hypotheses were formulated for the purpose of ANOVA.

H₀ 9: The mean achievement score of the students selected from urban school, taught through BBL teaching method, is not significantly different from the mean achievement score of the students selected from urban school, taught through conventional teaching method. (Main effect of teaching methodology on the three levels of academic achievement)

H₁ 9: The mean achievement score of the students selected from urban school, taught through BBL teaching method, is significantly different from the mean achievement score of the students selected from urban school, taught through conventional teaching method. (Main effect of teaching methodology on the three levels of academic achievement)

H₀ 10: The mean achievement score of the students selected from rural school, taught through BBL teaching method, is not significantly different from the mean achievement score of the students selected from rural school, taught through conventional teaching method. (Main effect of teaching methodology on the three levels of academic achievement)

H₁ 10: The mean achievement score of the students selected from rural school, taught through BBL teaching method, is significantly different from the mean achievement score of the students selected from rural school, taught through conventional teaching method. (Main effect of teaching methodology on the three levels of academic achievement)

H₀ 11: There is no significant difference among the mean achievement scores of the students selected from urban school who are placed in any of the three levels of achievement, namely high achievers, average achievers and low achievers. (Main effect of the three levels of academic achievement).

H₁ 11: There is a significant difference among the mean achievement scores of the students selected from urban school who are placed in any of the three levels of achievement, namely high achievers, average achievers and low achievers. (Main effect of the three levels of academic achievement).

H₀ 12: There is no significant difference among the mean achievement scores of the students selected from rural school who are placed in any of the three levels of achievement, namely high achievers, average achievers and low achievers. (Main effect of the three levels of academic achievement)

H₁ 12: There is a significant difference among the mean achievement scores of the students selected from rural school who are placed in any of the three levels of achievement, namely high achievers, average achievers and low achievers. (Main effect of the three levels of academic achievement)

H₀ 13: There is no interaction between teaching methodology and the levels of achievement (based on 8th class annual examination score) in the selected urban school.

H₁ 13: There is an interaction between teaching methodology and the levels of achievement (based on 8th class annual examination score) in the selected urban school.

H₀ 14: There is no interaction between teaching methodology and the levels of achievement (based on 8th class annual examination score) in the selected rural school.

H₁ 14: There is an interaction between teaching methodology and the levels of achievement (based on 8th class annual examination score) in the selected rural school.

1.5 CONCEPTUAL FRAMEWORK OF THE STUDY

The study includes two variables i.e. teaching methodology and academic achievement. Teaching methodology is the independent variable whereas academic achievement is the dependent variable. The independent variable of teaching methodology was manipulated into BBL teaching method and conventional teaching

method whereas academic achievement was further divided into three levels, namely high, average and low achievement. The conventional teaching method stands for lecture method in this study. First of all, a secondary school was selected from urban area and another secondary school was selected from the rural area through purposive sampling. All the students of 9th class belonging to each of the selected schools were separately placed on the normal distribution of their respective 8th class annual examination scores (AES). Then 60 students were chosen as sample of the study from the students falling under $M \pm 2s$ of the normal distribution of AES in the urban school. Then, a sample of 60 students was taken from the rural school on the same basis. Thus 120 students were altogether selected as sample of the study. Later on, the sample of 60 students each was equally divided into high achievers, average achievers and low achievers through systematic random sampling. The effectiveness of the BBL teaching method was compared with the conventional teaching method and it was measured through the academic achievement of the selected students. The selected students of the experimental and control groups were taught through BBL teaching method and conventional teaching method respectively for 8 weeks. A 2×3 factorial design was followed for the study. Focus of the research study was to compare the effectiveness of BBL teaching method and conventional teaching method to teach mathematics to the students of 9th class.

For the purpose, researcher followed Caine and Caine's (1997) Model of 12 Principles' Design based on twelve in-built faculties of human brain under the umbrella of the innovative teaching method based on BBL theory. The researcher also incorporated the essence of twelve principles of BBL theory in light of Tompkins' "Brain-Based Learning Theory: An Online Course Design Model" which is his

Dissertation of PhD (Education) and submitted to The Liberty University, USA in February, 2007. Resultantly, five of the in-built faculties of brain were applied through cognitive practices and the remaining seven in-built faculties were applied through generation of enriched environment of classroom.

The researcher reviewed the model of Davenport Community School District (Davenport Community School, 2008) and Waters (2005) research study of ‘The Reality of Brain Research Strategies’ to generate the enriched environment of the classroom in the perspective of the above-mentioned 12 Principles’ Design. The researcher also reflected on the research work of Avaci and Yagbasani (2005), ‘A Study on Impact of Brain Based Learning Approach on Students’ Achievement of Knowledge about “Work-Energy”’ to develop lesson plans and brain friendly learning activities.

1.6 SIGNIFICANCE OF THE STUDY

The study may help working teachers of mathematics at secondary level to organize such instructional strategies which may activate the in-built faculties of brain. For the purpose, teachers may present meaningful content, assure students of having say in the classroom, generate enriched classroom environment etc in light of the study. They may avail the findings of the study to enhance the levels of achievement of the learners. The teachers may improve concentration, interest, confidence and conceptual understanding of the students in light of the study. The teacher may be able to form homogeneous subgroups of the students and then assign suitable tasks to the students accordingly. The students, who lack in clarity of thinking and solving problem,

maladjustment in classrooms and depend on cramming, may be better managed by the teachers for deep understanding of mathematical concepts.

The study may help mathematics teachers to compare between the instructional strategies of both the teaching methods and enable them to differentiate between brain-friendly and brain-unfriendly teaching learning activities. The teachers may, then, understand the conditions which are favorable or unfavorable for the teaching learning process.

School administration may avail the findings of the study to facilitate learners with interactive classroom environment so that they may avail a teaching method which may habituate them to explore the mathematical problems with the help of real life situations as mentioned in the study.

The curriculum of mathematics at secondary level may be revised by the concerning authorities in light of the findings of the study which suggest elaboration of concepts and formulas according to the requirements of thinking brain. The mathematics curriculum authorities may add or delete such content which may enable learners to process meaningful content smoothly.

1.7 DELIMITATIONS THE STUDY

The study was delimited to:

- i. F.G. (Federal Government) model secondary schools located in rural and urban areas, working under FDE (Federal Directorate of Education), Islamabad

- ii. only male students of 9th class, studying mathematics
- iii. all such students of 9th class, studying textbook of Mathematics for 9th class, 2007, published by Punjab Textbook Board, Lahore, under the jurisdiction of Federal Board of Intermediate and Secondary Education, Islamabad elsewhere in Pakistan

1.7.1 Limitation of the Study

The school administrations of the selected schools allowed the researcher to conduct the experiment without disturbing the overall school time tables. The researcher followed the said limitation and conducted the experiments of the study at the time which was reserved for mathematics classes in the schedules of the concerning schools.

1.8 PROCEDURE OF THE STUDY

The study was accomplished through the following the steps.

1.8.1 Population

All the 9th class students studying mathematics in Secondary/ Higher Secondary Schools of Pakistan were included in the population of the study.

1.8.2 Sample

The experiments of the study were conducted at two secondary schools independently. A secondary school was selected from the urban area and another

secondary school was selected from the rural area of district Islamabad through purposive sampling. An overall sample of 120 students of 9th class was equally taken from the two secondary schools on the basis of normal distribution of their 8th class annual examination scores (AES), obtained in the centralized 8th class annual examination, 2007 held by FDE Islamabad. The students falling under $M \pm 2s$ of their respective normal distributions were retained for the ultimate selection of sample of the study whereas the rest of students were excluded from the sample of the study. Thus a sample of 60 students each, falling under $M \pm 2s$ of their respective normal distributions, was taken separately in the selected schools of rural as well as the urban areas.

1.8.3 Research Tool

An academic achievement test was constructed by the researcher. The items of the research tool were based on five innate faculties of the human brain i.e. parallel processing; innate search of meaning; pattern formation; perception through creation of parts and wholes; and uniqueness. The research tool of the study was observed as valid through table of specification, consultation with the working teachers of mathematics and experts' opinions. The reliability of the research tool was observed through split-half method. The research tool was administered prior to start as well as at the immediate end of the experiment as pre-test and post-test respectively to all the students included in the sample of the study.

1.8.4 Data Collection and Analysis

Data of the study comprising pre-test, post-test and achievement scores (the difference between post-test and pre-test scores) as well as 8th class AES (annual examination score of FDE examination, 2007). The achievement scores were collected

for high achievers, average achievers and low achievers. A 2×3 factorial design was followed in the study. The statistical tests of Pearson's Correlation r , independent sample t test and two-way ANOVA were applied through SPSS 12. Pearson's Correlation was applied to investigate the valid grouping of students by correlating the pretest scores with the AES of the selected students. The independent sample t test was applied for the investigation of significant difference between high achievers belonging to cell I versus cell IV; average achievers belonging to cell II versus cell V; and low achievers belonging to cell III versus cell VI given in the factorial design of the study. ANOVA was applied to measure the main effect of teaching methodology (1st factor), main effect of academic achievement (2nd factor) as well as to investigate the interaction between both of the factors given in the factorial design of the study. Findings, conclusions and recommendations of the study were inferred from the results of the stated statistical tests.

CHAPTER 2

REVIEW OF RELATED LITERATURE

The purpose of the study was to investigate the comparative effectiveness of BBL and conventional teaching methods to teach mathematics at secondary level in Pakistan. Brain based learning theory emphasizes on how brain learns instead of what it learns. The brain receives information in a meaningful way and meaninglessness imposed upon it inhibits its processing.. The brain is the site of reason and intelligence, which includes components such as cognition, memory, perception, attention and emotions (Wikipedia, 2007). The structure and functions of various parts of the human brain reveal lot of necessary data about how learning process occurs within human brain. Consequent upon neuro-research work of eminent researchers like Edvard Moser, May-Britt Moser, Watson, Ramachandran, Vilayanur.; Hirstein, William and David Mahoney in 1990s (<http://en.wikipedia.org/wiki/Neuroplasticity>, 2006), the functions of various parts of brain were explored with concrete evidence and learning mechanism underwent a new turn. The psychology of human brain shifted its paradigm to physio-psychological study. In this chapter, following topics are discussed to build up understanding of different dimensions of brain based learning theory:

- 2.1. Historical background of BBL theory
- 2.2. Definitions of BBL
- 2.3. Principles of BBL and their implications for classroom

- 2.4. Teaching techniques of BBL
- 2.5. Application of BBL theory in developing teaching learning materials
- 2.6. BBL and some contemporary concepts
- 2.7. Criticism on BBL theory
- 2.8. Conventional Teaching Method
- 2.9. Differences Between Conventional and BBL Teaching Methods
- 2.10. Research Underpinnings for BBL theory

The following lines will elaborate the stated sub-headings below.

2.1 HISTORICAL BACKGROUND OF BBL THEORY

Since ancient ages, man was interested in unfolding the mysteries of brain. For example, Plato's idealism built the reality of an object on the basis of its idea only while Aristotle's realism believed in concrete evidence for reality of an object. Both schools of thought were convinced by the role of brain in identifying the reality of objects and concepts. The concept of presence of evil spirits is half-million years ago due to which all psychological problems were attributed to these evil spirits and patient's skull was chipped away with stony instruments to create a hole for evil spirits to escape.

Afterwards, the Greek philosopher Hippocrates proposed that human personality is a blend of four temperaments. They were sanguine (cheerful and active), melancholic (sad), choleric (angry and aggressive) and phlegmatic (calm and passive) and all of them were based on body-brain single entity. Body and brain were supposed to be a single entity before Descartes' interactive dualism which separated mind from body. He also believed in presence of animal spirits which traveled through hollow nerves. Since brain

was encapsulated in skull, study of skull also attracted psychologists to disclose different traits of human being. Man had been attributing bumps on human skull to different mental faculties. Consequent upon such observations, the phrenology of Gall related typical brain areas to typical functions and attributed shape of skull to show different faculties of brain. Afterwards empiricism of Locke declared knowledge to be obtained through five senses, admitting the role of brain in thinking process. Darwin's survival of fittest theory put forward the concept of continuous development of species due to environmental adaptation (Feldman, 1999; Hayes, 1999; Reber, 1995).

The study of human brain continued on and curiosity to look deep into brain went on increasing. The structuralism/functionalism schools of thought suggested focus on the structure and function of human mind/consciousness respectively and, on the contrary, behaviorism believed in scientific measurement of observable behavior (Baron, 2006), declaring mental processes as unimportant and focusing on stimulus response association to study the behavior (Hayes, 1999). Behaviorists declared human brain as black box but the four Gestalt laws of continuity, closure; proximity and similarity; given by Wertheimer, Kohler and Koffka (Reber, 1995) opposed the views of structuralism and behaviorism and termed perception and behavior as an integrated whole. Thereafter, role of brain became of valuable importance for psychologists. Cognitive revolution in 1960s and Gestaltian psychology promoted the paradigm shift from behaviorism to cognitivism and psychologists became interested in understanding brain mapping to elaborate the complex learning mechanism. Kant's constructivism assumed learning as a result of experience and declared brain a filter which takes information from outside world through senses and develops its own constructs, enabling learners to set a body of

knowledge based on those constructs (Ertmer and Newby, 1993). These constructs are modified throughout the life by the brain.

Knowledge of role of brain in thinking, emotions and memory caused to commence an era of brain research and researchers were interested to study contribution of brain in learning. Sperry's (1962) left and right brain theory (<http://www.freeessays.cc/db/39/pnl237.shtml>), McClean's (1970s) concept of the triune brain, Bandler and Grinder's Neuro-linguistic programming (NLP) in 1970s and Hart's (1975) Proster Theory opened doors for fresh dimensions of research in the perspective of application of neurological findings on teaching learning process.

The review of the implications of these theories discloses that the information processing styles for right or left hemispheres of brain are different than each other. The logical left brain processes information linearly, sequentially, symbolically, verbally, and realistically whereas the intuitive right brain does the same holistically, randomly, concretely, nonverbally and imaginatively (<http://frank.mtsu.edu/~studskl/hd/LRBrain.html>). The triune brain model, according to McClean, consists of the R-complex, the limbic system, and the neocortex. Reptilian Brain (R-complex) contains brain stem and cerebellum which controls instinctive survival behavior and thinking. The amygdala, hypothalamus and hippocampus are parts of the limbic system which supervises the emotions and some of instincts like feeding, fighting etc. Higher-order thinking skills, reason and speech are controlled by the neocortex (Wikipedia, 2007).

Afterwards, Proster theory declared knowledge as formation of programs which are incorporated into structures (prosters) on the basis of similitudes. The theory proposes two types of thinking: SSM (symbol selection and manipulation) thinking which is

conscious and step-by-step, and PAC (perception, analysis, choice) thinking which is intuitive or natural (Reifschneider, 1983; Hart, 1975). Hart (1983) emphasized on the natural functioning of brain before designing the learning mechanism for the learners and termed it absurd to design a hand glove by ignoring the structure of hands. He, therefore, emphasized on developing learning by juxtaposing teaching learning materials with the natural functions of brain Hart coined the term brain-compatible for the first time and declared brain as an organ of learning (Teacher Tap, 2008). He (Hart) also proposed what was brain antagonistic. The NLP proposed a therapy for some psychological problems like phobias, depression, learning disorders etc (Wikipedia, 2009). The work on brain and its typical functions resulted in many new ideas e.g. Piaget's theory of cognitive development, Ausubel's subsumer theory of advance organizers and Vygotsky's zone of proximal development were based on the involvement of brain in the learning process. But the study of a live brain was still not possible and autopsy and lesion were the main sources of studying the human brain. With these sources, many parts of brain could not be explored and nobody knew the functions of different parts of the thinking brain. Rousseau opined that research on functioning of brain and intelligence might create a new perspective of thought about our own selves and others (Koch, 2005).

Neuroscientists were interested more in obtaining data of live human brain and they went on working on the idea. At last, they startled the world on July 3, 1977 when the first MRI examination was performed on a human being, which took almost five hours to produce one image (Gould, 2007). This proved a giant leap in the field of neurosciences and study of live human brain became possible for the first time in the history of humanity. Furthermore, the latest techniques like Magnetic Resonance Imaging

(MRI), Functional Magnetic Resonance Imaging (fMRI), Computerized Axial Tomography (CAT or CT) scan, Electroencephalography (EEG) and Positron Emission Transaxial Tomography (PET or PETT) scan disclosed the mysteries of brain to the neurologists which encouraged cognitive and constructive psychologists to conduct researches pertaining to role of brain in teaching learning mechanism.

Now we are able to know about a live human brain with the help of above-mentioned techniques. Several research institutes were established to conduct research works on brain e.g. the Institute of Brain Chemistry and Human Nutrition (IBCHN) started the research work in 1989 at Metropolitan University London (known as University of North London earlier) (IBCHN, 2009). Further studies on brain gave more data about the functions of some parts of brain. “Decade of brain was a designation for 1990-1999 by U.S. President George H.W. Bush”, by saying, “to enhance public awareness of the benefits to be derived from brain research” in this decade (Wikipedia, 2007). The zeitgeist of brain has been prevailing since 1990 (Conte, 2003) and the 21st century is called as the century of brain (Lee, 2003).

Following the Hart’s theory, educational psychologists like Caine and Caine (1991); and Jensen (2005) laid foundations of a new learning theory which was based on the application of the latest findings about human brain in the field of neurology on teaching learning process by emphasizing more on how to learn than on what to learn. This theory is known as brain based learning (BBL) or brain compatible learning (BCL) theory. BBL brings professional competence in teachers and students can enjoy the successful learning because it is a research-oriented strategy which links closely with the common sense (Erlauer, 2003). According to The Eric Database (2003), during decade of

brain or soon after: some of the topics, which were accepted by the researchers and the awareness about the application of brain findings on the teaching learning environment became widespread, contained the emotional, social, cognitive, physical and reflective systems of brain (Barbara, 2002); developing thinking climate, teaching thinking skill, thinking via interaction and metacognition of thinking (Fogarty, 2002); establishing non-threatening atmosphere, meaningful learning tempo, diversified input and first hand feedback (Caulfield, *et al*, 2000); exploring the brain processes of attention, patterning, memory, context and motivation (Palombo, 2000); and learning the principles of brain on the basis of brain research (Reardon, 1999).

The gap between brain sciences and educational field reduced considerably during the past 20 years. Besides brain research articles of journals, some organizations like OECD (Organisation for Economic Co-operation and Development), Harvard University's establishment of a Master's programme 'Mind, Brain and Education' and the opening of the Centre for Neuroscience in Education at Cambridge University are working to grow connection between physiology of brain and its natural capacity to learn (Tommerdahl, 2008).

2.2 DEFINITIONS OF BBL

The natural functioning of brain is the essence of BBL theory. The concept of BBL theory drew attention of many educational psychologists and they defined the theory in different ways. All definitions are focused on the capacities and incapacities a brain possesses naturally. Hart (1983) proposed the pivotal role of brain in teaching learning process and emphasized on creating an enriched environment which is

compatible with the nature of brain. Caine and Caine (1991) added that BBL involves acknowledging the brain's rules for meaningful learning and organizing teaching with those rules in mind. So brain is a disciplined entity which follows a set pattern of some of the principles. The violation of those principles will disturb or even cease brain to work naturally.

The distinguished concept became more famous during decade of the brain and Jensen (2005) named brain based naturalist an addition to learning schools of thought besides survival of the fittest and determined behaviorist. Thus BBL, according to him, is nothing other than learning as it naturally occurs. The principles of brain must be consistent with the nature of physiology of the brain. Jensen (2005) defines that BBL is learning in accordance with the way the brain is naturally designed to learn. It is a multidisciplinary approach that is built on the fundamental question, "What is good for the brain?" This learning theory believes that learning will keep on happening if brain faces no disturbance in its normal functioning. The relation between some contemporary concepts and BBL was never denied.

Spears and Wilson (2002) termed Brain-Based learning a comprehensive approach to instruction which is based on how current research in neuroscience suggests our brain learns naturally. The instruction ends in getting some information through exploration of ideas. Personal understanding of concepts plays an important role in cognitive development of learners and BBL is supposed as a blend of brain science and common sense (Teacher Tap, 2008). Neurologists have provided data that reveal functions of various parts of brain by using latest techniques. Their findings helped in

establishing a relationship between BBL teaching learning strategies and a successful learning during classroom teaching.

ASCD (Association for Supervision and Curriculum Development) also defines BBL by saying 'Brain-Based Learning involves using approaches to schooling that rely on recent brain research to support and develop improved teaching strategies'. Unluckily, rote-learning has been a common practice in traditional classrooms because brain-antagonistic teaching learning activities are frequently used by the teachers traditionally. Some of such activities are presentation of fresh concepts without creating a linkage between the fresh and previous concepts of the learners, encouraging verbatim note-taking by the students, least involvement of learners in preparation of agenda for the classroom sessions etc. To replace rote-learning with conceptual learning, BBL is an effective teaching method which enhances the knowledge of learners by utilizing natural faculties of brain to strengthen spatial memory. Brain-based teaching is the application of a meaningful group of principles that represents our understanding of how our brain works in the context of education (Karen, 2005).

Designing learning strategies consistent with the innate brain tendencies to learn is a viable plan and BBL is a theory that lays its foundation on the structure and function of the brain and encourages learning process to occur under normal functioning of brain (<http://www.funderstanding.com/content/brain-based-learning,1> 998-2001; Zagranski, *et al*, 2009). Brain is social, having intra-personal intelligence (Gardener), and it likes an interactive environment. Hence Brain-based learning believes in designing teaching strategies proportionately with respect to the learners and environment so that the areas of brain pertaining to emotions, attention or memory can be activated (Social Emotional

Learning, 2008). Teaching through BBL method is not an activity of a single task. It is done with the help of a set of strategies that promotes natural way to gather information. Brain-compatible teaching strategies are workable because they match common sense and promote teaching the way students learn (Erlauer, 2003).

BBL, based on learning styles and a research oriented methodology, serves as a tool of gaining information which adds knowledge to brain without punishing it. It helps us understand the best ways and approaches to getting new material with the best retention and memory (Jasinski, 2008). Brain-based learning involves using approaches to schooling that rely on recent brain research to support and develop improved teaching strategies (ASCD, 2005). The same idea is there in the definition of Seith (2000) who defines brain-based learning as “An understanding of learning based on the structure and function of the brain. Learning occurs if the brain is not prohibited from fulfilling its normal processes.” Similarly Craig (2003) defines that brain-compatible learning is a set of some principles which state that how the human brain learns on a neuroscientific base.

Melton (2009) defines brain-based education broadly and says that it is a source of orchestration of realistic problems, enrichment and suitable experiences for best use of learners which encourage them extract meaning of different concepts. A conclusive definition that is based on the ongoing definitions and discussions is that BBL is an eclectic approach to teaching learning process that depends on the inculcation of information based on natural physiology and functioning of brain.

The above discussion is on the definitions of BBL theory. This theory includes some certain principles which are significant for the teaching learning environment.

2.3. Principles of BBL Theory and Their Implications for Classroom

In the following, there are three sets of principles which are applicable in BBL methods on classroom teaching learning process. First of all, Caine and Caine (1991) designed 12 principles which are based on different researches about brain-based learning. These principles provide the basis of BBL theory. Caine and Caine are the pioneers of development of these principles which describe brain based learning theory in concrete terms. These principles would always pave way for any type of further advancement in the field of BBL Caine and Caine's 12 principles are given as follows and each of the principle is explained in terms of its practicability in classroom teaching learning process.

1. The brain is a parallel processor

The brain performs many function simultaneously like seeing, thinking, listening, responding etc. So the brain performs multitasks at a time without any disturbance. Greater the connection between the neurons, larger the storage of information and faster the process of parallel processing within the brain will be. Physiology of brain is oriented to establish coordination between several performances instantaneously.

Learning brain cannot keep itself confined to a single function. Teachers should make use of diversified approaches to elaborate the concepts and satisfy the needs of brain that is oriented to process a variety of tasks simultaneously for the deep understanding of content. All the dimensions of parallel processing of brain can be

observed for effective teaching learning (Caine and Caine 1991, 1997) and University of Nebraska at Omaha, 1999).

2. Learning engages the entire physiology

The brain functions according to physiological rules. Hygienic problems hamper natural functioning of brain. BBL believes strongly that a healthy body possesses a functional brain and vice versa. Learning is a natural phenomenon for brain just like breathing, feeling and responding. Learning can be inhibited or facilitated. In fact, the actual “wiring” of the brain cannot be separated from the life or experiences of an individual.

All factors, which affect health, do affect learning capacity of brain. Healthy bodies possess active brains. Nature makes special arrangement for the development of brain from very beginning. The human physiology reserves 70% of the fetal energy consumption to development of brain (IBCHN, 2009). Teachers must organize such activities that are focused at improvement of health of the learners, which lead to mental health. Therefore, nutrition, physical exercises, stress management or relaxation techniques can be imbibed along with content materials (Caine and Caine 1991, 1997) and University of Nebraska at Omaha, 1999).

3. The search for meaning (making sense of our experiences) and the consequential need to act on our environment is innate / automatic

Brain is oriented to seek meaning of an experience in the forms of words or senses. The meaninglessness is inconsistent with the natural working of concerned parts of the brain. If brain finds no aspects of familiarity or novelty in the incoming data,

meaning seeking function will be suppressed and concerning parts of brain will be poorly utilized. In case of rote memorization or likewise situations, the brain ceases functioning normally and goes into the state of downshifting. Downshifting is a psycho-physiological modified state of brain wherein it feels itself in a helpless condition. To get out of a downshifted state, the brain gets relief to do a task repeatedly. Cramming is a therapy for a downshifted brain.

Teachers should incorporate the aspects of familiarity, curiosity, discovery, novelty and self-exploration into teaching learning materials so that the inbuilt tendency of brain to seek meaning must be availed of. Students should have choices and lessons must be meaningful. Meaninglessness punishes brain and spatial memory stops working which activates the rote-memorization. Brain downshifts and its physiology changes (Caine and Caine 1991, 1997) and University of Nebraska at Omaha, 1999).

4. The search for meaning occurs through “patterning”

Brain prefers to form its own patterns to understand meaning of an idea when it receives fresh information. To understand a new idea, brain designs the creative patterns related to the idea. These patterns are designed or interpreted on the basis of its previous knowledge so that the new information may be fitted into them and converted into a meaningful body of knowledge.

Learning process should be organized in a way so that brains are creating patterns themselves. Teachers can stop or disturb natural patterning skill of brain by coercing learners to end a task within a narrow margin of time. In stead, sufficient time must be given to students for generation of patterns. Teaching must be thematic instead of textual

wherein learners are forming creative and related patterns (Caine and Caine 1991, 1997) and University of Nebraska at Omaha, 1999).

5. Emotions are critical and at the heart of patterning

Learning and emotions are closely related to each other. The meaningful organization of content and categorization of information are called patterning. Patterning leads brain to a unified body of information and provides brain to process it. Memory and learning are related with the emotions. Happiness, sadness, anger, boredom, fatigue, threat, fear, stress and all other emotional states of body change the brain physiology and pattern formation is also affected.

Moods and feelings of the students play an important role in pattern formation. Teachers must create a cheerful environment within classroom so that brain may function naturally. Exciting and motivating attitudes of teachers generate a balanced emotional state of the brains of learners. Such supportive atmosphere helps brain to form patterns (Caine and Caine 1991, 1997) and University of Nebraska at Omaha, 1999).

6. Every brain simultaneously perceives and creates parts and wholes

Brain works systematically and absorbs incoming data by disintegrating the complex information into smaller pieces. These smaller pieces of information are blended back into easy-to-understand form. The left and right brain capacities may also involve in creating parts and wholes as well. Inductive and deductive reasoning match with this principle of BBL theory.

The teaching learning material should be divided into inter-related parts so that the brain may process them and afterwards develop them into wholes. Such parts and wholes are simultaneously processed by the brain. Integration of parts into wholes is a natural process for the brain if parts are interrelated and do not look like isolated from one another. (Caine and Caine 1991, 1997) and University of Nebraska at Omaha, 1999).

7. Learning involves both focused attention and peripheral perception

The brain absorbs information in direct and indirect ways. Learning by focused attention occurs during classrooms where teachers impart fresh ideas and learners gain information through processing them by their brains. The peripheral perception occurs unknowingly during classroom sessions and observant brain records apparently less important looking data automatically.

Brain goes on processing information continuously. Teachers should formulate such activities, which may be processed later by the brain. Charts, models, hands-on tasks, debates, discussions, reflections and graphical representations may work for peripheral processing of brain and learner may enhance knowledge (Caine and Caine 1991, 1997) and University of Nebraska at Omaha, 1999).

8. Learning always involves conscious and unconscious processes

Conscious learning is analogous to focused attention learning and unconscious learning is analogous to peripheral perception learning. The gestures, cues, verbal communication etc may be sources of unconscious learning. The processing of information is a ceaseless process which brain goes on doing. The learning may occur at the end of a classroom even after many hours or days. Teacher affects the unconscious learning process as well.

The auditory, visual and kinesthetic learners absorb information in their own styles. They differ in taking and processing information. The deep understanding emerges out of self-exploration of ideas and the unconscious learning skill of brain. In classroom teaching learning environment, some information is imparted to the learners. If content is personally meaningful for the learners, brain will automatically organize it in knowledge (Caine and Caine 1991, 1997) and University of Nebraska at Omaha, 1999).

9. We have (at least) two types of memory systems: spatial and rote learning

Spatial or autobiographical memory is our natural memory which brain maintains automatically. The peripheral information is recorded by spatial memory which can be retrieved easily. One has no need to learn about meals last night taken, colours of suit of a guest who met yesterday etc. The natural storage of brain registers all details of such events without involvement of the person concerned. Second portion of memory is rote-learning which a person knowingly maintains. It is memorization of facts where understanding of content is avoided (Wikipedia, 2009). Brain is oriented to maintain spatial memory ceaselessly. Rote learning is short lived storage of information as compared to the spatial memory which is rather a permanent storage of information.

Memorization is contrary to the natural functioning of brain and little data can be retrieved in this form. Traditional teaching promotes rote learning and does not do much for shifting data into spatial memory. Meaningful content, familiar as well as novel information, related to interest of student and diversified learning activities may cease memorization and activate spatial memory (Caine and Caine 1991, 1997) and University of Nebraska at Omaha, 1999).

10. The brain understands and remembers best when facts and skills are embedded in natural spatial memory

Memory is of two types i.e. short-term memory and long-term memory. Short-term memory works for short interval of time from one second to 24 hours before being dismissed or converted into long term memory. Rote learning is related to this memory. Working memory helps brain to manipulate the information and it is used interchangeably with short tem memory. The long-term memory can be divided into explicit (conscious) and implicit (unconscious) memories. Explicit memory is divided into episodic (specific personal events and their contexts) and semantic (general knowledge about the word) memories. Implicit memory is divided into priming (recall of recent experiences) and procedural (carry out common tasks without consciously thinking about them) memories (Brain Fitness Channel, 2009; Crossroad Institute, 2009). Spatial memory is concerned with long term memory and its types. The strengthening of natural spatial memory results in a permanent storage of information which can be retrieved any time. Brain is capable of sending information naturally to spatial portion. The sent items must have characteristics of familiarity and novelty so that they may fit coherently into the existing data. Isolation from prior knowledge activates rote memorization and brain does not understand meaning which results in its downshifting.

Inter-related content and real life activities help learners to strengthen spatial memories. Classroom interactive environment and absence of threat or fear activates the connection formation of brain considerably and learning takes place as it must be. The integration of some subjects like science, mathematics and history may also enhance the

data of spatial memory (Caine and Caine 1991, 1997) and University of Nebraska at Omaha, 1999).

11. The brain downshifts under perceived threats and learns optimally when appropriately challenged

The brain works well in a challenged situation and downshifts in a threatened atmosphere. When the brain is under any sort of a threat, its hippocampus functions poorly. Learning is inhibited in state of threat and enhanced in state of a challenging atmosphere.

Threat, stress and fear change the orientation of brain, which results in a psychophysic disorder of brain that causes downshifting of brain. The learner feels himself/herself in a state of helplessness and seeks safety in a task doing it repeatedly. Cramming is one of such tasks. Teacher should generate an atmosphere that is low in threat and high in challenge. In such classrooms, a learner must feel full safety. Learners must have a say in such classes (Caine and Caine 1991, 1997) and University of Nebraska at Omaha, 1999).

12. Every brain is unique

Physiology of brain changes as learning occurs. The learners get same information differently, which reshapes their physiology of brains in unique ways.

Teachers must acknowledge the individual differences of learners. Emotions, choices, interests, learning styles, thinking patterns and responding behaviors vary from person to person. Each learner has typical limitations with respect to absorption and reproduction of input data. Diversified learning activities must be introduced so that all

individuals may extract meanings of their own levels (Caine and Caine 1991, 1997) and University of Nebraska at Omaha, 1999).

Caine and Caine's principles of BBL theory were followed by other neuro-psychologists and resultantly Lackney (2008) stated following 12 principles of BBL theory as well.

1. The uniqueness of brain is obvious.
2. The threat or high stress not only impairs learning but it kills the cells of brain also.
3. The emotions promote learning and influence our memory, attention and meaning seeking capability.
4. Besides spatial memory, the information is gathered and processed with the help of several neural paths.
5. The mind-body movement, drugs, foods etc affect the learning mechanism.
6. Any effective change in adaptive system of brain changes complex system of brain.
7. The understanding occurs through patterning.
8. Brain asks meaning of fresh ideas.
9. Learning occurs through processing of parts and wholes. It is non-conscious as well.
10. Brain unifies with other brains. It is social in nature.
11. Different stages of readiness develop brain.
12. Brain seeks an enriched environment to maximize its neural connections.

There are seven principles of BBL theory stated by Kagan (2001). These principles overlap the principles stated by Caine and Caine and Lackney. These principles are given as follows:

1. Brains need nourishment. The brain's alertness, functioning and learning habits depend positively on increased supply of oxygen and blood.
2. Brains are social organs. Brain learns more actively in an interactive environment as compared to self-doing.
3. Brains seek safety. This principle admits that in a frightened state, fight or flight response of brain activates itself and such anxieties or threats stop learning to occur.
4. Brains are emotional. Brains are oriented to respond to emotions of pain, fear, pleasure etc differently.
5. Brains seek and process information. The capabilities of brain ranging from attentive to novelty; parallel processing, feedback and pattern seeking to meaning construction, enable it store, process and retrieve input data as required.
6. Brains have styles. Its cognitive styles are diversified. The styles change oppositely in the following ways:
 - a. Impulsive vs. Reflective
 - b. Auditor vs. Visual vs. Kinesthetic vs. Tactile
 - c. Abstract vs. Concrete
 - d. Mastery vs. Interpersonal vs. Understanding vs. Expressive
 - e. Inductive vs. Deductive
 - f. Sequential vs. Simultaneous

- g. Stimulation Seeker vs. Avoider
- h. Introvert vs. Extrovert
- i. Curious vs. Adventurous vs. Harmonious vs. Responsible

Similarly, eight multiple intelligences correspond to various parts of brain or using same parts in different ways. Procedural, episodic and semantic memories of brain indicate retrieval tendency of brain in different ways.

7. Brains develop. Brain works on "Use it or lose it" principle. The embryonic brain development results in forming new neurons continuously.

The above-stated principles by the three psychologists are slightly different to one another but the basic theme behind them is same because all of them concern with the functioning and structure of different parts of brain. The principles stated by Caine and Caine are particularly fundamental because they provide base to other psychologists to design further principles. Hence, 12 principles of Caine and Caine only were discussed above in the perspective of their implications, which cover comprehensively classroom teaching learning process.

2.3.1 Application of Caine and Caine's 12 Principles of BBL Theory on Classroom

The groundbreaking design of 12 principles of BBL theory, proposed by Caine and Caine, can be applied in the classroom environment in a 2-way strategy. First strategy is to engage the learners in such cognition-based activities, which are compatible with the natural functioning of brain. The second strategy is to generate an enriched

environment, which helps brain to work properly without threats or stresses. Both strategies are meant for involving the learners in teaching learning process through sharpening the innate faculties of human brain. For the purpose, five of the principles of BBL theory based on five in-built faculties of human brain, can be applied on classroom environment through learning activities of cognitive practices and remaining 7 principles based on seven in-built faculties of human brain can be applied through generation of enriched environment. These principles can be applied in the following ways:

2.3.1.1 *Application of Principle 1 (P₁): The brain is a parallel processor*

Brain can do many tasks simultaneously. Seeing, breathing, thinking, speaking and responding occur at the same time and brain conducts them smoothly. The same tendency of doing more than one task can be utilized by teachers through presentation of such learning activities which contain diagrams, re-corrections, blank fillings, columns matching, concept mapping, flow charts, audio-visual aids, charts, hands-on tasks, posters, placards, banners and worksheets. Math giftedness can be effectively measured through visual spatial ability tests (Webb, *et al.* 2007) and parallel processing of brain is activated in such tests. Personal experiences of learners are also helpful in parallel processing and metaphors, similes and analogies promote functioning of brain naturally. Teacher can manage debates, discussions, seminars and quizzes; and incorporate suggestions, reflections and modifications of learners into a compact body of information. Teacher should facilitate learners to explore latent facts by giving relevant examples, connecting them with real life and previous knowledge of learners and discovering conclusions in Aha! Style. Multimodal parallel processing of brain is also

linked with teacher's own tone, dress and hairstyle; and also concerns with seating arrangement, temperature, time and distracters. (Caine and Caine, 1990, 2005; Jensen, 2005; MOEC, 1999; Kagan 2001; Wilson, 2005)

2.3.1.2 Application of Principle 2 (P₂): Learning engages the entire physiology

Physical health is an important factor for teaching learning process. Healthy bodies possess healthy brains and vice versa. Teacher should play a role in maintaining health of learners. Teacher should display a chart of balanced diet in the classroom and inform learners periodically about nutrition. Fruits, vegetables, nuts and lean meats promote optimal learning (Jensen, 2005). Airy, well-lit and neat classrooms are also helpful in maintaining health. Dehydration impairs learning, disturbs attention span, causes lethargy and enhances stress on brain because brain is made up of more water as compared to any other organ in human body (Jensen, 2005). Students should be encouraged to bring water bottles with them into classrooms and allowed them freely to drink water. More bathroom breaks must be arranged. Movement, foods and different chemicals help learning to occur in brain. Amount of sleep, fatigue, nutrition, social relationships etc do play roles in learning because our body is physiologically programmed. Students must have full liberty to encode information physically, talk, walk, handle, react and write within classrooms. Such free movements decrease stress levels and generate new pathways to memory (Caine and Caine, 1990, 2005; Jensen, 2005; MOEC, 1999; Kagan 2001; Wilson, 2005).

2.3.1.3 Application of Principle 3 (P₃): The search for meaning (making sense of our experiences) and the consequential need to act on our environment is innate / automatic

Brain wants to make sense of each new experience and meaningfulness, if imposed on brain, ceases its natural learning process. Teacher should avoid presenting isolated or irrelevant material. In stead, content must highlight the aspects of familiarity and novelty as well as it must satisfy the curiosity of learners who avail choices to process the information. Previous knowledge of learners must be utilized to enable brain understand meanings of new information. If the teacher believes in accrediting the prior learning, he or she may enable learners to fit the fresh information into the already existing relevant folder of information into the observant brain. Brain does not like boredom or uniformity and likes innovative approaches. Innovative incorporation of concepts into examples shapes novelty and such fresh and unconventional information is compatible with the physiology of brain. Students must be encouraged to reflect on their mistakes and learn from them thereafter. (Caine and Caine, 1990, 2005; Jensen, 2005; MOEC, 1999; Kagan 2001; Wilson, 2005)

2.3.1.4 Application of Principle 4 (P₄): The search for meaning occurs through “patterning”

Self-concept of learners plays an important role in enhancement of knowledge. Extraction of meaning out of patterns is a continuous process. Teacher should improve problem solving ability of learners by presentation of coherent material and encourage them to incorporate their reflections freely. Brainstorming sessions, debates, quiz competitions, individual and group presentations as well as projects, question-answer

sessions, critical thinking, daydreaming, peer tutoring etc are some of learning activities, which excite the pattern formation skill of learners. Mistakes, misconceptions, confusions and contradictions of learners are also helpful in generation of personal patterns of learners and an effective teacher should admit and, thereafter, supervise them to arrive at a meaningful exploration. The predictable patterns of brain are also helpful in creating new patterns, which assure student to have a say in the class (Caine and Caine, 1990, 2005; Jensen, 2005; MOEC, 1999; Kagan 2001; Wilson, 2005).

2.3.1.5 Application of Principle 5 (P₅): Emotions are critical and at the heart of patterning

Emotions and learning are mutually correlated. The moods, biases, prejudices, feelings, self-esteem, social interactions and psychological needs generate emotions to function accordingly. Effective learning and emotional health of learners are closely linked with each other. Thoughts and memory of brain depend upon a stimulus and emotions may be one of them. Teacher should create a cheerful environment within classrooms. Motivating approaches must be adopted. Plenty of choices must be given to learners. Jokes and humorous environment release extra tension of learners. Best learners are those who go on laughing which generates emotions of happiness, enjoyment, satisfaction, safety and relaxation and such mind-sets enable brain to create patterns. The emotional climate of classroom must be kept at balanced level and the teacher must constantly monitor it. Boredom must be eradicated in classroom by introducing physical activities, acknowledging individual differences of learners and presenting meaningful content. Emotional instability affects learning badly and anxiety disorder reduces gray matter volume of brain which is involved in emotional response of a stimuli. Similarly,

negative stresses affect the short-term memory of brain (Craig, 2003; Caine and Caine, 1990, 2005; Jensen, 2005; MOEC, 1999; Kagan 2001; Wilson 2005; Milham, et al. 2005; McEwen and Magarinos, 2001).

2.3.1.6 Application of Principle 6 (P₆): Every brain simultaneously perceives and creates parts and wholes

The inductive and deductive reasoning are consistent with this principle. Teacher should divide content into small inter-related fragments. The integration of these parts into a meaningful whole must be done with the help of reflections of students. Brain naturally fits new information in parts to larger existing wholes and generates knowledge. Teacher must disintegrate wholes into parts and facilitate learners to synthesize them again. The equations and scientific principles must be presented in parts to wholes or wholes to parts formats. Ausubel's concept of advance organizers and Piaget's schema resemble to this principle. It should make certain that parts are not isolated from each other; rather they must be coherent with each other. Learning is a developmental and cumulative process in which parts and wholes reinforce each other (Craig, 2003, Caine and Caine, 1990, 2005; Jensen, 2005; MOEC, 1999; Kagan 2001; Wilson 2005, Milham, et al. 2005. McEwen and Magarinos, 2001).

2.3.1.7 Application of Principle 7 (P₇): Learning involves both focused attention and peripheral perception

The content presented in classroom comes under focused attention. But the peripheral perception of ideas and concepts is equally important for the learners. Brain records important or less important data indiscriminately. The external attitude of learners

is not each and all; rather the internal attitude must also be developed by utilizing interests and enthusiasm of learners to relate unconscious signals to what is being learnt. Teacher should give importance to every aspect of student's personality whether it belongs to community, family or technology. Effective teacher will use all available resources to enhance peripheral perception such as peer discussion, illustrations, group and individual tasks, critical reflections, modeling and one-man shows (Craig, 2003, Caine and Caine, 1990, 2005; Jensen, 2005; MOEC, 1999; Kagan, 2001; Wilson, 2005, Milham, et al. 2005, McEwen and Magarinos, 2001)

2.3.1.8 Application of Principle 8 (P₈): Learning always involves conscious and unconscious processes

Teacher must give proper pauses to learners so that brain may process the information coherently. The creativity is an unstoppable process which enables learner to think internally. The conscious learning occurs during classroom sessions but active brain records some data automatically which lay foundations of unconscious learning. The students must be gifted with downtime during which the creative students may develop fresh ideas. Such innovative approaches will enable brains of learners to function naturally to learn in unconscious ways. External stimuli shut down during down time and brain finds opportunities to develop more and more neurotic connections. Periodical pauses, intervals, breaks or recesses and holidays during academic sessions play important role in unconscious learning processes (Craig, 2003, Caine and Caine, 1990, 2005; Jensen, 2005; MOEC, 1999; Kagan, 2001; Wilson, 2005, Milham, et al. 2005, McEwen, and Magarinos, 2001)

2.3.1.9 Application of Principle 9 (P₉): We have (at least) two types of memory systems: spatial and rote learning

Knowledge based on memorization makes poor development of understanding and raw storage of knowledge in short term memory of brain is faded away after some time due to absence of its regular rehearsals. Teacher should take measures to enhance the spatial memory storage of learners. Enriched environment will be helpful in this regards. According to Davenport Community School (2007), following strategies are helpful in creating enriched teaching learning environment.

1. Teaching learning mechanism should continue under absence of every kind of threat.
2. Collaborative tasks are consistent with the natural functioning of social brain. Teacher must encourage students to work in small groups and gather information through peers as well.
3. The plants, lamps, aromas, colours, air fresheners, oxygenated as well as well-lit classrooms, hands-on activities and comfortable seating arrangements generate a natural environment for brain to process and store data in spatial memory.
4. Adequate time to process information with free available choices of how to proceed on is highly compatible with anatomy of brain which likes learning naturally and dislikes memorizing facts.
5. Meaningful content inhibits brain to become downshifted. Rather it adds to spatial memory storage of brain. Similarly, immediate feedback provides teacher first-hand data about gains of students.

Teacher must equip himself/herself with these two tools (Meaningful Content and Immediate Feedback) so that rote learning may be diminished and brains learn naturally.

6. Humors and jokes are also helpful in learning as the best learners are those who laugh. (www.funderstanding.com, 1998-2001)
7. A physical activity mitigates effects of stresses and helps brain to work without fears. The young brains can improve learning and memory by physical exercise whereas physical exercises as well as mental practices enhance memory (Harburger, *et al*, 2007).

Role of memorization is important in certain learning tasks like tables of multiplication, spelling and vocabulary of unfamiliar words, learning abstract concepts and basic principles or formulas in different disciplines (Caine and Caine, 1997). The onus of creating understanding of multiplication, syllables of words and formulas or principles can be attributed to teaching methodology of the teacher. Teacher can improve memory of the learners by recognizing their emotions, creating sensory associations, relating learning personally to students, using creative repetition, remembering the importance of start and end of a lesson; and teaching specific recall techniques (Prigge, 2002).

2.3.1.10 Application of Principle 10 (P₁₀): The brain understands and remembers best when facts and skills are embedded in natural spatial memory

Teacher can build the spatial memory block of learners by the help of following activities.

- 1 Real-life activities related to the content through which brains of learners may develop associations between abstract and concrete ideas. Hence, classroom demonstrations, projects, field trips, visuals of certain experiences and best performances; stories, metaphor, similes and drama etc must be introduced (Caine and Caine 1997).
- 2 Integration of certain subjects like mathematics, science and history will enhance the conceptual canvas of learners and overlapping concepts of such disciplines can be understood collectively (Caine and Caine 1997).
- 3 Teacher should gain the attention of learners and this can be done through integrating novel or strong emotional connections to learning, using laughter, allowing movements and giving proper downtime to students (Prigge, 2002).
- 4 Activities like reminding/relating previous knowledge of students, students analyzing one another and projecting themselves through individual/group work, finding differences and similarities between two concepts, drawing diagrams and preparing concept maps can be introduced to improve retrieval of memory data (Politano and Paquin, 2000).
- 5 A chart of balanced diet must be displayed in classroom and teacher should give health tips periodically to students (Avaci and Yagbasani, 2004). Students should be encouraged to bring water bottles with them into classrooms and asked them to have water as soon as they feel themselves thirsty. Suitable toilet breaks must also be allowed (Jensen, 2005). A healthy body possesses a healthy brain normally and dehydration disturbs the functioning of brain.

- 6 Brain responds to challenge, stimulation and interactivity: it learns spontaneously (Wagmeister and Shifrin, 2000). These three components may be introduced during any classroom teaching.

2.3.1.11 Application of Principle 11 (P₁₁): The brain downshifts under perceived threats and learns optimally when appropriately challenged

Threats change the normal physiology of brain and it downshifts in such states (Hart, 1983). Negative stresses inhibit the learning process and positive stresses enhance learning capabilities of learners. To lower threats or negative stresses and enhance challenges or positive stresses, following steps could be taken:

- 1 Students should feel themselves in such safe atmosphere where they can think or take risks freely. This is called a relaxed alertness, which reduces the threat of failure or getting lower grades in students.
- 2 Proper seating arrangements, well-lit and airy classrooms; and comfortable atmosphere must be available to the students so that they feel themselves physically sound. The smiling face of a teacher makes the atmosphere friendly.
- 3 Emotional unrest of students will hamper the learning process. Teacher should generate a cheerful environment of the classrooms. Jokes and funny stories can be told for this purpose. Discouragement, sarcastic remarks, anger, physical punishment and blunt rejection of students' point of view cause emotional instability among students. Such types of behaviors should be avoided. Different feelings and attitudes of students should be taken psychologically and learning strategies must be designed accordingly.

- 4 Teacher should realize students that they have says in the classroom equally. Teacher's attitude must be unbiased. Unjustified preference of any student on others or neglecting any student constantly results in social maladjustment of students in the classroom. Teacher should encourage shy students to come to the dais and present views before whole class. Such efforts make students feel socially safe in the classrooms.
- 5 Students must be given complete liberty to ask any question whether it is relevant or irrelevant, plausible or absurd, easy or difficult etc. They must be certain that teacher will respond to such questions positively. Teacher must not make fun of any question, being asked by the students. Suitable suggestions, reflections or information of students must be incorporated into the content so that they may believe that the teacher has acknowledged their contributions. Corrections, modifications and contradictions of students must be done so carefully so that students realize that teacher is going to improve them and not proving them wrong (Caine and Caine, 1990, 2005; Jensen, 2005; MOEC, 1999; Kagan, 2001).

2.3.1.12 Application of Principle 12 (P₁₂): Every brain is unique

Every brain is unique like finger prints, complexions and DNA, and it responds variably for same situations from person to person. Educators should apply this BBL principle in the following ways:

- 1 Teacher should classify whole class into three categories of auditory, visual and kinesthetic learners through specific tests and design learning strategies accordingly.

- 2 Choices must be given to each learner and learning should occur according to the plan of learners and not according to the spoon-feeding plan of the teacher. Interests, likes, dislike and a teacher while constructing teaching learning strategies must not neglect personalized mental make-up of learners. No doubt, it will be the hardest job for the educators, as it needs huge resources.
- 3 Down time will be different for different learners and educators must assess it individually before moving to a new content in classroom teaching.
- 4 Activities like recalling pre-information about the topic by the students, students analyzing floated ideas of peers, projecting themselves in group study, question-answer sessions, teamwork etc must be introduced in classroom to sharpen the intellectual skill of learners individually.

(Politano and Paquin, 2000, Craig, 2003, Avaci and Yagbasani, 2004; Caine and Caine, 1990, 2005; Jensen, 2005; MOEC, 1999; Kagan, 2001)

The given principles are applicable and effective in teaching learning process. Caine and Caine applied these principles on classroom teaching learning process effectively. That is why based on these 12 principles, three teaching techniques of BBL theory have been coined by them.

2.4. Teaching Techniques in BBL Teaching Method

Following are the three teaching techniques in BBL teaching method (Caine and Caine, 1991, 1997).

- i) Orchestrated Immersion (OI)

ii) Relaxed Alertness (RA)

iii) Active Processing (AP)

The details of these techniques are given as follows:

2.4.1 Orchestrated Immersion (OI)

Orchestrated Immersion is a technique of BBL theory through which learner is exposed to a variety of teaching learning activities and he or she is free to choose best fit activity to understand meanings of a learning activity effectively. OI generates a conducive learning environment which converts any learning into an enjoyable learning activity because OI relates classroom information to real-life situation in the brains of learners (Caine and Caine (1991). Making learning contextual and related to student interests; structuring learning around real problems; and aiding learning with humor are also helpful in OI (Lucas (2004). In this technique, both students and teachers mutually plan teaching lesson. To extract meaningful patterns, students must be provided diversified opportunities so that neurotic connections are maximized. To trigger creativity among learners, Caine and Caine suggest ‘dynamic gestalts’ must be offered to them. Dynamic gestalts are the comprehensive patterns of understanding which incorporate fragments of information into a cohesive meaning and thereby students can explore more and more facts. Some examples of dynamic gestalts include establishing curricular themes; offering complex and real projects of personal interest to students; providing multisensory presentations, telling stories and exploring myths by using metaphors;

considering the entire physical context; and providing social relationship and a sense of community (Caine and Caine, 1997).

2.4.2 Relaxed Alertness (RA)

Relaxed alertness state of brain enables the learners to receive information from a teaching learning environment, which is free of threat or negative stress, and it is rather highly challenging for the learners. Under this teaching technique, the learner realizes that he or she is academically, socially, emotionally and physically safe. Teacher generates a friendly atmosphere that is free of fear or threat. The teacher acknowledges the different degrees of interest and differences in mood, curiosity, predispositions, and intensity of excitement. Students have no fears of failures or getting lower grades. Challenging atmosphere is created through accomplishment of individual/ group tasks, “who can do first” tactic and innovative performances. RA also facilitates students to explore new thoughts, make neural connections and trains them to tolerate ambiguity, uncertainty and delay of gratification (Caine and Caine 1991). By creating challenging environment, playing a soft tone, lighting brightly, spraying scents or air fresheners and accepting different individual differences, relaxed alertness can be practiced within a classroom. Caine and Caine (1997) have proposed following elements of instruction that incorporate RA into teaching.

- a) Students’ responses to different stimuli within classroom depend upon thinking and feelings of the teacher. This places teacher at a distinguished position in the classroom. Thus, teacher’s prestige must be maintained. Prestige means the authority of teacher in the eyes of students due to supremacy of knowledge.

Double plainness and expertise are two elements of prestige. Double plainness of teacher's prestige means the degree of congruence between teacher's inner beliefs and values and his external behavior. Expertise of teacher means his or her natural perception of facts in discovering or exploring ways. Teacher assures students that all learning is open-ended.

- b) RA prevails under two conditions, namely the childlike state and passive listening. The childlike (not childish) state of learners means a willingness to learning experiment, an openness to unexpected consequences and a sense of positive anticipation in creative and playful ways. In passive listening, learners are involved in learning activities in relaxed and attentive moods.
- c) In OI, students work in a soft environment. RA allows all kinds of immersions, which help in inculcating information naturally. This can be done in three ways. Firstly, such themes must be presented intelligently which are consistent with need of learners. Secondly, real-life experiences must be included because they add knowledge in relaxed ways. Thirdly, social interactions of learners must be equalized.
- d) Two types of relaxation techniques may be introduced in classrooms. However, teachers must be trained to do so. In meditation, relaxation is produced inwardly which influences positively to physical functioning of body. Learners can be trained to do so through audiotapes. Focusing exercises are second relaxation technique that improves attention level of learners. They can be done through detailed description of an object, process or scene.

- e) Traditional grading and testing create stresses for learners. Hence evaluation techniques must be reconstructed because stress due to grading disturbs the immune system of learners. In stead, educative feedback must be introduced which includes phrases like “I found myself thinking..... when you did that” or “what would happen if...” Collaborative tasks must be assigned and individual tasks must help individual to succeed.
- f) Orderliness is critical to RA. It creates a sense of safety for risk taking and encourages learners to participate in learning activities actively. Orderliness makes students creative, excited and spontaneous.

2.4.3 Active Processing (AP)

Active processing is a continuous process of deep understanding of learning concepts even after many hours the classroom ends. Unconscious learning is the natural function of human brain that goes on processing ceaselessly. Active processing is the consolidation and internalization of information to maximize connections, gain deeper insights, and perceive the additional possibilities that are hidden in an experience. AP does not occur at a specified time or in a single way during any part of the lesson, it goes on reshaping or reconstructing meanings of an experience in an exploring way. According to Caine and Caine, there are five elements of AP. They are given as follows:

1. Capitalizing (benefiting from) on an experience
2. Reflection
3. Contemplation
4. Creative Elaboration

5. Combination Process

The detailed elaboration of these five elements is given as follows.

- Student capitalizes on a learning experience by asking such questions to himself or herself.

- ✓ What did I do?

- ✓ Why did I do?

- ✓ What did I learn?

Such questioning enhances the intrinsic motivation of students.

- Reflection is related to higher order thinking and learning. This complex process occurs in three ways.

- ❖ Firstly, it happens on feedback from others.

- ❖ Secondly, it happens without assistance of anybody.

- ❖ Thirdly, it occurs because of personal awareness of deep meaning of a learning experience.

- Contemplation is a non-analytical style of thinking. It prevents learners to create misconception in understanding an idea. Focusing is a particular technique of contemplation by which a learner thinks on an idea internally and draws conclusions out of it.

- Creative elaboration of an idea can be done in three ways.

- Firstly, the experience must be reorganized in different ways and from different points of view.
 - Secondly, the idea must be literally and metaphorically turned upside down to re-perceive information.
 - Thirdly, personal analogies must be used to elaborate an idea like compare and contrast to fit new information into already existing relevant ones.
- Combination process promotes all procedures of reflection and contemplation in different ways. Two of the ways are important in this connection.
 - Firstly, students must be encouraged to write in journals or diaries and bring out their actual thoughts.
 - Secondly, thinking skills of students must be enhanced and sufficient time must be reserved for teaching of critical thinking (Caine and Caine 1991)

The concept of action learning i.e. self-study of own experiences by the learners themselves to enhance academic achievement may be linked with the concept of active processing. The Revans (Revans, 1980) formula in this connection is very important to note:

$$L = P + Q$$

where L stands for the learning, P for the programming and Q for the questioning. This will create an insight for the learners into the information got by the learners through seeing, hearing or feeling (http://en.wikipedia.org/wiki/Action_learning).

2.5. Application of BBL Theory in Developing Teaching Learning Materials

BBL theory has been in practice since 1980s. It has attracted many educationists and psychologists to come forward and work on its different dimensions. A variety of teaching learning materials has been developed which was based on the concept of BBL theory. Here are different approaches, which were used to develop instructional material based on BBL theory.

2.5.1. Integrated Thematic Instruction (ITI)

Susan Kovalik designed Integrated Thematic Instruction (ITI) model (a body-brain compatible model for teaching and learning) to increase student performance and teacher satisfaction in the light of brain-compatible instructions. (<http://www.journeytoexcellence.org/practice/instruction/theories/iti>). The ITI classroom is different from a traditional one. It is designed to encourage learning rather than hinder it (<http://www.freewebs.com/taol/biengthere.html>).

Kovalik is the pioneer of introducing brain-compatible environments at work, at home and at school. (<http://www.kovalik.com/founder.htm>). Currently, Highly Effective Teaching (HET) has replaced ITI and the primary purpose of the model is to grow responsible citizens. Thousands of schools in America, Europe and Asia have been

implementing HET. HET as a brain-compatible instructional model is working for the development of conceptual curriculum (<http://www.kovalik.com/home.htm>).

2.5.2. Power of Ten

Trevor Calkins, a Canadian teacher, developed an innovative and creative model of 'Power of Ten', which is a teaching learning approach of how to use numbers and based on researches on how brain learns. This model has been popularly adopted in Western Canada and the Northwest United States. Trust, respect, and creativity are part and parcel of this model. A complete set of materials, plans; and approaches for teaching numeracy at elementary and middle school levels; as well as providing an additional support through arrangement of different conferences or workshops is also the salient features of the model (<http://www.poweroften.ca/consulting/consultants.html>). Calkins rejected the old methods of teaching numeracy and mathematics arrived at a new approach, namely Power of Ten, by coupling his thoughts with the brain research, and formulated numeracy skills for the kids.

According to Power of Ten, A Brain Compatible Learning System for Numeracy Skills (2007), Power of ten has following four parts:

a. The Power of Ten Visual System

To teach basic skills of addition, subtraction, multiplication and division, the power of ten visual system helps learners to know about alpha and beta of different facts and gain numeracy skills.

b. Mastering the Basics

A set of assessment materials is the second part of this system. It is designed for 4-8 graders to master the basics which the learners got in first part. It is based on the curriculum of Western Canadian Consortium.

c. Mathematics as a Teachable Manual

Third part is the teacher's manuals at primary, middle or higher levels, which connect number sense, spatial sense and patterns with one another. Manuals are teaching tools that help teachers to design learning activities in accordance with the interests of the students.

d. Math Activities

Fourth part contains different math activities. Children learn mathematical concepts with the help of games and learning activities alongwith worksheets and assessment records.

2.5.3. The Five Finger Paragraph (FFP)

Johnnie W. Lewis has developed the Five Finger Paragraph and Five Finger Essay. It is a technique of writing an essay. Its author made use of a set of books and teaching aids and helped parents teach their kids what an essay is and how it is supposed to be structured. Using the concept of color-coding, the visual aid of the human hand, the five main colors i.e. Red, Yellow, Blue, Purple, and Green, and designating a finger for each, Lewis developed an easy-to-follow visual mechanism for children to learn how to write paragraphs and essays (<http://www.myshelf.com/writing/05/fivefingeressay.htm>).

According to Lewis “The Five Finger Paragraph is a brain-based learning method for teaching classroom or home schooled students to write basic paragraphs and five paragraph essays. The color-coded kinesthetic method uses mnemonics so that the student assimilates the method more quickly and remembers it longer than traditional rubrics”. (http://www.thefivefingerparagraph.com/what's_ffp.htm)

2.5.4. Science, Mathematics, Art, Reading and Technology (S.M.A.R.T.)

S.M.A.R.T. stands for Science, Mathematics, Art, Reading and Technology for Kids and believes in whole brain approach towards teaching learning environment. It is a brain-based academic enrichment program intended to develop skills in kids by activating all parts of the brain (<http://www.smartforkids.com>).

Based on the latest research on brain-based teaching and learning and being implemented for the academic achievement, four basic facts believed by S.M.A.R.T. (<http://www.smartforkids.com>) are given as follows:

- 1 “All children learn best through SMART experiences.
- 2 All children are SMART.
- 3 All children show how SMART they are in various ways.
- 4 All children can learn at high levels’ SMART instruction that is appropriate for their skill level”.

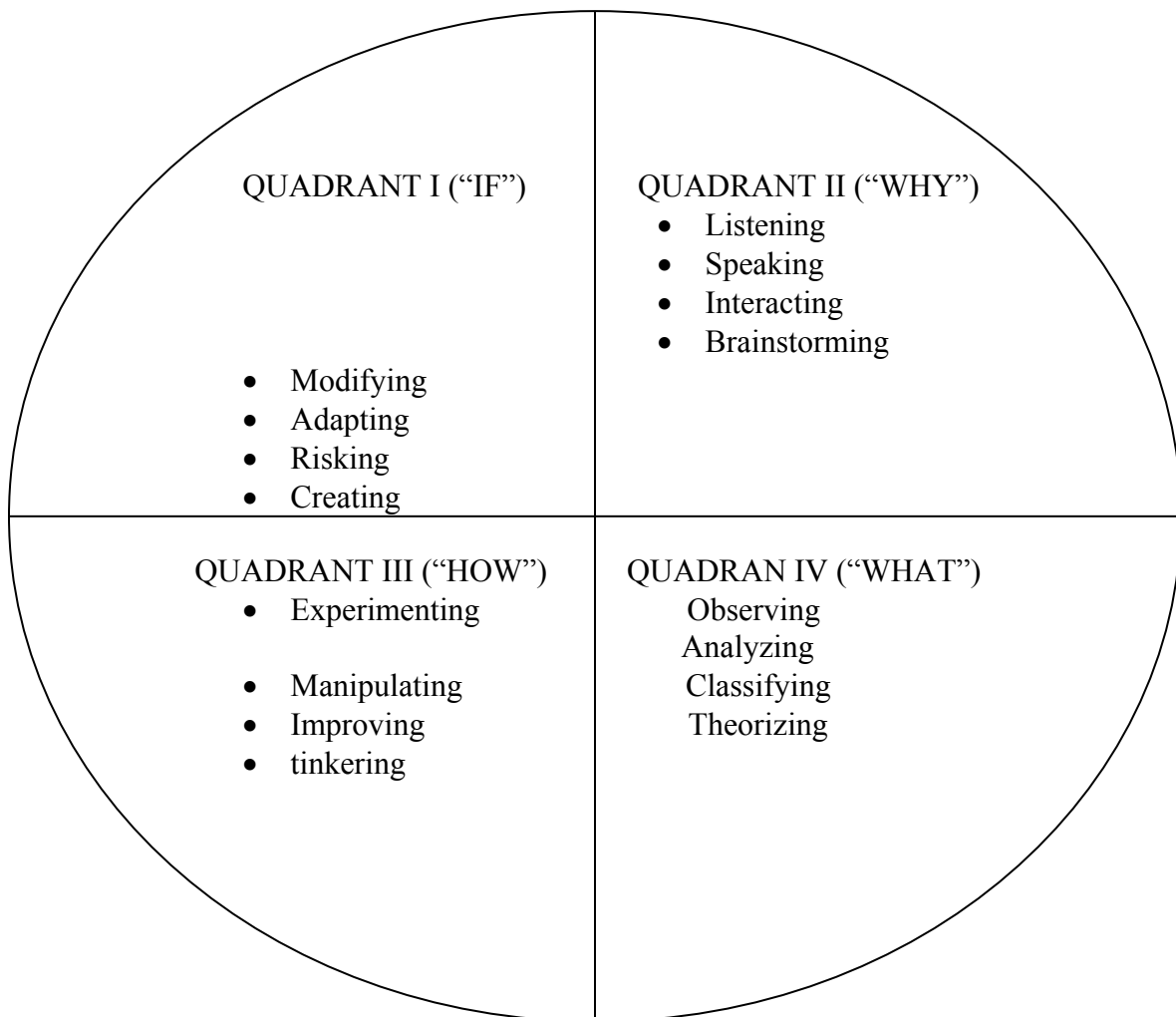
2.5.5. “4 MAT Cycle”

The “4MAT Cycle” is a brain-based teaching method that acknowledges different learning styles and learner’s individuality; it believes in teaching concepts as well as facts, and improves student thinking and performance on traditional as well high-stakes assessment programme (McCarthy and McCarthy, 2006), McCarthy’s 4MAT System identifies four learning styles. They are given as follows (<http://www.usd.edu/~ssanto/4mat.html>)

1. Innovative Learners believe in their own experiences and feelings and keep on learning by asking questions from others. They like to get answers of "If." Memorizing, tests, listening to long verbal explanations, giving oral presentations, conflict; and not being allowed to discuss their perceptions, are disliked by them. They continue on experiencing either by feeling or reflecting.
2. Analytic Learners learn individually through lectures, discussions etc. They like to get answers of "why". They perform actively in traditionally managed learning set-ups where verbal skills are sharpened. They do not like noisy environments, working in groups, role-playing etc. They enjoy independent research, analysis of data and hearing what the experts have to say. They gather information by reflecting and thinking.
3. Common Sense Learners are interested in how things work. They like to get answers of "how." Concrete, experiential learning activities work best for them. They like to learn by using manipulative, hands-on tasks, kinesthetic experience, active problem solving, discovery, touching, constructing, spatial task and enjoy competition. They perform poorly in open-ended tasks and work well if deadlines are given. Reading and verbal activity do not attract them.

4. Dynamic learners learn by self-discovery method and want to work independently. They like to get answers of "what." They like open-ended tasks involving risks. Routine work, visual complexity and time management have no attraction for them simply because they like creating items. Using the brain based learning approach; McCarthy made use of both right- and left-brain processing techniques to propose instructional set up for the four different kinds of learners. The figure 1 below illustrates the 4MAT cycle of learning (Huitt, 2000) which describes questions and learning strategies of each quadrant:

FIGURE 1: SKILLS OF THE FOUR LEARNING STYLES



Source: Huitt, W. (2000). Individual differences: The 4MAT system. Educational Psychology Interactive. Valdosta, GA: Valdosta State University.

2.5.6. Layered Curriculum Method of Instruction

Kathie Nunley developed the layered curriculum method of instruction by applying the BBL theory in the subject of biology. (Nunley, 2006) Layered Curriculum methodology is effective for all types of subjects and levels. Thinking styles of teachers and students are changed. There are three grades namely A, B and C which are given on the levels of students' understanding. The C grade reflects basic understanding of core concepts, B grade shows an understanding of the material as well as a personal discovery on the basis of application or manipulation of the content and A grade describes mastery of concepts and ability of critical analysis among the students. According to her, layered curriculum is a five-step solution of differentiating whole classroom for an effective learning. These steps are given as follows:

Step One

On first step, all concerning lesson plans, containing objectives, assignment options and evaluation criteria, are handed over to students in advance.

Step Two

The content is divided into three layers based on levels of understanding. The layers are named as A, B and C. The bottom layer is called C layer. This layer has following characteristics:

- 1 Students can get C grade if they strictly follow this layer.
- 2 Different assignments are offered to students, which have different shades, depending on nature of tasks.

- 3 Students should have a clear understanding of the topic. Diversified assignments are given for the purpose.
- 4 Assignments should be based on learning styles of the learners. Hands-on activities and physical works are suitable to kinesthetic learners. Similarly videos, slides, charts, art projects, models etc are some activities for visual learners whereas lecturing is best for auditory learners.
- 5 Different disciplines must be integrated to create a better understanding.
- 6 The core curriculum should be covered in this layer.

Step Three

Afterwards, the second layer B is created. The thinking process of students is engaged here. The information learned in layer C is applied to build this layer. In this layer, learning activities like problem solving and brainstorming are introduced. Different assignments are given in this layer e.g. interdisciplinary study, history fairs, application of new words etc.

Step Four

Finally, a third layer A is added which is related to critical thinking. Traditional thinking patterns are mixed with values, personal opinions and morality to link real world situation to classroom environment. The students collect at least three latest researches about the topics and students prepare critical notes on basis of researches. The product of this layer comes in the form of oral presentation or defense as well as in any official correspondences to relevant authorities in light of critical conclusions.

Step Five

This step assesses the achievement level of students in a unique way. Students comment one by one on what they learned soon after completing an assignment. Teacher helps in clarification of their ideas and assures of achievement of objectives of the exercise (Nunley, 2007).

2.6. BBL and Contemporary Concepts

BBL theory believes in developing teaching learning strategies according to the natural functioning of brain. The findings of neuroscience have revolutionized research work and psychologists and educationists lay the foundations of fresh concepts on natural wiring of brain. Learning styles, multiple intelligences, peer tutoring, mastery learning and cooperative learning are some of the contemporary concepts, which have similarities with BBL theory. Brief introductions of these concepts are given in the following lines.

2.6.1. Learning Styles

Learning styles are divided into different models. The Felder-Silverman learning model divides learners into active or sequential learners and reflective or global learners. Active or sequential learners learn through sensing, visual aids and inductive approaches. Reflective or global learners learn conversely by intuitive, verbal and deductive styles. Moreover, learners are also divided into three types such as auditory, visual and kinaesthetic (Pithers and Mason, 1992; Felder, 2002).

The Hermann Brain Dominance Instrument classifies learners on the basis of thinking. It considers logic as activity of left brain cerebral, holistic thinking as activity of right brain cerebral and sequential thinking as activity of left brain limbic and emotional thinking as activity of right brain limbic. The Kolb's learning style inventory classifies learning into four quadrants of concrete experience, abstract conceptualisation, active experimentation and reflective observation (Pithers and Mason, 1992; Felder, 2002).

Honey and Mumford's system of learning believes that learners are activists, reflectors, pragmatists and theorists. Competitive, avoidant and dependent learners store information accordingly under The Grascha-Riechmann Student Learning Style Scale. Myers-Briggs divides learners into Jungian psychological types. Judgers or perceivers, thinkers or feelers, introverts or extroverts and sensors or intuitors are some kinds of learners according to this style (Pithers and Mason, 1992; Felder, 2002).

2.6.2. Multiple Intelligences

Gardner's theory of multiple intelligences is originally based on biological proofs of different kinds of intelligences found in the human brain. This theory turned down the concept of intelligence quotient, known as I.Q. Initially, the theory contained seven intelligences like verbal-linguistic, logical-mathematical, visual-spatial, bodily kinesthetic, musical-rhythmic, interpersonal, and intrapersonal (Gardner 1983, 1991, 1993). Later on, the naturalist intelligence (Meyer, 1997) and existential intelligence (Gardner 1998) were also added to the list. These intelligences have biological proofs but existential intelligence was considered as half intelligence because it had no biological evidence (Connell, 2000). It is not necessary that each human possesses the nine kinds of

intelligences but one may lack in some of them. All human beings are not at par with respect to the stated intelligences. These intelligences are varying and developed on high, moderate or poor levels (Gardner 1983). This difference is due to encouragement, enrichment, and instruction that cast a positive influence on these intelligences (Armstrong, 1994).

2.6.3. Peer Tutoring

Peer tutor who works under the instruction of teacher, belongs to same class, grade and age-group. In classroom peer tutoring sessions, all students share their abilities with one another and spend enough time in learning and practicing new contents. Each student may be paired with other and so on. One student uses the instructions of teacher to convey to next one. Peer tutoring can be practiced in groups where a tutor passes on instructions of teacher to group collectively. Peer tutoring is an effective method of instructions by which tutees and tutors both develop themselves academically and socially (Cohen and Kulik, 1982). Contrary to this concept, different studies showed concerns over some factors like academic deficiency and age-fellowship of tutors which lower the effectiveness of this method (Willis and Crowder, 1974; DePaulo et al., 1989). Even then, the impact of peer tutoring in subject of mathematics at primary level was reported as good with respects to accuracy in reproduction and rates of solving problems (Haris and Sherman, 1973). Like BBL teaching method, peer tutoring also focuses on a

diversified approach to learn new ideas. Choices, collaborations and less threatening atmospheres are common traits of both methods.

2.6.4. Mastery Learning

According to the website www.funderstanding.com. (2008), mastery learning believes that in the presence of suitable teaching learning environment, all children can learn. Benjamin Bloom's Model of Mastery Learning is a teacher-paced and group-based instructional program which can be referred as application of mastery learning. Like brain based learning, it also encourages students to work in groups as well as individually.

According to Bloom, following five steps must be followed for mastery learning:

- 1 Statement of major objectives must be prepared because it will define mastery of the subject.
- 2 Content must be divided into smaller parts and each part should have its objectives and assessment criteria.
- 3 Necessary learning materials and their relevant instructional strategies must be developed with details of learning activities and evaluation procedures.
- 4 Diagnostic test must be administered at the start of each unit of content.
- 5 Learning instructions must be prepared in the light of results of diagnostic tests (Hunter, *et al*, 1987).

Observance of the above-mentioned 5-step strategy of mastery learning results in gaining proficiency in the current task among the students and the students are able to advance to a subsequent learning task afterwards (Wikipedia, 2007) It resembles to BBL with respect of curriculum as both believe effectiveness of learning more than the content. Instructional strategies of mastery learning are nearly identical to BBL theory as both prefer to expose learners to a variety of learning activities and students are free to interact with the activities according to their choices. Frequent and immediate feedback is the common assessment strategies of the two concepts whereby instant information of achievement of the students is utilized to move ahead in a classroom teaching.

2.6.5. Cooperative Learning

Cooperative learning is the instructional use of small groups whereby students maximize their self and one other's learning during group studies (Apple Learning Interchange, 2003). In cooperative learning, learners are divided into small teams heterogeneously and diversified learning activities are managed to enhance the understanding of concepts. Each member of a team offers help to other teammates in achieving concepts effectively. Assignments are given to each student per team. In this way all group manages to achieve the learning content effectively. The participants of each group do their best so that all their teammates avail each other's efforts, believe in common fate of the group, admit mutual role in learning concepts and be proud of achievement of any group member. Positive interdependence, face-to-face interaction, individual and group accountability, interpersonal and small group skills and group

processing are the five conditions of elements of cooperative learning (<http://edtech.kennesaw.edu/intech/cooperativelearning.com>; Apple Learning Interchange, 2003).

2.6.6. Emotional Intelligence

Self-Awareness, Self-Regulation, Motivation, Empathy, and Social Skills are five dimensions of Emotional Intelligence, proposed by Goleman (1994, 1998). The brain-based research also emphasizes to create enriched emotional climate for an effective learning. Challenging and safe climate were proposed for such learning (Wolfe and Brandt, 1998). If a child is experiencing intimidated, rejected or risky situation, he or she will focus attention more on self-protection than on learning process (Tomlinson and Kalbfleisch, 1998).

2.7. Criticism on BBL Theory

BBL theory is a fresh concept in the teaching learning field. Different objections have been raised against this concept in many parts of the world. Biological base of this theory and central role of brain in learning, memory, thinking and feelings have attracted attention of many psychologists and educationists all around. But the critics of this theory have some reservations about this concept. They say that every educational process is brain-based and no one can be termed as non brain based. Following are the critical views of different critics.

- a) Some critics of brain research consider its findings as a popular mix of speculations, misconceptions and facts. They are of the view that brain-based

education is not based on research. The academic achievement of students cannot be termed because of brain based strategies only. There are some other factors which may be responsible for this achievement level like enhanced attention of students on hands-on activities, teachers' concerns to satisfy needs of students, external managerial pressures on teachers and students etc. (Jorgenson, 2003). Similarly, Strauss (2001) has mentioned some opposing views to brain based education. According to him, Fischer, the Director of, 'Mind, Brain and Education program at Harvard' was against of taking neuroscience to classroom due to little knowledge of neuroscience so far. Similarly, Bruer, president of the 'McDonnell Foundation' in St. Louis, maintained that there is no research which connects learning techniques or methodologies to change in brain physiology. Bruer also opined that it seems not necessary to develop curriculum particularly for BBL.

- b) Meanwhile the proponents of BBL theory believe that learning activities of brain gym, which is an example of physical movement strategy of BBL theory, increases focus of brain on learning but neuroscientists do not agree. The opponents of BBL theory agree with the principles of Mozart Effects. They are also in favour of using brain based learning approaches. But they criticize on information and findings of brain research due to unavailability of concrete evidence and credentials of BBL theory (Hendrix, 2008). Paglin (2000) denies of brain research support to Mozart effect because research does not imply it about teaching or learning.
- c) Jensen (2000) has commented on four critical views about BBL, which are stated herein. They are discussed as follows.

- 1 Firstly, according to him, some people often misinterpret the findings of brain research. This misleading attitude leads to wrong conclusions.
 - 2 Secondly, BBL approach is not a new idea and this idea has been in practice since many years ago. No claims of discovery of a new learning approach are consistent with the pre-existing body of knowledge.
 - 3 Thirdly, brain research is changing too rapidly to be given importance. Newer findings are contradicting older ones quickly and brain research period is in transitory state.
 - 4 Fourthly, brain-based learning is a confusing concept because there is little consensus on its different factors.
- d) Tommerdahl (2008) has mentioned three difficulties, which enable findings of neuroscience to play an active role in teaching learning practices.
- According to him, the complexity of both physiology of brain and teaching-learning process is the first difficulty, which are hampering the success of this field.
 - Equipment limitation is the second difficulty. There are two types of machines that can monitor brain activity. One of them gives primary spatial information and shows where activities happen in brain. The other machine gives primary temporal information, which shows the timing of brain activities. Nevertheless, machines have either high spatial or high temporal capabilities but not both simultaneously. The whole picture of an activity of brain cannot be shown exactly.

- The third difficulty is named as complex road from the laboratory to the classroom. The findings of equipments in the laboratory cannot be applied directly on classrooms. This transition can be done after lot of necessary researches about them.

According to Tommerdahl, the levels of neuroscience and cognitive neuroscience; psychology, educational theory and testing; and finally the classroom are the five paths, which must be followed during the transition of findings from laboratory to classrooms. Same point of view was adopted by Willingham (2006) who criticized BBL by declaring advancement of neuroscientists about how brain works in the wrong direction. He observed that neuroscientific claims and facts lose their original form when they are applied to classrooms.

- e) Madigan (2001) maintained that students must be guided to learn through such methods, which are research-oriented. He further criticized that in stead of using good sense, educators have adopted wrong techniques of brain based theories whose actual testing in classrooms does not exist. He added that educators are conducting brain based learning kits and workshops just because it has become a fashion to use the term brain based but it is actually a fashionable fad which is inhibiting researchers to study the complex field of education.
- f) Bruer and James, (1999) are prominent opponents of BBL theory. They opine that ideas of brain based learning are based on misconceptions. These ideas have been over generalized in wrong directions and educators can get nothing of them. At present, educational application of brain research is not possible because

neuroscience has little information so far about classroom applications. They disclosed that research articles in the favour of BBL theory were written by either educational futurists or cognitive (not brain) scientists. Even a single article was not written during 1997-98 by a neuroscientist in favour of BBL. Emerging claims about brain and education are outdated, metaphorical or vague mostly and based on mere misconceptions. BBL depends on data provided by neuroscience but according to Bruer and James, there is not enough information about link between neural function of brain and educational practices and neural activities of brain are unable to direct classroom activities in a meaningful way. Bruer (1999) does not agree that there is any link among brain science and Bloom's taxonomy, Vygotsky's social learning theory, thematic instruction, cooperative learning and the portfolio assessment of BBL because there are no ample evidences in favour of these links.

2.7.1. Logical Justification of BBL Theory

Several objections by contemporary psychologists have been raised against BBL theory during last two decades. Jensen (2005) considered five of them and responded accordingly. They are given as follows:

- 1) Firstly, the critics maintain that proponents of BBL theory do not verify the sources of findings about brain. Jensen partially agreed to this objection but he suggests to use various available authentic resources to verify findings about brain research. For this purpose, he himself used to adopt a specific procedure. He uses neuroscientific resources first and then he searches for available

clinical studies to confirm the application of findings on teaching learning process. At the end, he used to study educational practices reports or available action researches on the topic under discussion.

2) Second objection on BBL theory is that there is nothing new in it and its stuff is cheating everyone. Jensen defends by saying that past 10 years are vital for brain research period and lot of facts has been discovered about brain in this period. He refers to following ten facts about brain which have been discovered during past 10 years and contradicts objection of “nothing new in BBL theory”. They are as follows:

- a) Brains can grow new neurons in a regulated way and these new neurons are related to memory.
- b) Stable baseline of stress does not exist and human brain goes on responding to changing stresses by forming a new baseline.
- c) The aggressive behavior therapies, drugs and stem-line implantation are used to regulate or repair brain-based disorders.
- d) It has been discovered that particular teenage behavior is due to some fast-changing factors and not due to mere excretion of some hormones.
- e) Genes are not found in fixed forms and genetic set-ups can be modified.
- f) Research findings state that a delicate interplay is present between cognition and emotional states of brain.
- g) Music can affect cognition and aid learning.

- h)** The attention, reading ability and hearing can be improved by using such software programs, called as Fast-forward, which make use of plasticity of brain.
 - i)** Physical movement and exercise can increase cognition, new cell growth and mood regulation.
 - j)** If human beings are implanted with 'brain chips', they can perform controlled mechanical functions.
- 3) Critics objected BBL proponents for misinterpretation of brain findings and on the basis of these findings; they suggested invalid implications for teaching learning process. But Jensen termed this objection valid in most of cases. For example, positive impact of Mozart effect on learning was wrongly interpreted by generalizing that all kinds of music are good for all learners. To avoid it, Jensen proposed to wait for corroborating studies before interpreting and generalizing findings of a fresh study.
- 4) BBL was criticized as some of brain researches were conducted on animals in stead of human beings. Same criticism is there on famous psychologists like Skinner, Pavlov etc. Jensen commented on this criticism by quoting findings of a study (Overman and Bachevalier, 2001) which concluded that animal testing procedure can be applied to children directly. But the findings of this study are not sufficient to defend the fourth objection. Jensen further categorically stated that Norway rats and macaque monkeys are neuroanatomically identical to humans. Though human studies are ideal but it is not possible to do so in all cases because humans are biased unlikely to animals.

- 5) Critics say that many ideas of brain based learning theory have been borrowed from sociology, psychiatry or psychology. How can brain-based education be declared as lying within field of brain science only? Jensen turned down it by saying that different disciplines like sociology, biology, pedagogy, psychology and psychiatry describe human behavior physiologically, clinically or verbally. Similarly study of brain is significant for understanding and developing human behavior. Recent books of stated disciplines include separate chapters exclusively about anatomy, functions and processes of brain. Since learning, memory, feelings, emotions and intelligence are closely linked with functioning of brain, brain based education does prefer physiology and functions of various parts of brain by keeping its individuality. Brain based education means application of brain findings on teaching learning processes.
- 6) Lastly, Jensen addresses to all opponents of BBL theory and says categorically that all opponents are fighting a losing battle against this fresh approach because thousands of neuroscientific studies are being conducted each year and some of them have been applied on classrooms practices. Thousands of teachers are practicing BBL theory all over the world. Since the theory helps brain to make sense of a learning experience and matches with the natural functioning of brain, all such criticism will die out sooner or latter.

2.8. Conventional Teaching Method

The conventional teaching method is practiced in our school system. Lecture method is one of its prominent forms. The conventional teaching method is applied for teaching different disciplines at all levels invariably. In this teacher-centered and teacher-paced teaching method, a teacher conveys the information authoritatively. Some characteristics of the conventional teaching method are given as follows:

- 1 It relies on listening skills of the learners mainly.
- 2 Conventional teaching method helps students to memorize facts. Such instruction results in generation of surface knowledge (Caine and Caine, 1995). In our schools, reproduction of the taught material is encouraged. The evaluation of students relies mainly on the verbatim retrieval of information given in the textbooks only.
- 3 In a conventional teaching method, students are threatened by punishing physically or rewarding grades. Students work in an atmosphere of command and obey and they have little says in classrooms.
- 4 The conventional teaching method promotes one-way communication and there is little space of questioning, discussion and immediate practice during classroom teaching learning sessions (McIntosh, 1996). In our teaching learning sessions, the teacher is to write on the blackboard/whiteboard and students are to take its notes. The teachers do not discuss the topics mostly because the focus of teacher is on the coverage of syllabus at the cost of its earliest finish.
- 5 There is lack of interaction between students and teachers in a conventional teaching method (Munson, 1992). It can be observed in a classroom of our educational network that most of the teachers create a pin-drop silence in the

- classrooms and it is the voice of teacher that remains audible for maximum time of the period.
- 6 The conventional schooling promotes abstract perceiving and reflective processing (www.funderstanding.com, 1998).
 - 7 In conventional classes, students are supposed to be passive learners. (Steinhorst and Keeler, 1995). This is easily observable in our classroom sessions where students are taught through traditional lecturing.
 - 8 The conventional teaching method consists of mainly delivering lectures by the teachers and students are cognitively active but physically inactive. Students may be busy in note taking (Haghighi, Vakil and Weitba, 2005). In our classroom teaching learning sessions, the only physical task done by the students is either note-taking or standing on the seat to answer any question of the teacher.
 - 9 Traditional teaching is the formal presentation of content (Vella, 1992) or oral presentation of teaching learning content (Ruyle, 1995).
 - 10 Conventional teaching method works against the natural functioning of human brain (Weber, 2006). Students are involved in rote-learning. Teacher coerces the students to reproduce the material that had been taught to them. Physical punishment, resentment of the teachers and threatening role of authoritative teacher is observable mostly in our classrooms.
 - 11 During the prolonged conventional teaching sessions, interests and attention of learners cannot be maintained (Cangelosi, 2003).
- The survey of different traits of the conventional teaching method tells that that all of the stated traits are being applied in our classrooms where teachers use

traditional method to teach different disciplines. Such practice can be observed easily where interaction of student to teacher or student to student is discouraged during teaching learning session.

2.9. Difference Between Conventional and BBL Teaching Methods

The conventional and BBL teaching methods are different from each other according to their set patterns. BBL teaching method engages brain in the learning process by considering the natural functioning of its various parts whereas conventional teaching method promotes rote-memorization of facts. Both the teaching methods are different from each other. That's why the effect of the two teaching methods is generally perceived to be different which shows the effectiveness of a particular method. The term effectiveness is defined in the context of education that to what extent the objectives of the educational program have been achieved. Similarly effectiveness of a teaching method is determined to find out its impact on academic achievement of the students through application of the teaching method being tested. It is further concerned with the accomplishment of the instructional objectives for the specified content.

Educationists have drawn clear differences between the two teaching methods. Biller (2007) developed the following differences between BBL (brain friendly) and conventional (brain unfriendly) classrooms. **Table 1 (on the next page please)** illustrates the stated differences.

Table 1. Differences between BBL and conventional teaching methods

BBL Teaching Method	Conventional Teaching Method
(A Brain-Friendly Classroom)	(A Brain-Unfriendly Classroom)
<ul style="list-style-type: none"> ▪ Generation of threats-free environment. ▪ Distribution of students in small groups ▪ Incorporation of individual ideas of students into teaching learning activities ▪ Use of positive language ▪ Encouraging questioning of students ▪ Stimulation of brain through music, physical movement or aromas ○ Inter-linkage between different subjects ○ The instant feedback by the teachers 	<ul style="list-style-type: none"> ▪ Threatening of students by physical punishments and rewards like grading individually ▪ Use of negative language on and off ▪ Limiting students to give a single answer or pin-drop silence ▪ No Physical movement of students ▪ Instructions given collectively for the most of time ○ Delayed and indefinite feedback. ○ Examinations and tests used to pass final examinations only.

- joyful learning linked with real life situations
- Shaping learning creative, fun and easy.
- End of learning session in a celebrative way
- Highlighting suggestions, quarries and discussion of students most part of the time.
- Learning for the sake of certificates
- Students having little liberty to talk infer or demand.
- End of a sessions end soon after the allotted time finishes
- .Divergent end of a traditional

Caine and Caine (1991) also compared natures of BBL and traditional teaching methods. Table 2 depicts the following differences between the two teaching methods.

Table 2. Differences between BBL and conventional teaching methods

Factors	BBL Teaching Method	Conventional Teaching Method
1. Source of Information	<ul style="list-style-type: none"> ▪ Complex source of information Teaching content gathered from discovery, individual reflections, role playing, social interaction groups and integrated subject matter 	<ul style="list-style-type: none"> ▪ Simple source of information Information directed from teacher to book or worksheet
2. Classroom Organization	<ul style="list-style-type: none"> ○ Thematic and integrative instructions ○ Cooperative learning ○ Students working in small groups ○ Assignments of individualized 	<ul style="list-style-type: none"> ○ Active role of teacher for classroom organization ○ Students working individually or directed by the teacher.

projects.

- | | | | |
|-------------------------|--|---|---|
| 3. Classroom management | • Teacher delegates powers to students | • Teacher-Controlled | • Teacher deciding about running teaching learning activities in classrooms |
| 4. Nature of Outcomes | ✓ Convergent and Divergent | ✓ Convergent and focused on one dimension | |

2.10. Research Underpinnings for BBL and Conventional Teaching Methods

BBL theory has attracted many psychologists and educational researchers in many parts of the world, especially in USA, Europe, Australia, Japan, Turkey, Thailand etc. The groundbreaking model of BBL's 12 Principles by Caine and Caine opened doors of research in the field of BBL theory and many researchers followed them and contributed to this fresh approach while designing teaching learning environment.

Prigge (2002), a professor of special education at Central Washington University, in the research article "Intervention in School and Clinic: Promote Brain-Based Teaching and Learning" proposed six ways to prepare the learner, four ways to manage the environment, four ways to gain and keep learner's attention and six ways to increase memory and recall. But Davis (2004) in a research paper on the topic "The Credentials of Brain-Based Learning" discussed the limited contribution of brain science in understanding the nature of learning. Gulpinar (2005) in his study "The Principles of Brain-Based Learning and Constructivists Models in Education" considered the three concepts of individual differences, contextuality and complexity to evaluate the

experiential learning, self-regulated learning, collaborative learning and multiple intelligences (constructivist's learning models) in the context of brain-based learning principles. He concluded that problem-based learning, experiential learning and cooperative learning are brain-compatible approaches as they admit uniqueness of learner; generate a safe and non-threatening enriched environment which is challenging for the learners, promote meaningful and realistic content; give choices, opportunities and down-time to learners to reflect on as well as process the information effectively for a better understanding of concepts.

Soonthornrojana (2007) worked on the topic "A Teaching Model Development for Reading Comprehension by Brain-Based Learning Activities". Main objective of the study were to compare the reading comprehension achievement in brain-based and conventional teaching methods and to observe satisfaction of students on BBL method. Three schools were selected and 244 students of the third interval level were conveniently taken as sample of the study. The students were taken from six classrooms by selecting two classrooms per school equally. Number of students selected from three schools were 96, 62 and 86 respectively and each of them were divided equally into two experimental and control groups. Four tools, namely high quality reading comprehension plan for brain-based learning activities, high quality reading comprehension plan for conventional learning activities, three sets of sixty-item achievement test with four choices and a five-rating-scale satisfaction performa with 20 items were administered to both groups during one year duration of the study. The researcher drew conclusions by applying *t* test. He concluded that the model is of good quality and efficiency range. It was also concluded that experimental groups have better reading comprehension

achievement than control groups and the learners participating in brain-based model activities were satisfied significantly.

Ozden and Gultiken (2004) conducted a study on the topic of “The Effects of Brain-Based Learning on Academic Achievement and Retention of Knowledge in Science Course” at 5th grade science in a Turkish primary school. Pre-test Post-test control group design was used for this 3-week study. A sample of 44 students out of 84 from two intact classes was divided equally in experimental and control groups. The main objective of the study was to compare the impact of conventional teaching method vs. BBL teaching method on academic achievement as well as the retention of students. Students in the sample were equalized on the basis of a personal information survey which contained five characteristics of the learners. They were gender, average family income, educational background of mother as well as of father and getting private lessons or not. The Achievement test, containing 40 MCQs related to the unit of “Movement and Power,” was administered as pre-test, post-test and retention test on both groups. The study concludes that BBL approach is more effective than the conventional teaching in the subject of science for 5th graders ($t = 2.65, p < .05, df = 42$). It was also concluded that there is a significant difference (14.55) between mean scores of retention tests and experimental group showed significantly better retention than control group. ($t = 3.25, p < .05, df = 42$).

Another researcher Waters (2005) investigated impact of brain compatible strategies. He, in his study “The Reality of Brain Research Strategies”, determined the effects of brain based learning strategies and techniques on the academic achievement of seventh grade math students at Palmetto Middle School and arrived at the conclusion that

the the results of using the brain based strategies of hydration, exercise and music showed positive signs.

Duman (2006) studied “The effect of brain-based instruction to improve students’ academic achievement in social studies instruction”. The study was aimed at a comparison of social studies teaching instructions which are based on the brain-based instruction and the conventional teacher-centered approach. It was also aimed at finding the effects of BBL on academic achievement and motivation of sixth graders in the subject of social studies. The pre-test, post-test, one experimental group and one control group design was selected for the study. A sample of 113 students from three different sections of same class was taken. These students were divided into three groups. The two experimental groups were named as classes B and C respectively, containing 39 and 38 students respectively, and third control group was named as class A, containing 36 students. Two tools, namely ‘Academic Achievement Test of Social Studies’ and ‘Interview method of qualitative research’, were used to collect data for the study. The data were analyzed by the analysis of covariance (ANCOVA) and *t* test. The study concludes that there is a significant difference between mean achievement scores of the classes B, C and the class A ($F_{2-110}=18.57, p<.05$). The study also revealed that there is no significant difference between the mean achievement scores with respect to gender ($t_{111}=1.65, p=.101$). The students also admitted that BBL activities created positive feelings and ideas according to qualitative results of the study.

Furthermore, Avaci and Yagbasani (2005) applied BBL method on seventh graders in a study under the title of “A Study on Impact of Brain Based Learning Approach on Students’ Achievement of Knowledge about ‘Work-Energy’.” The main

objective of the study was to measure the impact of brain-based learning method on achievement and retention of knowledge of 7th graders in the subject of science. They selected 91 students as sample of the study that was divided into three groups. One of the groups was taken as experimental and the other two were named as control groups. Experimental group contained 30 students while control groups I and II contained 30 and 31 students respectively. The pre-test, post-test control group design was used for the study. Three tools i.e. 'work-energy achievement test', 'brain dominance instrument' and 'attitude and perception inquiry' were used to collect data for the study. The researchers themselves instructed experimental group and control group-I while control group-II was taught by the local science teacher of the concerned school. The Brain Dominance Instrument disclosed that 43.3% of the students of experimental group used slight preference toward the left brain, 26.7 % of students showed slight preference toward the right brain and 30% of students were inclined to moderate preference for the left brain. One way variance analysis (ANOVA) and Scheffe test revealed a statistical difference between experimental group and control group-I and between experimental group and control group II ($F_{(2-88)} = 13.092$, $p < 0.05$) in the favor of experimental group. The study also concluded that there is significant difference between experimental group and control groups I and II, favoring the experimental group ($F_{(2-88)} = 15.707$, $p < 0.05$) in both cases.

Following Avaci and Yagbasani, Cengelci (2005) conducted a research study in an elementary school under the topic "The Effect of Brain- Based Learning to Success and Retention in Social Studies". The pre-post test control group design was used and data were collected quantitatively and qualitatively. The main objective of the study was to

observe if BBL has a positive effect on academic achievement and retention skill of learners in the subject of social studies at elementary level. Data of the study were collected through different instruments like a questionnaire (for biographic information), pretest-posttest (for academic achievement and retention), different lesson plans and teaching materials for classroom activities. Two intact classes, 7-A and 7-B, were selected as sample of study. They were randomly named as experimental and control groups containing 30 and 26 students respectively. The researcher reported experimental group more successful academically than control group. The study also revealed significant retention level.

The concept of BBL theory was also applied to develop teaching learning materials at different levels. For example, in his dissertation topic “Brain-Based Learning theory: An Online Course Model”, Tompkins (2007) designed an online course design model on the basis of BBL theory. Earlier, in Australian Catholic University, Strathfield, White (2004) in his dissertation topic “Pedagogy-The Missing Link in Religious Education: Implications of brain based learning theory for the development of a Pedagogical framework for Religious Education” presented the ‘DEEP’ framework, standing for Discernment, Enrichment, Engagement and Participation whereas ‘an orientation towards wholeness’ was recognized as fifth principle.

In “The Impact of Odyssey of the Mind on the Cognitive and Psychosocial Development of Adolescents”, Weeks (2003) concluded in his thesis of master of Science in Student Development in Higher Education, Department of Counseling and Family Therapy, Central Connecticut State University, New Britain, Connecticut that a program design provides a balance of challenge and support and appears to accelerate students’

psychosocial and cognitive development. Several programming characteristics were reported to contribute to this result e.g. the use of small teams; the presence of a mentoring coach; an emphasis on teamwork and originality; the use of open-ended problems and a requirement that project work be completed exclusively by the students,”

The researchers also investigated about particular faculties of brain in the context of functioning of its four lobes. For this purpose, Magnesen (2002) concludes in his study “how we learn” that we learn 10% of what we read, 20% of what we hear, 30% of what we see, 50% of what we see and hear, 70% of what we say and 90% of what we any and do. On same pattern but with a broader preview, another researcher Glasser (2003) concludes in his study that we learn 10% of what we read, 20% of what we hear, 30% of what we see, 50% of what we see and hear, 70% of what is discussed with others, 80% of what is experienced personally and 95% of what we teach somebody. To explore brain, same task was undertaken at organizational levels as well. A research sponsored by Union Pacific foundation (2002), on the topic “What does brain-based research say about how adolescents learn”?, concluded that adolescent brain is a parallel processor; talks to and communicates with both hemispheres, seeks patterns; looks for prior knowledge to connect new information with it; is naturally curious; looks for novelty and embraces meaningful and complex investigations; bears aspect of uniqueness and thrives when given choices; takes in information in the immediate and peripheral environment; learns from an emotional base; learns when it feels physically and emotionally safe; learns information from whole-to-part-to-whole; learns best from a stimulating, however, not an over stimulating, environment which is optimal for mere synaptic connections to occur and for dendritic connections to be made; builds on prior knowledge and experiences in

order to make long-term and meaningful connections; begins a major pruning process round age of 11 and continues through the early 20s and continues to develop well into the 20s as the frontal lobe is the last to mature.

The early research on BBL theory is also important to know because it shows the directions of brain research for the beginners. VanDevender, Evelyn, Rice, Dale (1984) in their study “The Effect of Three Types of Brain-Based Instruction on the Mathematics Achievement and Attitudes of Second Grade Students” explored the ‘effects of a left-hemispheric, right-hemispheric, or integrated teaching approach on students' achievement and attitudes. The researcher divided a sample of 118 students of 2nd grade into four groups. During 2-week study, students were instructed about geometry. Each group was given different treatment than other groups. These four instructional approaches were structured textbook approach, hands-on and manipulative activities without textbook usage, textbook and manipulative approach and without instruction in the perspective of brain based instructions. Half of the pupils took the pretests and half took the posttests. The greatest gain in achievement and attitudes occurred with the manipulative approach (right hemispheric), while the textbook approach (left hemispheric) resulted in the least gains’.

Furthermore, in “Using Brain-Based Learning Techniques in High School Science”, David (1994) examined how brain-based learning environments could produce better learning conditions for students by using ‘thematic teaching, enriched language, naturally complex, long-term design and construction projects, and multifaceted assessment tools. The one-year curriculum indicated that teachers need not to sacrifice content mastery for learning process skills’ whereas Della Neve, Charmaine and Others (1994) concluded in

their study “ Huge Learning Jumps Show Potency of Brain-Based Instruction” that "brain-compatible" learning, especially Proster Theory can be applied to transform conventional, graded classrooms into "multi-teacher interactive learning units" that promotes thinking in terms of programs and patterns.

Another researcher Behlol (2010) reported in his recent research study that high achievers of the experimental group performed significantly better than the high achievers of control group ($t=3.76$, $df=28$, $p=.001$) and low achievers of the experimental group performed significantly better than the low achievers of control group ($t=3.80$, $df=28$, $p=.001$) as well.

A review of above mentioned researches in the field of BBL theory reveals that BBL method is an effective method as compared to the traditional methods which are either teacher-centered or text-book based. In order to create deep understanding of concepts, one has to present teaching learning material after juxtaposing it with the natural capacity of thinking brain that processes and retrieves information for effective learning.

CHAPTER 3

RESEARCH METHODOLOGY

The study was conducted to compare the effectiveness of BBL teaching method with the conventional teaching method in teaching mathematics at secondary level in Pakistan. The conventional method stands for the lecture method in this study. The researcher selected three chapters i.e. chapter 2, chapter 4 and chapter 5 from the textbook of Mathematics for 9th class, 2007. The main topic of chapter 2 i.e. System of Real Numbers, was divided into five subtopics i.e. Properties of Real, Rational and Irrational Numbers; Square Root and Qth Root; Surds; Exponents and its Laws; and Rational Exponents. The main topic “Algebraic Expressions” of chapter 4 contained five subtopics i.e. Variable and Constant; Orders and Values of Expressions; Algebraic Expressions; Algebraic Formulae; and Elements in Division of Polynomials. “Factorization; H.C.F (Highest Common Factor); L.C.M (Least Common Multiple); and Simplification and Square Root” was the main topic of Chapter 5. The five subtopics given in chapter 5 were Factorization of Expressions of the Forms $a^2 - b^2$, $ax^2 + bx + c$; Factorization of Expressions of the forms $a^3 \pm b^3$, $a^3 + b^3 + c^3 - 3abc$; Factorization of Cyclic Order; Factor Theorem and Square Root of Algebraic Terms; H.C.F. and L.C.M. of Algebraic Expressions; and Multiplication, Division, Addition and Subtraction of Algebraic Fractions.

Lesson plans based on BBL teaching method (Appendix H) and those based on conventional teaching methods (Appendix I) were developed separately by the researcher which covered each of the above-mentioned topics. These lesson plans were validated

through pilot testing, consultation with working teachers of mathematics and a panel of experts (Appendix G). The research tool of the study (Appendix E) was an academic achievement test which was constructed by the researcher in the perspective of five innate faculties of human brain, namely parallel processing, innate search of meaning; pattern formation; perception through creation of parts and wholes; and uniqueness. The experiments of study were conducted at two secondary schools, working under FDE Islamabad. One of the schools was selected from rural area and the other school was selected from the urban area of ICT (Islamabad Capital Territory) through purposive sampling. The students of rural and urban schools selected as samples of study were divided into experimental and control groups through systematic random sampling (Appendices A and B).

3.1. Research Design of the Study

Focus of the study was at comparative effectiveness of BBL vs. conventional teaching methods in teaching mathematics at secondary level in Pakistan. Teaching methodology and achievement were two variables of the experimental study. Teaching methodology was independent variable and academic achievement was dependent variable. Teaching methodology was named as factor A while academic achievement was named as factor B. The teaching methodology was manipulated into BBL teaching method and conventional teaching method whereas the academic achievement of the students was trifurcated into three levels, i.e. high achievers (HAs), average achievers (AAs) and low achievers (LAs) on the basis of their performance in the centralized annual 8th class annual examination scores (AES), 2007. The suitable research design

consistent with the nature of the study was a 2×3 factorial design which is given as follows:

Table 3: Research Design of the Study

		Factor 'B'		
		(Academic Achievement)		
Levels of achievement→		High Achievers (HAs)	Average Achievers (AAs)	Low Achievers (LAs)
Factor 'A'	Methodology↓			
	BBL Teaching Method (For Experimental Group)	Cell I (n = 10)	Cell II (n = 10)	Cell III (n = 10)
(Methodology)	Conventional Teaching Method (For Control Group)	Cell IV (n = 10)	Cell V (n = 10)	Cell VI (n = 10)

3.2. Population

All the students of 9th class, studying mathematics in Secondary/Higher Secondary Schools of Pakistan were included in the target population of the study. All the students of 9th class studying mathematics in F.G. Boys Model Secondary Schools working under the administration of Federal Directorate of Education (FDE), Islamabad were the accessible population of this study.

3.3. Sample

Since the experiments of the study were conducted at urban as well as rural areas, so following procedures were adopted to select the locality-wise schools and then the 9th class students for the sample of the study.

3.3.1 Sampling of the Schools

The educational administrative set-up of FDE Islamabad comprises five sectors i.e. Islamabad City, Bhara Kau, Ternol, Nilore and Sihala. Only Islamabad City sector is located in the urban area within the ambit of FDE Islamabad whereas remaining four sectors (Bhara Kau, Ternol, Nilore and Sihala) are located in rural areas (named as federal area i.e. F.A. in the official language of FDE). The Sihala sector is a prominent sector among other rural area sectors on account of comparatively better results of annual centralized examinations at elementary and secondary levels. Hence Sihala sector was purposively selected to conduct experiment of the study at rural area whereas the City sector was the only choice for the conduct of experiment at urban area.

The researcher selected only model secondary schools to conduct the experiments of the study. This was done due to availability of better infra structure, well equipped teaching learning classrooms and a sufficient number of students. To conduct the experiment of the study at urban area, FG boys model school, I-8/4 was selected through purposive sampling from Islamabad City sector whereas FG boys model school, Hummak was selected from rural area through purposive sampling to conduct the experiment at rural locality. Following factors were considered for purposive sampling of the stated model secondary schools.

1. The availability of more than 60 students studying mathematics in 9th class
2. Availability of conducive environment for experiments of study
3. Facilitation of ample cooperation rendered by the concerning Principal, teachers and students of the respective schools to conduct experiment smoothly
4. Willingness of the administration for the particular sampling of students
5. Manageable distance between the two selected schools in rural and urban areas for the researcher to conduct experiment daily
6. Ceaseless flow of traffic and availability of highway to travel from one school to the other within 20-25 minutes

3.3.2 Sampling of the Students

To conduct the experiments of the study at the secondary schools of rural as well as urban areas, an overall 120 students were included in the sample of the study. Sixty of the students were taken from the secondary school of rural area and then 60 of the students were taken from the secondary school of urban area.

With the consent of the concerning Principals of the selected model secondary schools, the researcher collected 8th class AES (annual examination scores), held under FDE, Islamabad in 2007, for all the students studying mathematics in 9th class from official records of the concerning schools. Then the researcher calculated the mean (M) and standard deviation (s) of the AES of all the 9th class students of the selected school in urban area. Afterwards, mean (M) and standard deviation (s) of the AES of all the 9th class students in the selected school of rural area were also calculated. The researcher determined the upper and lower ranges of the normal distribution of AES lying under $M \pm 2s$ for the students of the urban secondary school as well as for the students of the rural

secondary school. Only those students were considered for the selection of sample of study in each of the selected schools which were lying under $M \pm 2s$. The students falling outside ranges of $M \pm 2s$ were not considered for the sample of the study. The table 2 summarizes different calculations on AES about the students of 9th class, studying in the selected schools of urban as well as rural areas.

Table 4: Normal Distribution of the Students on AES

Names of Schools	FG Boys Model School, I-8/4 Islamabad (Urban Area)	FG Boys Model School, Hummak Town (Rural Area)
Total Nos. of students	80	211
Mean (M)	409	309.60
Standard Deviation (s)	83	64.30
Ranges of $M \pm 2s$	243- 575	181-439.2

The ranges of $M \pm 2s$ for the students of urban school were found to be 243-575 whereas the same ranges for the students of rural school were found to be 181- 439.2. Then the 9th class students of the rural school, lying under $M \pm 2s$, were enlisted with respect to the descending order of their AES whereas the 9th class students of the urban school, lying under $M \pm 2s$, were enlisted separately in accordance with the descending order of their AES.

Some of the AES were occurring more than once. It was noted that the AES of 250, 288 and 290 for LAs in the urban school occurred thrice, twice and thrice respectively. In the same school, the AES of 320 and 349, for AAs, occurred twice and

thrice respectively whereas the AES of 416, 421, 443 and 575, for the HAs of the urban school, occurred twice each. It was also noted during the numbering process of LAs in the rural school that the AES of 210, 215, 221 and 228 occurred five times, twice, twice and thrice respectively. For AAs of the same rural school, the AES of 306, 307, 309, 312 and 313 occurred thrice, thrice, thrice, twice and twice respectively whereas the AES of 442 for the HAs of the rural school occurred thrice. The stated recurring AES of the students in the rural area were placed, enlisted and then numbered randomly on their places in their specified list. Similarly, the stated recurring AES of the students in the urban area were also placed, enlisted and then numbered randomly on their places in their specified list. In this way, a list of 9th class students at rural area was developed and another list of 9th class students at urban area was also developed.

From the stated list of students of the urban school, 20 students each from top, center and bottom were chosen as sample of the study at the urban area school. The same procedure was repeated with the list of students of the rural school and 20 students each from top, center and bottom of the list were chosen as sample of the study at the rural area school. The rest of the students in both of the lists were excluded from the sample of the study. In this way, a sample of 60 students was selected at the urban school (Appendix A) and a sample of 60 students was selected at the rural (Appendix B). At both of the selected schools, the sample of 60 comprised 20 students each as HAs, AAs and LAs. In both of the selected schools, the selected 20 HAs were numbered from 1-20 whereas the selected 20 AAs were numbered from 21-40 and the selected 20 LAs were numbered from 41-60 according to their places in their respective lists.

Table 4-A depicts how was a sample of 120 students selected from rural as well as urban localities independently.

Table 4-A. Selection of students as sample of the study from urban and rural localities

Names of areas \longrightarrow	Urban Locality			Rural Locality			Total
Sample Size \downarrow							
Experimental Group	30			30			60
Ability-wise equal trifurcation of the experimental group	HA	AA	LA	HA	AA	LA	
	10	10	10	10	10	10	60
Sample Size of Control Group	30			30			60
Ability-wise equal trifurcation of the control group	HA	AA	LA	HA	AA	LA	
	10	10	10	10	10	10	60
Overall sample size at rural as well as urban localities							120

3.4. Formation and Equivalence of Groups

The 60 selected students each at the rural as well as urban areas were divided equally into experimental and control groups as per need of the study. To do so, the HAs numbered from 1 to 20 were distributed equally into two groups through systematic random sampling. The two groups were randomly named as Group I and Group II. Afterwards, the AAs numbered from 21 to 40 were also distributed equally into Group I and Group II through systematic random sampling. Lastly, the LAs numbered from 41 to 60 were also distributed equally into two Group I and Group II through systematic

random sampling. Later on, Group I and Group II were randomly named as control group and experimental group.

Each control and experimental group of the selected students comprised 10 members each taken from HAs, AAs and LAs. Table 3 summarizes the procedure for the systematic sampling of the students for HAs, AAs and LAs and the formation of experimental and control groups of the 9th class selected students studying in the urban and the rural secondary schools.

Table 5: Formation of Experimental and Control Groups

S. Nos.	Levels of Achievement	Group I (Control Group) Numbering of the students in the specified list	Total No. of Students Included in the Sample	Group II (Experimental Group) Numbering of the students in the specified list	Total No. of Students Included in the Sample
1	HAs	1,4,5,8,9,12,13,16,17,20	10	2,3,6,7,10,11,14,15,18,19	10
2	AAs	22,25,26,29,30,33,34,37,38,40	10	21,23,24,27,28,31,32,35,36,39	10
3	LAs	41,44,45,48,49,52,53,56,57,60	10	42,43,46,47,50,51,54,55,58,59	10

It is obvious from table 3 that each of the control and experimental groups of the students selected as sample of the study in the selected secondary school of urban area comprised 30 students which further consisted of 10 students each taken from HAs, AAs and LAs. Likewise, each of the control and experimental groups of the students selected

as sample in the secondary school of rural area also comprised 30 students which further consisted of 10 students each taken from HAs, AAs and LAs. Hence two groups of students were formed at rural as well as urban areas and the group equivalence was ensured through normal distribution on the performance of the selected students in the annual 8th class examination and their random nomination for experimental and control groups.

3.5. Selection of Text

Following factors were considered for the selection of text to conduct experiments of the study in the selected rural and urban schools.

1. Consultation with working teachers of the concerning 9th classes
2. Scheme of studies proposed by FDE Islamabad
3. Local examination constraints of the concerning schools

The researcher selected three chapters from text-book of mathematics for 9th grade, published by Punjab Text-book Board, 2007, Lahore. The details of the three selected chapters and their sub-topics are given as follows:

Chapter 2 “System of Real Numbers”

This chapter contained the following subtopics:

- i. Properties of real, rational and irrational numbers
- ii. Square root and qth root
- iii. Surds
- iv. Exponents and its laws
- v. Rational exponents

Chapter 4 “Algebraic Expressions”

This chapter contained the following subtopics:

- i. Variable and constant
- ii. Order and values of Expressions, Values of Algebraic expressions
- iii. Algebraic Expressions
- iv. Algebraic Formulae
- v. Elements in Division of Polynomials

Chapter 5 “Factorization, H.C.F, L.C.M, Simplification and Square Root”

This chapter contained the following subtopics:

- i. Factorization of expressions of the forms $a^2 - b^2$, $ax^2 + bx + c$
- ii. Factorization of expressions of the forms $a^3 \pm b^3$, $a^3 + b^3 + c^3 - 3abc$
- iii. Factorization of cyclic order, Factor theorem and square root of algebraic terms
- iv. H.C.F. and L.C.M. of algebraic expressions
- v. Multiplication, Division, Addition and Subtraction of algebraic fractions

3.6 Development and Validation of Lesson Plans

The researcher constructed 38 lesson plans which covered all the stated sub-topics in two different ways. At first, 38 lesson plans were developed by the researcher under BBL teaching method (Appendix H). Thereafter, 38 lesson plans were developed in the

perspective of conventional teaching method (Appendix I). The 12 principles of BBL theory, and the 12 faculties of human brain implied in them, were applied for the development of 38 lesson plans to practice them in the experimental groups. The conventional teaching method was reflected on the 38 developed lesson plans to be practiced in the control groups. Format of the lesson plan was adopted from the website of http://edtech.tennessee.edu/~bobannon/lesson_plan.html because this format was suitable for the nature of experiments. All teaching learning sessions of experimental and control groups were accomplished according to same lesson plans at the selected rural and urban schools. The concerning teachers of experimental and control groups taught strictly according to the said lesson plans. The lesson plans based on BBL teaching method were pilot tested by the researcher in FG boys model secondary school I-9/4 Islamabad. All the lesson plans of conventional teaching method were discussed with the working teachers of the concerning selected schools.

3.6.1 Lesson Plans for Control and Experimental Groups

The selected students of experimental and control groups of the selected schools were taught the same content on the same day and in the same period within the specified classrooms. Same format, with the same components, of the lesson plans for the control and the experimental groups was used. Lesson plans for control groups were designed in the perspective of conventional teaching method whereas the lesson plans for experimental groups were designed in the perspective of BBL teaching method. The components of the stated format of lesson plans are explained as follows:

3.6.1.1 Classroom Layout and Grouping of Students

Both the experimental and control groups were containing 10 each students taken from high (HAs), average (AAs) and low achievers (LAs) (Appendices C and D). The 30 students of experimental group were divided into 5 groups such that the groups stood at par on ability with one another. The students of mixed abilities were taken to form each of the groups. Each of the 5 groups contained 2 members each selected randomly from HAs, AAs and LAs.

The selected students of each of the 5 experimental groups were managed to sit in U-shaped form in the specified classroom so that all members of each group were in eye-contact with one another within the group or face-to-face postures, 3 students on each side, with a desk between them. But in control groups of both selected schools, whole class was treated as a single group and no further sub grouping of 30 students was done. Conventional seating arrangements of students were preferred in control groups. The whole room was utilized for teaching learning purposes in the experimental groups whereas, in stead of whole classroom, only whiteboard and space for seating arrangement of students were utilized for teaching purposes in control groups.

Instructional methods of control and experimental groups were not alike. In experimental groups, the instruction was delivered in small groups, for most of the time, and on individual basis, as well, with the help of worksheets, pictures, diagrams, flowcharts and printed materials. Self-exploring capability of students was availed of at maximum. To propagate a general rule or a fundamental formula, instruction was imparted collectively as well. But in control groups, the instruction was delivered

collectively with the help of whiteboard for most of the time. Individual instruction was given very rarely in the control groups.

3.6.1.2 Instructional Objectives of Lesson Plan

The general objectives of lesson plans of experimental groups were to organize a brain drill for the students, develop low threat and high challenge states of brain, minimize the role of rote-learning and maximize benefiting from thinking brain and design a brain compatible modus operandi to teach mathematics. But the general objectives of lesson plans of control groups were to develop skill of solving mathematical problems given in the text-book by memorization, create tendency to reproduce information through rote-learning, enable students to go through annual examination and habituate students to listen to a teacher and understand information under the instruction of teacher. The specific objectives of the lesson plan of the experimental group were to develop understanding of the taught content through brain-friendly activities whereas the same was done in the control groups through memorization and solving the problems or examples included in textbook exercises only.

3.6.1.3 Materials

Teaching learning materials for experimental and control groups of both of the selected schools comprised the three selected chapters from 9th class mathematics text-book, pre-test and post-test in both of the selected schools.

3.6.1.4 Optimal Environment for Classrooms

Two different classrooms were arranged to teach control and experimental groups through conventional and BBL teaching methods respectively. The optimal environments for classrooms were arranged according to the natures of conventional and

BBL teaching methods. The BBL teaching method facilitated learners to avail of the in-built faculties of their brains at maximum. Since the BBL teaching method was applied in the perspective of the in-built faculties of human brain which were implied in the twelve principles of BBL theory, so the teaching learning sessions of experimental group were designed accordingly. For the purpose, five in-built faculties of the human brain were availed through cognitive practices. The activities involving diagrams, puzzles, riddles, brain energizers, group or individual tasks, problems related to real-life situations and deductions of formulas through relevant examples etc. were organized. The five in-built faculties of the human brain stated under five of the principles of BBL theory, practiced in the classroom are given as follows.

P₁: The brain is a parallel processor.

P₃: The search for meaning is innate.

p₄: The search for meaning occurs through “patterning”.

P₆: Every brain simultaneously perceives and creates parts and wholes.

P₁₂: Every brain is unique.

The remaining seven principles of BBL theory in the perspective of the seven other in-built faculties of human brain were also applied to enable human brains to function naturally and create soothing impacts on learning, thinking and memory of the students. The researcher did so through generation of enriched environment of classroom in the following ways.

Principle 2 (P₂) “Learning engages the entire physiology” was applied by displaying balanced diet chart in the classroom, encouraging students to bring water bottles with them and giving hygienic tips off and on by the teacher.

Principle 5 (P₅) “Emotions are critical to patterning” was applied by creating cheerful atmospheres through brain energizers and jokes; Using soothing colors (green, blue and brown) of worksheets etc, playing soft tones on few occasions, reflecting students’ interests in content and using praising words for all the students.

Principle 7 (P₇) “Learning involves both focused attention and peripheral perception” was applied through home assignments, individual tasks, group discussions, exploring similarities and differences between two mathematical concepts, assuring students of having says in the classroom and solving problems related to real-life situations.

Principle 8 (P₈) “Learning always involves conscious and unconscious processes” was applied through giving pauses and adequate time during lessons to process information, displaying assignments of each group in classrooms, encouraging students to ask questions, encouraging other students to answer them, appreciating innovation and acknowledging ambiguities of students.

Principle 9 (P₉) “We have (at least) two types of memory systems: spatial and rote learning”, and Principle 10 (P₁₀) “The brain understands and remembers best when facts and skills are embedded in natural spatial memory” were applied through generation of safe and friendly environment, presenting meaningful content, constructing new ideas tied with already relevant existing ideas, reflecting familiarity and novelty in teaching

learning materials, encouraging students to form own patterns, acknowledging individual differences of students; encouraging smiles and laughter, and promoting critical thinking.

Principle 11 (P₁₁) “Learning is enhanced by challenge and inhibited by threat” was applied to reduce threats through physical activities, sarcasms free jokes and teacher’s friendly attitude towards students whereas a challenging atmosphere was created through individual tasks, exploration of ideas, home assignments, unfolding riddles, solving problems related to real life situations and appreciation of innovative thinking of students.

The environment of control groups contained a neat, airy and wel-lit classroom whose walls were decorated with charts of different subjects which had been pasted at a considerable height. The conventional classroom contained a lecture dice, seating chair for the teacher and a whiteboard. There were fixed seating arrangements for all the students and students had to sit on them till the end of each learning session. In this teacher controlled classroom, flow of instruction was from teacher to student.

3.6.1.5 Pre-Requisites for Brain-Compatible and Conventional Classrooms

Students of experimental groups were encouraged to write classroom agenda, expectations or targets on notice board and their viable suggestions were highlighted in the plan of study. But most of the students responded poorly in these regards. Students were noticing themselves their self-assessment through classroom tasks, interaction with peers and teacher, solving quizzes, homework assignments from exercises of text-book and individual or group assignments. Instant feedback record could

not be maintained by the students due to time constraint. Initial five minutes of each period in the experimental groups were reserved for collection of homework, minor physical activities by the students or reflections of students on the classroom agenda.

In control groups, seating arrangements of students were in traditional row wise pattern where all the students were to sit at their fixed or teacher-allotted positions in a back to back posture. First five minutes of every period were reserved for roll call and collection of notebooks for checking purposes.

3.6.1.6 Instructional Procedures

Firstly, there was a contrast in the start of each lesson plan for control and experimental groups. In control groups, teachers asked students to open their mathematics text-books at the concerning pages. The teachers explained the concerning concepts through book reading; oral and written explanations; and solution of examples given in the textbook only, if any, in lecturing style. But the teacher of experimental groups, besides a preliminary physical exercise by the students, started with a 'lesson set' which contained a real-life mathematical problem based on the previous knowledge of the learners. Students explored the solution of problem and the teacher linked it with the coming sub-topic of the concerning unit. Contrary to conventional methods, teacher enhanced interest of students and pre-understanding about topic of the lesson.

Secondly, teachers of control groups presented and explained teaching learning materials given in the textbook only whereas teacher of experimental groups explored the topic of each day through unseen problems related to real-life mathematical situations. In control groups, the problems and examples given in the textbook were solved first and

then assigned to write solutions of the same problems and examples on notebooks but the experimental group teacher explored the concerning concepts or formulas with the help of solution of unseen mathematical problems and then assigned students to apply concept of unseen problem on the problems given in the exercises of the text-book.

Thirdly, instructions were imparted collectively in control groups on maximum occasions and were directed from teacher to students. But, in experimental groups, learning instructions were imparted through individual or group assignments for maximum of time. The collective instructions were also imparted to explain the formulas or key concepts of concerning lessons in experimental groups.

Fourthly, in conventional classrooms, physical movements of students were discouraged by the teacher whereas students of experimental groups were encouraged to change seats within the groups, visit whiteboard, display center or notice board freely; do a physical exercise daily and move within whole classroom to avail peer help.

Fifthly, students of control groups were not allowed freely to talk, laugh, ask questions, go out to drink water or toileting, interrupt teacher during the course of period and the teacher showed resentment over such distractions. But the classroom environments of experimental groups were free of threats, friendly and democratic in which students had maximum liberty to act or react within the decorum of classroom.

3.6.1.7 Product of Students

The performance of students in the forms of products during teaching learning sessions for control and experimental groups was not same. The only product of students belonging to control groups was solution of problems or examples related to all exercises included in the three selected units of mathematics text-book for 9th graders.

There were many products of students in experimental groups of both of selected schools in rural and urban areas e.g. solutions of all exercises included in the three selected units of mathematics text-book for 9th graders through self-exploration by the students, unfolding riddles, group discussions and Individual reflections; different physical activities, quizzes, drawing figures and displaying assigned tasks, exploring real life situations of lesson sets, maintaining classroom notice board and tasks done on worksheets.

3.7 Development of Tool of the Study

An academic achievement test (Appendix E) was constructed by the researcher on the basis of five innate faculties of the human brain. Restricted response items were included in the research tool. The test was administered as pre-test and post-test on the experimental groups and control groups. The tool of the study was developed through the following steps:

3.7.1 Preparation of Tables of Specification

The researcher developed three tables of specification related to three already selected chapters Nos. 2, 4 and 5. Each table of specification was a two-way representation of proportionate test items with respect to five innate faculties of human brain and sub-topics of each of the selected chapter. The five innate faculties were parallel processing; innate search for meaning; patterning; perception through parts and wholes; and uniqueness of brain.

3.7.2 Construction of Test Items

Initially, the researcher constructed 27 test items from chapter No. 2; 25 test items from chapter No. 4; and 25 test items from chapter No. 5 in the perspective of the stated innate faculties of the brain. In this way, 77 test items altogether were constructed from the three selected chapters in accordance with the respective tables of specification. The stated test items were based on the five in-built faculties of human brain. The faculties were parallel processing; innate search for meaning; patterning; perception through parts and wholes; and uniqueness of brain. Following aspects were considered to reflect the stated five faculties of human brain on the items.

1. All items related to the parallel processing of human brain were denoted by P₁ (Principal 1). For the purpose, such items were constructed which contained diagrams, figures, corrections, blanks fillings and columns matching which would engage the brains of learners in seeing, thinking and doing simultaneously.
2. All items related to faculty of the innate search for meaning of brain this faculty were denoted by P₃ (Principle 3). The test items consistent with this faculty were bearing the aspects of familiarity and novelty in them. The learners were made to solve such items in a novel and innovative way by using their previous knowledge.
3. The items related to innate faculty of patterning were denoted by P₄ (Principal 4). Learners were expected to develop their own patterns to solve the test items based on this faculty. The patterns given in the items were related to self-concept of learners who were expected to generate their own patterns as well on the basis of

- their previous knowledge to solve the problem. The problems related to the concepts of mathematical formulas were constructed on the basis of patterning.
4. All items related to the in-built faculty of simultaneous perception and creation of parts and wholes of the human brain were denoted by P_6 (Principal 6). This faculty of human brain was employed in two different ways. Firstly, the test items were divided into parts which were to be assembled by the learners into a meaningful whole. Secondly, items were given in a whole form and the learners were to divide them into small inter-related parts to understand and solve the problem.
 5. All items based on innate uniqueness of human brain were denoted by P_{12} (Principle 12). Such test items related to this faculty were constructed which contained varieties and provided free choices for the learners. Learners were made to think and react distinctly in response to such test items. The test items were similar to individual projects for the learners.

The given five in-built faculties of human brain are different to great extent in their nature particularly due to their implications but they are not categorically isolated from one another and have some overlapping aspects like the six levels of cognitive domain in Bloom's Taxonomy. The researcher constructed the test items by applying the stated factors related to these particular faculties. For the purpose of construction of the test items, the researcher availed of nature of items given in 9th class mathematics textbook, GRE pattern and O level mathematics of D series (fourth edition).

3.7.3 Validity of Test Items

Following procedures were adopted to improve the 77 test items constructed by the researcher:

- 1 Matching test items of each chapter proportionately with the respective table of specification (TOS)
- 2 Experts' opinions
- 3 Pilot testing

Initially 77 items were constructed based on the concepts given in the three selected chapters of 9th class mathematics textbook. Initially, 17 items out of 77 were excluded from the pool of items in the light of experts' opinions, matching with TOS, suggestions from working teachers and pilot testing. Later on, the 60 test items were categorized as easy, moderate and difficult (<http://fcit.usf.edu/assessment/selected/responsec.html>) through experts' opinions. Finally, only 44 moderate test items were retained for the final selection of test items. The rest of difficult or easy test items were excluded from the final selection for items of the research tool.

Now the researcher selected 16 items out of these 44 validated items for the academic achievement test (the research tool of study). The final selection of the 16 items was decided by considering the following factors.

- 1 Matching the proposed 16 items proportionally with the TOS of each chapter
- 2 Proportionate reflection of the five of innate faculties of the human brain
- 3 Consultation with the panel of experts

Resultantly, five items out of 16 were pertaining to the sub-topics of the chapter 2, five items were belonging to the sub-topics of the chapter 4 and six of the items were taken out from the sub-topics of the chapter 5. Thus, the items of the research tool of the study, taken from chapters two, four and five were found to be in the ratios of 5 : 5 : 6 respectively.

It was also observed that 3 of the test items based on parallel processing; 4 items based on innate search of meaning; 3 items based on patterning; 3 items based on perception and creation through parts and wholes; whereas 3 items based on uniqueness of human brain. Thus, five of the innate faculties of human brain were incorporated into the items of the research tool of the study in the ratios of 3:4:3:3:3. In this way, the researcher developed the research tool of the study in the form of an academic achievement test.

3.7.4 Reliability of Test Items

Split-half method was used to check the reliability of the test items included in the tool of the study. The research tool of the study was in the form of a 16-item academic achievement test. The 16 items were moderate in nature whereas difficult or easy items were not considered for final selection by the researcher during item analysis. Each of the consecutive two test items were nearly of the same nature. All the test items were bearing restricted responses. The research tool was administered to 20 students of 10th class in FG boys Model School I-9/4, Islamabad. The correlation between scores of even and odd test items was significant (Reliability coefficient $\alpha = .8546$) which showed that the research tool was reliable.

3.7.5 Scoring Procedure of Test Items

A rubric was developed by the researcher in light of nature of the test items included in the research tool i.e. academic achievement test (appendix F). The step-wise award was calculated for each item of the stated test.

3.8 Selection of Teachers

In order to teach control and experimental groups in the specified classrooms of the selected schools, a mathematics teacher of 9th class from the rural model secondary school was selected to teach the control group through conventional teaching method whereas another mathematics teacher of 9th class from the urban model secondary school was selected to teach the control group through conventional teaching method.

The researcher himself taught the students of the experimental groups at both the rural and the urban model schools through BBL teaching method. The teachers of the control and experimental groups were selected after equating them on the factors like age, sex, academic qualification, teaching experience, mathematics teaching experience etc.

3.9 Description of Experiments of Study

The experiments of the study were conducted in the two selected model secondary schools working under FDE, Islamabad. FG boys model school, Hummak Town (Sihala Sector) was selected for execution of experiment of the study in rural area whereas FG

boys model secondary school, I-8/4 Islamabad was selected for execution of experiment of the study in the urban area. The details of experiments are given as follows.

3.9.1 Duration of Study

The experiments of the study were executed during September-November of academic session 2008-09 soon after end of the Holy month of Ramazan. For both of the selected schools, a 40-minute period per day was specified to teach the students of the control group and a 40-minute period, in parallel, per day was specified in the same school to teach the students of experimental group. The experiments prolonged for 8 weeks (a 6-day week).

3.9.2 Teaching of Experimental and Control Groups

The researcher himself taught the experimental groups of the selected rural as well as urban schools at their premises. The following factors were considered to do so:

1. Training of teachers about a fresh teaching method was not a viable idea due to time constraint because the FDE reduced academic session of the year abruptly by 5 months and a further delay in execution of experiments was not possible due to the coming local examinations of the concerning schools (which started soon after the end of the experiment of the study). Moreover, Principals and teachers of the selected schools were conscious to finish the allotted syllabus well before the commencement of annual examinations 2008-2009 to secure good annual results.

2. There was no awareness among the working teachers about BBL theory. The decision of teaching experimental groups through a trained teacher might prove somewhat risky.
3. The researchers followed the example of Avaci and Yagbasani (2005) who taught the experimental group themselves.

The researcher himself did not teach the control groups at both the selected schools of rural and urban areas. Following factors were considered to opt for the stated strategy.

1. Under the approved sampling of the study, the researcher was to conduct the experiment of the study at the selected school of a rural area as well as at a selected school of the urban area. So the workload of four periods per day, in case the researcher teaching control groups in both selected schools too, could create boredom or fatigue for the researcher which could hamper the smooth functioning of the experiments.
2. The researcher was facilitated for the adjustment in a single period only in the daily time tables of the selected schools by the concerning principals. The teachers and the principals of the selected schools were not ready to provide the researcher with another period due to an abrupt shortening of nearly 5 months in the teaching learning session of that year.
3. Moreover, the researcher was to teach experimental group through BBL teaching method in the rural school during first period and in the urban school during 4th period on the same day. The researcher had 80 minutes of time to switch over from rural to the urban school which was located at

a distance of nearly 20 km from the rural school. The journey took nearly half an hour and the researcher was to take proper rest prior to teach experimental group at the urban school.

4. Both schools were located at accessible distance from the main Islamabad Highway and flow of traffic continued ceaselessly on it during the execution of the experiments of the study.
5. The factors like age, sex, academic qualification, teaching experience, mathematics teaching experience etc. were considered prior to selection of the mathematics teacher from the concerned school to teach the selected units through conventional teaching method. A close resemblance was found on the stated factors between the teachers of experimental and control groups.
6. All the teaching learning sessions of control groups in both of the selected schools were conducted in accordance with the 38 lesson plans which were developed by the researcher for the purpose and the principles had assured the researcher of strict administration of the stated lesson plans by the selected teachers during their particular sessions of the control group.

3.9.3 Equivalence of Academic Opportunities

Following opportunities were available equally to the selected students of the experimental and control groups of the both areas.

- 1 Total number of teaching hours/days
- 2 Number of chapters taught
- 3 Number of lesson plans

- 4 Duration of period per day
- 5 Time of period per day
- 6 Time of administration of pre-test and post-test

3.9.4 Consent of Students and Parents

The consent of participants and their parents was ensured through the principals of the selected schools. The selected students and their parents cooperated well with the researcher in accomplishment of the study. The students included in the sample of the study were also requested through the Principals of their schools not to avail any sort of extra coaching for the selected content during experiment of the study. All the selected students were periodically asked by the teachers if they were getting extra coaching about the content of the study. Any of the selected students did not report to do so during the study. The selected students attended classes regularly and punctually and the role of the school management remained active in this regard.

3.9.5 Physical Facilities Provided by the Concerning Schools

Following physical facilities were provided by the principals of the selected schools of the rural and urban areas on the request of researcher.

- 1 Two airy and well-lit classrooms
- 2 Suitable furniture including whiteboards, notice boards, dusters, dais and almirahs
- 3 Proper seating arrangements for students
- 4 Vases of plants
- 5 Facilitation of photocopier and printer

3.9.6 Teaching Method for Control Groups

Lecture method was already in practice in the selected schools, included in the sample of the study at secondary level. So lecture method was named as conventional teaching method in this study. The control groups of both rural and urban schools were taught through the lecture method i.e. conventional teaching method in accordance with the 38 lesson plans designed by the researcher for the purpose. The selected teachers of the related schools taught three selected chapters of mathematics to all the students included in control groups. Principals of both the schools had already assured of strict administration of the lesson plans on the control groups. The following strategies were adopted by the control group teachers in the light of implications of the 38 lesson plans, developed by the researcher for the purpose.

- 1 Promoting rote learning
- 2 Delivering content through whiteboard writing or lecturing for most of the time
- 3 Compulsion of note taking
- 4 Poor interaction between students and teacher
- 5 Nearly zero interaction of students with one another
- 6 Assigning homework and classroom tests from the text-book only
- 7 Engaging students in individual work
- 8 Forcing students to maintain their notebooks in any case
- 9 Threatening students through blaming, taunting, passing sarcastic remarks, punishment etc.
- 10 Making students physically passive and cognitively active

- 11 Explaining concepts and solving problems/examples/exercises given in text-book only.
- 12 Authoritative classroom management
- 13 Explaining mathematical concepts or formulas given prior to exercises through textbook reading or writing simply on whiteboard and asking students to copy and cram them
- 14 Neglecting readiness, motivation and individual differences of students
- 15 Showing resentment or anger to students on poor attention, copying from blackboard slowly, imperfectly, differently, talking or laughing of students with one another, making mistakes, questioning during teaching sessions and seeking permission to drink water or toileting during teaching session by the students.

3.9.7 Teaching Method for Experimental Groups

In experimental group, the teacher created such teaching learning environment which was compatible with the natural functioning of human brain. So the teacher encouraged students to avail of the different in-built faculties of their brains as maximum as possible to deepen the understanding about the selected mathematical concepts of the concerning chapters. According to the essence of BBL theory, the experimental group teacher developed such states of the brains of the selected students which helped them to utilize the stated in-built faculties of the brain for better understanding of the mathematical concepts. To do so, the teacher of the experimental group adopted a two-way strategy under the umbrella of the principles of BBL theory. Firstly, an enriched

environment was generated in the light of the seven principles of the BBL theory. Secondly, the remaining five principles of BBL theory were applied through cognitive activities. The details of these two strategies are given below:

3.9.7.1 Generation of Enriched Environment

The researcher followed the model of Davenport Community School District (Davenport Community School, 2008) to generate brain-compatible environment in the classrooms of experimental groups formed in rural and urban schools. The researcher applied the said Model on classrooms of experimental groups after some modifications in the perspectives of financial and time constraints and socio-cultural variations of our education system. The researcher introduced seven components Davenport Community School District research-based model in experimental groups as follows.

1. **Absence of Threat:** Researcher generated a threat free environment by adopting following strategies.
 - Encouraging students to prepare chapter wise-agenda of learning activities inside and outside the classrooms
 - Holding target discussions on different concepts to improve attention spans of the learners
 - Encouraging students to display their suggestions and expectations on display center of the classroom
 - Delegating different responsibilities to students

2. **Collaboration:** Following strategies were adopted to make use of this component in the classrooms.

- Dividing 30 students of experimental groups into five homogeneous groups of mixed abilities
- Assigning group-work tasks
- Encouraging each student to contribute to his group at maximum

3. **Brain-Friendly Environment:** To sharpen the in-built faculties of the brain, create soothing impacts on the brain in accordance with the principles of BBL theory and facilitate learners' brains function naturally, following factors were highlighted in the classrooms of the experimental groups.

- ❖ Designing learning activities related to real-life situations
- ❖ Involving students into unfolding riddles and brain energizers
- ❖ Assuring each student to have a 'say' in the classroom through friendly and unbiased attitude by the teacher
- ❖ Using worksheets, posters etc of green, brown and blue colours (avoiding bright colours) in the classrooms
- ❖ Playing soft tones with the help of mobile phones on few occasions
- ❖ Placing vases of different fresh plants in the classrooms to make environment charming and conducive to learning

4. **Adequate Time:** Suitable pauses were introduced during teaching learning sessions to allow students to think over and then to react in the following ways.

- Exploring concepts through forming own patterns related to real-life situations
- Asking students to pinpoint similarities and differences between the two concepts under discussion
- Encouraging students to discuss with one another in groups
- Assigning individual task
- Involving students in physical activities, telling jokes or brain energizers

5. **Choice:** The orchestrated immersion technique of BBL theory was the key to introduce this component in the classroom environment. Following steps were taken to do so.

- Preparing student to solve a problem by setting data related to personal information of the students
- Facilitating learners to build freely mental maps of various concepts by contrast and compare method
- Involving students in discussion on different mathematical concepts

7. **Meaningful Content:** The teaching learning materials were consistent with the difficulty levels of the students. Ambiguities, confusions and misconceptions were removed from the presented content. Following strategies were adopted to offer meaningful content to the selected students.

- Relating unfolding of riddles and solution of problems to utilization in real life

- Linking mathematical figures or concepts with other disciplines
- Presenting content by exemplifying from existing objects

7. **Immediate Feedback:** It was made certain that students would be well aware of their performance instantly. Following measures were taken in this regard.

- Assigning tasks under guided practice in classrooms
- Self-assessment of students through sharing and responding within the group or the whole class
- Holding group competitions
- Responses of group discussions and individual work
- Unfolding riddles or reacting with brain energizers

3.9.7.2 Brain-Friendly Teaching Learning Activities

The researcher managed following learning activities for the students of the experimental groups.

- 1 A physical exercise of 2-3 minute was arranged in the start of each lesson to refresh the brains of learners and reduce the effects of different threats.
- 2 The students were encouraged through orientation session to write their reflections, expectations and general suggestions on the notice board of the classroom soon after entering the classroom.
- 3 Students were also encouraged to prepare a group wise agenda of each lesson. But the students responded insignificantly.
- 4 Suitable alterations in the lesson plans, on few occasions only, were made in the light of suggestions of the students. However, it was observed that most of the

- suggestions were not too suitable to be included in the lesson plans. Students were reluctant to do so.
- 5 Then a real-life situation, in the form of problem or riddle, was presented before learners in each lesson plan. This strategy was known as lesson set of each lesson plan. It served two purposes. Firstly, this was done to start each lesson by relating the above-mentioned real-life situation to the topic of the day. Secondly, the learners were motivated to apply their previous knowledge to solve the problems or unfold the riddles given in the start of each lesson. The students responded actively.
 - 6 Figures, diagrams, posters, worksheets, quizzes, competitions, jokes, brain energizers and group or individual presentations by students were introduced to create suitable environment in the perspective of relaxed alertness, orchestrated immersion and active processing.
 - 7 Students were encouraged to bring bottles of water with them into the classrooms and allowed freely to drink water as they felt thirst. Students were allowed to go to toilets as they felt its need.
 - 8 Firstly the mathematical concepts or formulas given prior to each exercise were explored with the help of the students through related situations, unfolding riddles, forming patterns, group discussions, individual reflections and examples from real-life situation. Content of such strategies was not taken from the textbook. Secondly, all problems and examples given in or before each exercise were assigned to them as homework.

- 9 Difficulties in doing home assignments were addressed through group work or peer help. Teacher solved the common problem of most of the students on whiteboard during initial minutes of the session. The extra time was borrowed from the teacher of next class in such cases.

3.9.8 Execution of Experiments

The experiments were preceded in the following order.

3.9.8.1 Orientation of the Selected Students of Experimental Group

All necessary procedures, nature of assignments, pre-requisites and required behaviors related to the study were elaborated by the researcher and verbal commitment of students to accomplish them were obtained prior to start of the proceedings of experiment. The selected students promised to cooperate with the researcher fully till the end of experiment. The school management was also involved in the session.

3.9.8.2 Statistical Equivalence of Experimental and Control Groups

The AES scores of the experimental and control groups were correlated with the corresponding pre-test scores to establish validity of grouping. All correlations were found significant. Hence the researcher retained the grouping of the students as they were formed earlier.

There were three levels of achievement i.e. HAs, AAs and LAs categorized by the researcher on the basis of the AES of the students. The correlation between the AES of each of HAs, AAs and LAs and their respective pre-test scores were also found significant. Hence the researcher retained the grouping of the students into HAs, AAs and LAs as they were formed earlier.

3.9.8.3 Administration of Pre-Test

The research tool of the study was administered as pre-test to all the selected students prior to start of the experiment of the study. The scores obtained from administration of pre-test were termed as pre-test score of each student included in the samples of study. These scores also set up base-lines of mathematical ability of each student prior to start of the study.

3.9.8.4 Teaching Learning Sessions

The researcher conducted the study during academic session 2007-2008 which was to be continued till August, 2008 but the session was reduced suddenly by five months by FDE and schools were directed to end the academic session of 2007-2008 till 31st March, 2008. Despite of this abrupt change, each of selected teachers of the concerning schools taught the students of their respective control groups for 8 weeks in light of the developed lesson plans. Similarly the selected students of experimental groups belonging to each of rural and urban schools were taught through BBL teaching method in light of the 38 validated lesson plans designed by the researcher under the umbrella of 12 principles of BBL theory. The treatment continued for 8 weeks.

3.9.8.5 Control of Variables of the Study

The experiments of the study were conducted in two different schools. The researcher took following measures to minimize the effect of different extraneous variables. The following six variables given below are related to internal validity of the experiment. The detail of the variables and the measures to control them are given as follows.

- 1) **History and Maturation:** No such incident occurred during the study which might cast influence on the results of the study. So the history did not affect the internal validity of the study. The maturation was occurring equally within students of both the experimental and control groups.
- 2) **Testing:** The concept of BBL theory was very new to all students as well as to the teachers. The text-book based pre- or post-tests would sensitize the students which might become threat to validity of experiment. But the research tool developed by the researcher was quite new for the students because its items were content based and not text-based. The uniqueness of the unseen items, a 2-month duration between administration of pre-test and post-test and keeping the students unconscious about the administration of post-test made it possible to control for the threat of testing.
- 3) **Instrumentation:** The researcher used the same tool of the study as pre-test as well as post-test and the achievement score was calculated through the difference between scores of post-test and pre-test. The research tool itself was validated before administrating it on the students. So, the researcher managed to control the variable of instrumentation through administration of same test as pre-test or post-test as well as by the research design of the study.
- 4) **Statistical Regressions:** This variable was controlled in two different ways. Firstly, sampling of students was based on normal distribution of students on their AESs and the students lying outside the ranges of $M \pm 2s$ had been excluded already. Hence the outliers were not included in the sample of the study.

Secondly, the pre-test scores and AESs of each student were found to be significantly correlated.

- 5) **Differential Selection of Subjects and Selection-Maturation Interaction:** This variable was controlled by the researcher because intact classes were not taken as samples of the study. The researcher, in stead, determined students' level of achievement through the normal distribution of the AESs of all the 9th class students. Furthermore, all the students included in the sample were pre-tested and the pre-test scores were found to be consistent with the concerning AESs.
- 6) **Mortality:** This variable was also controlled by confining the experiment to a limited duration of 8 weeks. Besides, the consent of parents and students' willingness also ensured presence of all the students throughout the study and no student fell ill or remained absent during the study.

The variables given below are related to external validity of the experiment. The detail of the variables and their controlling measures are given below.

- 1 **Pretest-treatment interaction:** The researcher controlled for this variable by administering a pre-test which was unseen for all the students. The items of the achievement test were not taken from the text-book. They were rather concept-based and students solved them for the first time. The same test was re-administered as post-test after changing the order of items of the pre-test after a period of two months.
- 2 **Multiple-Treatment Interference:** This was also controlled since the subjects included in the samples of study were not ever involved in any research study.

Moreover, the researcher introduced a single treatment in the control groups as well as in the experimental groups in both of the selected schools.

- 3 **Selection-Treatment Interaction:** To minimize the effect of this variable, students were randomly selected through normal distribution procedure in each of the selected schools. Besides, the researcher did not distribute intact classes into control or experimental groups for the purpose of study. In stead, equivalent groups were formed on normal distribution the AESs of the students.
- 4 **Specificity of variables:** The study was conducted to measure effectiveness of BBL vs. Conventional teaching methods in the subject of mathematics. Students were taught through the specific 38 lesson plans and a 16-item test (researcher's made tools of the study) was administered indiscriminately on them. The experiment of the study was conducted during September-November of academic session 2008 and students were divided in two groups i.e. experimental and control ones. All of such specific situations did not influence on the results of the study significantly because a validated procedure was adopted for sampling of the students. The posttest was administered immediately after treatment of 8 months at the end of experimentation. Criteria of all parameters i.e. pre- and post-tests, rubrics, operational nature of principles of BBL theory, duration of study, length of period and achievement score related to execution of experiments were well defined which resulted in no significant interaction between history and treatment effects as well as for interaction between time of measurement and treatment effects.

- 5 **Experimenter Effects:** The concept of BBL theory is quite new in our perspective. The working teachers were not aware of the innovative concept. To train a teacher about BBL teaching method and then engage him to teach experimental group might create gaps between theory and practice. The researcher had been in touch with the innovative concept since past three years and got himself trained in BBL teaching method through review of literature, watching clips on youtubes and interacting with BBL experts of the world through emails. So the researcher opted to teach experimental groups himself in both selected schools through BBL teaching method. However, researcher did his best to minimize experimenter's effects because both experimental groups were taught through same lesson plans designed for the purpose. Rubrics made for objective scoring of pre- and post-tests were helpful to minimize the bias of scorer. The number of lesson plans, duration of period, time and venue of treatment, chapters and subtopics of content, sex and socioeconomic status of students, composition of homogeneous grouping of mixed ability, time of pre-testing and post-testing and approximate resemblance between teachers of both control and experimental groups were kept equivalent for control and experimental groups. So each of the stated factors were controlled by the researcher.
- 6 **Reactive Arrangements:** Students of control group were studying as usual by their own teachers who taught them by conventional teaching method. Moreover, these students were kept unaware of any sort of comparison. The students of the experimental group were also kept unconscious of comparison with other students at any stage of the experiment. Keeping students unconscious of any sort of

comparison and the 8-week duration of study proved helpful to control the Hawthorne effect. John Henry effect was minimized because the concerning principal of the respective schools had assured of the strict implementation of the specified lesson plans by the control groups' teachers. In this way, the over-ambitious performances of students were also controlled as they were allowed to react in light of the specified lesson plans. There was no role of placebo effect in this study because all students of control group enjoyed the treatment of conventional teaching method whereas the students of experimental groups were taught through BBL method indiscriminately. The 8-week duration of the study helped the researcher to mitigate the novelty effect of the treatments.

3.9.8.6 Administration of Post-Test

At the end of 8-week study duration, the above mentioned pre-test was now administered as post-test to all of the students selected as samples of the study in both of rural and urban schools. For this purpose, the items of pre-test were reshuffled. The scores obtained through scoring of post-test of each of the selected students were taken as post-test score. The researcher calculated achievement score of each student by subtracting their pre-test scores from post-test scores.

3.10 Analyses of Data

The data of the study contained the following scores.

- 1 **The Annual Examination Score (AES):** All 9th graders of experimental and control groups in urban and rural selected schools

had passed the annual 8th grade examination, held under FDE in 2007. The aggregate score obtained by each student in the 8th grade central examination, 2007 was named as annual examination score (AES) in this study. The AES of all selected students were obtained from the school records.

- 2 **Pre-Test Score:** The research tool in the form of an academic achievement test, containing 16-item was administered prior to start of experiment to all students selected for sample of study in selected schools of rural and urban areas. The score obtained by each pre tested student was called as Pre-Test Score in this study.
- 3 **Post-Test Score:** The same 16-item test after shuffling of its items was re-administered immediately at the end of 8-week experiment to all of the selected students. The score obtained by each post tested student was called as Post-Test Score in this study.
- 4 **Achievement Score:** The difference between pre-test and post-test scores of each student belonging to experimental and control groups was named as Achievement Score. The Achievement Score was calculated as follows:

$$\text{Achievement Score} = \text{Posttest Score} - \text{Pretest Score}$$

The researcher applied statistical tests of independent sample t test, two-way analysis of variance, and Pearson's correlation r at significance level (SL) of .05 (Appendix J). The Pearson's correlation r was applied for checking the consistence between AES and pre-test scores of each ability group of the students and also to observe

group equivalence and re-shuffling of the students, if any, with respect to their ability level. The researcher maintained the grouping of students into different ability groups because of the significant correlation between AES and pre-test scores. The purpose of independent sample t test was to test null hypotheses H_{01} to H_{08} which were concerning with comparison of performance of two different groups of the students. For the rejection or failure to rejection of the null hypotheses H_{09} to H_{014} , ANOVA was applied. Its purpose was to observe main effect of teaching methods on the performance of students falling in three levels of academic achievement; to observe main effect of three levels of academic achievement; and to observe the interaction between teaching methods and the academic achievement as well. Following assumptions were required for the two-way ANOVA.

1. The achievement score within each sample was independent.
2. All the samples were taken from normally distributed populations.
3. Equal variances were found among the populations.

(Gravetter, F.J. and Wallvau, L.B., 2004)

(The normal distribution of the population was ensured through Levene Test for the equality of variances of the population in this study).

The results of the stated tests were obtained through SPSS 12. These results were interpreted, conclusions were drawn and recommendations were suggested by the researcher.

CHAPTER 4

ANALYSIS OF DATA

The study was conducted to compare the effectiveness of conventional and BBL teaching methods in the subject of mathematics at secondary level. This experimental study investigated the comparative effectiveness of the two teaching methods in the two selected model secondary schools. One of the schools was located in rural area of district Islamabad and the other was located in the urban area. Two equivalent groups of students were formed to conduct the experiments of the study. They were randomly named as experimental and control groups. Data were collected through pre-test and post-test. There were four types of scores i.e. pre-test score, post-test score, achievement score and annual examination score (AES). The details of these scores are given in chapter III under heading of 3.10, namely Analysis of Data.

This chapter deals with analysis of data of the selected students of experimental and control groups formed at the selected rural as well as urban secondary schools. For this purpose, independent samples t tests, two way Between-Groups (Independent Groups) ANOVA and the Pearson correlation r were applied on the data of the study. All tests were applied at significance level (SL) of 0.05. SPSS 12 was used to apply the stated statistical tests and acceptance or rejection of null hypotheses was decided on the basis of their results. The results of these statistical tests are given as follows.

Table 6: Summary of correlation between Pre-test scores and AES for the students of experimental group in urban school

Types of Scores	M	SD	N	AES	<i>p</i> value
Pretest	13.90	3.88	30	.88	.000**
<i>M</i> = 13.90, <i>SD</i> = 3.88 , <i>N</i> = 30					
AES	354.07	89.97	30	-	-
<i>M</i> = 354.07, <i>SD</i> = 89.97, <i>N</i> = 30					

Table 6 indicates that the correlation between pretest scores ($M = 13.90$, $SD = 3.88$, $N = 30$) of students belonging to experimental group and their AES ($M = 354.07$, $SD = 89.97$, $N = 30$) in the urban school was highly significant, $r(30) = .88$, $**p < .005$, SL (significance level) = .05. This significant correlation indicates that the grouping of students into experimental group at the urban school on the basis of AES is also consistent with the pretest scores of the stated students.

Table 7: Summary of correlation between Pre-test scores and AES for the students of experimental group in rural school

Types of Scores	M	SD	N	AES	<i>p</i> value
Pretest	13.60	2.75	30	.89	.000**
AES	309.30	81.76	30	-	-

Table 7 indicates that the correlation between pretest scores ($M = 13.60$, $SD = 2.75$, $N = 30$) of students belonging to experimental group and their AES ($M = 309.30$, $SD = 81.76$, $N = 30$) in the rural school was highly significant, $r(30) = .89$, $**p < .005$, $SL = .05$. This significant correlation indicates that the grouping of students into experimental group at the rural school on the basis of AES is also consistent with the pretest scores of the stated students.

Table 8: Summary of correlation between Pre-test scores and AES for the students of control group in urban school

Types of Scores	M	SD	N	AES	<i>p</i> value
Pretest	14.77	3.86	30	.86	.000**
AES	357.33	87.59	30	-	-

Table 8 indicates that the correlation between pretest scores ($M = 14.77$, $SD = 3.86$, $N = 30$) of the control group students and their AES ($M = 357.33$, $SD = 87.59$, $N = 30$) in urban school was highly significant, $r(30) = .86$, $**p < .005$, $SL = .05$. This significant correlation also indicates that the grouping of students into control group at

the urban school on the basis of AES is consistent with the pretest scores of the stated students as well.

Table 9: Summary of correlation between Pre-test scores and AES for the students of control group in rural school

Types of Scores	M	SD	N	AES	<i>p</i> value
Pretest	13.47	3.15	30	.84	.000**
AES	311.40	82.46	30	-	-

Table 9 indicates that the correlation between pretest scores ($M = 13.47$, $SD = 3.15$, $N = 30$) of students studying in control group and their AES ($M = 311.40$, $SD = 82.46$, $N = 30$) in rural school was highly significant, $r(30) = 0.84$, $**p < .005$, $SL = .05$. This significant correlation indicates that the grouping of students into control group at the rural school on the basis of AES is also consistent with the pretest scores of the stated students.

Table 10: Summary of correlation between Pre-test scores and AES for high achievers (HAs) at urban school

Types of Scores	M	SD	N	AES	<i>p</i> value
Pretest	17.95	1.91	20	.64	.003**
AES	459.95	60.81	20	-	-

Table 10 indicates that the pretest scores ($M = 17.95$, $SD = 1.91$, $N = 20$) of the HAs of both experimental and control groups and their AES ($M = 459.95$, $SD = 60.81$, $N = 20$) in urban school were significantly correlated, $r(20) = .64$, $**p = .003$, $SL = .05$. This result indicates that the equivalent distribution of the HAs into experimental and control groups at the urban school on the basis of AES is also consistent with their pretest scores.

Table 11: Summary of correlation between Pre-test scores and AES for high achievers (HAs) at rural school

Types of Scores	M	SD	N	AES	<i>p</i> value
Pretest	16	1.46	20	.81	.000**
AES	410	17.49	20	-	-

Table 11 indicates that the correlation between pretest scores ($M = 16.15$, $SD = 1.46$, $N = 20$) of the HAs placed in experimental and control groups and their AES ($M = 410.95$, $SD = 17.49$, $N = 20$) in rural school was highly significant, $r(20) = .81$, $**p < .005$, $SL = .05$. This significant correlation indicates that the typical division of the

HAs into experimental and control groups at the rural school on the basis of AES is also consistent with their pretest scores.

Table 12: Summary of correlation between Pre-test scores and AES for Average Achievers (AAs) of urban school

Types of Scores	M	SD	N	AES	<i>p</i> value
Pretest	15.15	2.03	20	.64	.002**
AES	338.85	17.05	20	-	-

Table 12 indicates that the pretest scores ($M = 15.15$, $SD = 2.03$, $N = 20$) of the AAs of both the experimental and control groups and their AES ($M = 338.85$, $SD = 17.05$, $N = 20$) in the urban school was significantly correlated, $r(20) = .64$, $**p = .002$, $SL = .05$. This significant correlation indicates that the particular distribution of the AAs into experimental and control groups at the urban school on the basis of AES is found to be consistent with their pretest scores as well.

Table 13: Summary of correlation between Pre-test scores and AES for AAs of rural School

Types of Scores	M	SD	N	AES	<i>p</i> value
Pretest	14.05	2.06	20	.72	.000**
AES	301.85	23.91	20	-	-

Table 13 depicts that the correlation between pretest scores ($M = 16.15$, $SD = 1.46$, $N = 20$) of the AAs belonging to experimental and control groups and their AES ($M = 410.95$, $SD = 17.49$, $N=20$) in rural school was highly significant, $r(20) = .81$, $**p < .005$, $SL = .05$. This significant correlation indicates that the equal distribution of the AAs into experimental and control groups at the rural school on the basis of AES is also consistent with their pretest scores.

Table 14: Summary of correlation between Pre-test scores and AES for Low achievers (LAs) of urban school

Types of Scores	M	SD	N	AES	<i>p</i> value
Pretest	9.90	1.83	20	.85	.000**
AES	268.30	17.46	20	-	-

It is clear from Table 14 that the correlation between pretest scores ($M = 9.90$, $SD = 1.83$, $N = 20$) of the LAs belonging to experimental and control groups and their AES ($M = 268.30$, $SD = 17.46$, $N = 20$) in urban school was highly significant, $r(20) = .85$, $**p < .005$, $SL = .05$. This significant correlation indicates that the formation of the LAs

for experimental and control groups at the urban school on the basis of AES is also consistent with their pretest scores.

Table 15: Summary of correlation between Pre-test scores and AES for LAs of rural school

Types of Scores	M	SD	N	AES	<i>p</i> value
Pretest	10.40	1.57	20	.63	.003**
AES	218.25	7.19	20	-	-

Table 15 presents the significant correlation between pretest scores ($M = 10.40$, $SD = 1.57$, $N = 20$) of the LAs included in the experimental and control groups and their AES ($M = 218.25$, $SD = 7.19$, $N = 20$) in rural school, $r(20) = .63$, $**p = .003$, $SL = .05$. The result indicates that the equal distribution of the LAs into experimental and control groups at the rural school on the basis of AES is also consistent with their pretest scores.

Table 16: Result of independent sample *t* test on pre-test scores of experimental and Control groups in urban school

		Levene's Test for Equality of Variances		t test for independent sample			
		F	<i>p</i> value	<i>t</i>	df	<i>p</i> value	SE _D
Pretest	Equal variances assumed	.11	.737	-.87	58	.389	.9989
	Equal variances not assumed			-.87	58	.389	.9989

Table 16 indicates that there was no significant difference between the mean pretest score of students belonging to the experimental group ($M = 13.90$, $SD = 3.88$, $SE_M = .71$) and the mean pretest score of students belonging to the control group ($M = 14.77$, $SD = 3.86$, $SE_M = .70$) in urban school (Appendix Q) at alpha level of 0.05, $t(58) = .87$, $p > .05$, two tails.

It was concluded that the students of experimental and control groups in the urban school were equivalent on pre-test performance prior to start of the study.

Table 17: Result of independent sample *t* test on pre-test scores of Experimental and control groups in rural school

		Levene's Test for Equality of Variances		t test for independent sample			
		F	<i>p</i> value	<i>t</i>	df	<i>p</i> value	SE _D
Pretest	Equal variances assumed	.873	.354	.18	58	.862	.7631
	Equal variances not assumed			.18	56.97	.862	.7631

Table 17 indicates that there was no significant difference between the mean pretest score of students belonging to the experimental group ($M = 13.60$, $SD = 2.75$, $SE_M = .50$) and the mean pretest score of students belonging to the control group ($M = 13.47$, $SD = 3.15$, $SE_M = .57$) of rural school (Appendix Q) at an alpha level of .05, $t(58) = .18$, $p > .05$, two tails.

It was, therefore, concluded that the students of experimental and control groups in the rural school were equivalent on pre-test performance prior to start of the study.

Table 18: Summary of result of independent sample *t* test on pretest scores of HAs at urban school

		Levene's Test for Equality of Variances		t test for independent sample			
		F	<i>p</i> value	<i>t</i>	df	<i>p</i> value	SE _D
Pretest	Equal variances assumed	.122	.731	-.58	18	.57	.8673
	Equal variances not assumed			-.576	17.10	.57	.8673

It is obvious from table 18 that there was no significant difference between mean pretest scores of HAs belonging to the experimental group ($M = 17.70$, $SD = 2.06$, $SE_M = .65$) and mean pretest scores of HAs belonging to control group ($M = 18.20$, $SD = 1.81$, $SE_M = .57$), located in the urban area (Appendix Q), at alpha level of .05, $t(18) = -.58$, $p > .05$, two tails.

It was concluded that HAs belonging to control group and HAs belonging to experimental group had no significant difference on pretest performance and both groups of HAs in urban school were equivalent to each other prior to start of the study.

Table 19: Summary of result of independent sample *t* test on pretest scores of HAs of rural school

		Levene's Test for Equality of Variances		t test for independent sample			
		F	<i>p</i> value	<i>t</i>	df	<i>p</i> value	SE _D
Pretest	Equal variances assumed	.58	.46	.15	18	.88	.6708
	Equal variances not assumed			.15	17.10	.88	.6708

Table 19 summarizes that there was no significant difference between mean pretest score of HAs belonging to the experimental group ($M = 16.20$, $SD = 1.32$, $SE_M = .42$) and mean pretest score of HAs belonging to the control group ($M = 16.10$, $SD = 1.66$, $SE_M = .53$) at .05 alpha level, $t(18) = .15$, $p > .05$, two tails (Appendix Q).

It was inferred that HAs belonging to control group and HAs belonging to experimental group had no significant difference on pretest scores and both groups of HAs in rural school were equivalent to each other before start of the experiment of the study.

Table 20: Summary of result of independent sample *t* test on pretest scores of AAs of urban school

		Levene's Test for Equality of Variances		t test for independent sample			
		F	<i>P</i> value	<i>t</i>	df	<i>p</i> value	SE _D
Pretest	Equal variances assumed	.02	.904	1.74	18	.100	.8647
	Equal variances not assumed			1.74	17.57	.100	.8647

Table 20 shows that there was no significant difference between the mean pretest score of AAs belonging to the experimental group ($M = 14.40$, $SD = 1.78$, $SE_M = .56$) in the urban school (Appendix Q) and the mean pretest score of AAs belonging to control group ($M = 15.90$, $SD = 2.08$, $SE_M = .66$) at .05 alpha level, $t(18) = 1.74$, $p > .05$, two tails.

Hence AAs belonging to control group and AAs belonging to experimental group showed equal performance on pretest scores and both groups of AAs in the urban school were equivalent to each other before start of the experiment of the study.

Table 21: Summary of result of independent sample *t* test on pretest scores of AAs of rural school

		Levene's Test for Equality of Variances		t test for independent sample			
		F	<i>p</i> value	<i>t</i>	df	<i>p</i> value	SE _D
Pretest	Equal variances assumed	.13	.72	-.32	18	.755	.9458
	Equal variances not assumed			-.32	17.42	.755	.9458

Table 21 summarizes that there was no significant difference between the mean pretest score of AAs belonging to the experimental group ($M = 13.90$, $SD = 1.91$, $SE_M = .60$) and the mean pretest score of AAs belonging to control group ($M = 14.2$, $SD = 2.30$, $SE_M = .73$) of the rural school (Appendix Q) at alpha level of .05, $t(18) = -.32$, $p > .05$, two tails.

It proved that AAs of control group were well equated with AAs of experimental group on pretest scores in the rural school.

Table 22: Result of independent sample *t* test on pre-test scores of LAs of urban school

		Levene's Test for Equality of Variances		t test for independent sample			
		F	<i>p</i> value	<i>t</i>	df	<i>p</i> value	SE _D
Pretest	Equal variances assumed	1.07	.315	-.72	18	.479	.8300
	Equal variances not assumed			-.72	17.03	.480	.8300

Table 22 indicates that no significant difference was noted between the mean pretest score of LAs belonging to the experimental group ($M = 9.60$, $SD = 2.07$, $SE_M = .65$) and the mean pretest score of LAs belonging to the control group ($M = 12.20$, $SD = 1.62$, $SE_M = .51$) in the urban school (Appendix Q) at 0.05 level of significance, $t(18) = -.72$, $p > .05$, two tails.

Hence LAs belonging to control group and LAs belonging to experimental group showed equal performance on pretest scores and the stated groups in the urban school were equivalent to each other before start of the experiment of the study.

Table 23: Result of independent sample *t* test on pre-test scores of LAs of rural school

		Levene's Test for Equality of Variances		t test for independent sample			
		F	<i>p</i> value	<i>t</i>	df	<i>p</i> value	SE _D
Pretest	Equal variances assumed	.01	.932	.85	18	.407	.7071
	Equal variances not assumed			.85	17.42	.408	.7071

Table 23 indicates that the difference between the mean pretest score of LAs belonging to the experimental group ($M = 10.70$, $SD = 1.42$, $SE_M = .45$) and the mean pretest score of LAs belonging to the control group ($M = 10.10$, $SD = 1.73$, $SE_M = .55$) of the rural school (Appendix Q) with 0.05 alpha level, $t(18) = .85$, $p > .05$, two tails, was not significant.

It proved that LAs of control group were well equated with LAs of experimental group on pretest scores in the rural school.

H₀ 1: There is no significant difference between the performance of the students of urban school taught through BBL and conventional teaching methods.

Table 24: Result of independent sample *t* test on achievement scores of experimental and control groups in urban school

		Levene's Test for Equality of Variances		t test for independent sample			
		F	<i>p</i> value	<i>t</i>	df	<i>p</i> value	SE _D
Mean achievement score	Equal variances assumed	2.62	.11	2.99	58	.004	5.025
	Equal variances not assumed			2.99	56.55	.004	5.025

Table 24 figures out that there was a significant difference between the mean achievement score students belonging to the experimental group ($M= 45.80$, $SD= 17.84$, $SE_M = 3.26$) and the mean achievement score of students belonging to the control group ($M= 30.80$, $SD= 20.96$, $SE_M = 3.83$) of the urban school (Appendix R) at alpha level of .05, $t(58) = 2.99$, $p = .004$, two tails.

Hence the null hypothesis H₀ 1 was rejected in favour of the BBL teaching method for the selected students of the urban area. So the alternative hypothesis “H₁ 1: There is a significant difference between the performance of the students of urban school taught through BBL and conventional teaching methods” was accepted in stead

H₀ 2: There is no significant difference between the performance of the students of rural school taught through BBL and conventional teaching methods.

Table 25: Result of independent sample *t* test on achievement scores of experimental and control groups in rural school

		Levene's Test for Equality of Variances		t test for independent sample			
		F	<i>p</i> value	<i>t</i>	df	<i>p</i> value	SE _D
Mean achievement score	Equal variances assumed	3.818	.056	3.79	58	.000	4.014
	Equal variances not assumed			3.79	54.07	.000	4.014

It is evident from table 25 that a significant difference existed between the mean achievement score of students belonging to the experimental group ($M = 42.73$, $SD = 17.52$, $SE_M = 3.20$) and the mean achievement score of students belonging to the control group ($M = 27.53$, $SD = 13.29$, $SE_M = 2.43$) in rural school (Appendix R) with alpha level at .05, $t(58) = 3.79$, $p < .005$, two tails.

The result helped to reject the null hypothesis H₀ 2 and to accept “H₁ 2: There is a significant difference between the performance of the students of rural school taught through BBL and conventional teaching methods” for the stated group of students in the rural area.

Table 26: Group statistics of achievement scores of HAs of urban school

Score	Group	N	M	SD	SE _M
	Experimental	10	64.5000	3.3747	1.0672
	Control	10	57.6000	5.2747	1.6680

The table 26 gives the measurements for means, standard deviations and standard error of means on mean achievement score for the HAs of the experimental and the control groups in the urban school. The measurements for mean, standard deviation and standard error of mean for HAs of the experimental group were 64.5000, 3.3747 and 1.0672 respectively. The same values for HAs of control groups were observed to be 57.6000, 5.2747 and 1.6680 respectively. It is clear from the table that mean achievement score for HAs of experimental group is greater than that for HAs of control group in the urban school.

H₀ 3: There is no significant difference between the performance of the high achievers (HAs) of urban school taught through BBL and conventional teaching methods.

Table 27: Significance of difference on mean achievement scores for HAs of urban school

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	P	t	df	p	SE _D
Mean Achievement score	Equal variances assumed	3.662	.072	3.485	18	.003	1.9802
	Equal variances not assumed			3.485	15.311	.003	1.9802

It is obvious from table 27 that the measurements of t , df , p and SE_D were 3.485, 18, .003 and 1.9802 respectively. Hence a significant difference between mean achievement scores of HAs of experimental group and control groups in urban school at .05 alpha level, $t(18) = 3.485$, $p = .003$, two tails was observed (Appendices K and R).

That is why the null hypothesis H₀ 3 was rejected in favour of BBL teaching method for the category of the students stated above. So the alternative hypothesis “H₁ 3: There is a significant difference between the performance of the high achievers (HAs) of urban school taught through BBL and conventional teaching methods” was accepted.

Table 28: Group statistics of mean achievement scores of HAs of rural school

Score	Group	N	M	SD	SE _M
	Experimental	10	64.0000	5.6569	1.7889
	Control	10	40.2000	7.6999	2.4349

The table 28 gives measurements for means, standard deviations and standard error of means on mean achievement score for 10 HAs belonging each to experimental and control groups in the rural school. The measurements for mean, standard deviation and standard error of mean for HAs of this experimental group were 64.0000, 5.6569 and 1.7889 respectively. The same values for HAs of control groups were 40.2000, 7.6999 and 2.4349 respectively. It is evident from the table that mean achievement score for HAs of experimental group was numerically greater than that of control group.

H₀ 4: There is no significant difference between the performance of the high achievers (HAs) of rural school taught through BBL and conventional teaching methods.

Table 29: Significance of difference on mean achievement scores for HAs of rural school

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	P	t	df	p	SE D
Mean Achievement score	Equal variances assumed	1.571	.226	7.877	18	.000	3.0214
	Equal variances not assumed			7.877	16.523	.000	3.0214

It is clear from table 29 that the measurements of t , df , p and SE_D were 7.877, 18, .000 and 3.0214 respectively for the given group of the selected students. Hence the difference between mean achievement scores of HAs of experimental and those of control groups in rural school (Appendices N and R) at alpha level of .05, $t(18) = 7.877$, $p < .005$, two tails was statistically significant. Consequently, the researcher rejected the null hypothesis H₀ 4 in favour of BBL teaching method for the aforesaid HAs. Thus, the alternative hypothesis “H₁ 4: There is a significant difference between the performance of the high achievers (HAs) of rural school taught through BBL and conventional teaching methods” was accepted.

Table 30: Group statistics of mean achievement scores of AAs of urban school

Score	Group	N	M	SD	SE _M
	Experimental	10	48.8000	5.9029	1.8667
	Control	10	22.8000	10.3258	3.2653

Table 30 gives measurements for means, standard deviations and standard error of means on mean achievement score for each 10 of AAs belonging to experimental and control groups in the urban school. The measurements for mean, standard deviation and standard error of mean for AAs of the experimental group were 48.8000, 5.9029 and 1.8667 respectively. The same values for AAs of control groups were 22.8000, 10.3258 and 3.2653 respectively. It is clear that mean achievement score for AAs of experimental group is greater than those of control group.

H₀ 5: There is no significant difference between the performance of the average achievers (AAs) of urban school taught through BBL and conventional teaching methods.

Table 31: Significance of difference on mean achievement scores for AAs of urban school

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	<i>P</i>	<i>t</i>	df	<i>p</i>	SE _D
Mean Achievement score	Equal variances assumed	2.627	.122	6.913	18	.000	3.7612
	Equal variances not assumed			6.913	14.315	.000	3.7612

It is clear from table 31 that the measurements of *t*, *df*, *p* and SE_D were 6.913, 18, .000 and 3.7612 respectively. The table helped to conclude a significant difference between mean achievement scores of AAs of experimental and AAs of control groups in urban school (Appendices L and R) at .05 alpha level, $t(18) = 6.913, p < .005$, two tails. So the null hypothesis H₀ 5 was rejected in favour of BBL teaching method for the stated category of the selected students. Hence the research hypothesis “H₁ 5: There is a significant difference between the performance of the average achievers (AAs) of urban school taught through BBL and conventional teaching methods” was accepted.

Table 32: Group statistics of mean achievement scores of AAs of rural school

Score	Group	N	M	SD	SEM
	Experimental	10	40.9000	4.4585	1.4099
	Control	10	31.2000	3.5214	1.1136

Table 32 indicates measurements for means, standard deviations and standard error of means on mean achievement score for the AAs of experimental and control groups in the rural school. The measurements for mean, standard deviation and standard error of mean for AAs of the experimental group were 40.9000, 4.4585 and 1.4099 respectively. The same values for AAs of control groups were 31.2000, 3.5214 and 1.1136 respectively. It was noted from the table that the difference between mean achievement scores for AAs of experimental group and control group was of 9.7.

H₀ 6: There is no significant difference between the performance of the average achievers (AAs) of rural school taught through BBL and conventional teaching methods.

Table 33: Significance of difference on mean achievement score for AAs of rural school

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	<i>p</i>	<i>t</i>	df	<i>p</i>	SE _D
Mean Achieve ment score	Equal variances assumed	1.104	.307	5.399	18	.000	1.7966
	Equal variances not assumed			5.399	17.083	.000	1.7966

It is clear from table 33 that the measurements of *t*, *df*, *p* and SE_D were 5.399, 18, .000 and 1.7966 respectively. A significant difference was found between mean achievement scores of AAs of experimental and control groups in rural school (Appendices O and R) at .05 alpha level, $t(18) = 5.399, p < .005$. So the null hypothesis H₀ 6 was rejected in favour of BBL teaching method for the AAs of rural school students. The researcher accepted the alternative hypothesis “H₁ 6: There is a significant difference between the performance of the average achievers (AAs) of rural school taught through BBL and conventional teaching methods”.

Table 34: Group statistics of mean achievement scores of LAs of urban school

Score	Group	N	M	SD	SEM
	Experimental	10	24.1000	7.5638	2.3919
	Control	10	12.0000	4.3970	1.3904

Table 34 gives measurements for means, standard deviations and standard error of means on mean achievement score for the LAs of experimental and control groups in the urban school. The measurements for mean, standard deviation and standard error of mean for LAs of the experimental group were 24.100, 7.5638 and 2.3919 respectively. The same values for LAs of control groups were 12.0000, 4.3970 and 1.3904 respectively. It was also observed that mean achievement score for LAs of the experimental group is greater than that for LAs of the control group at the urban secondary school.

H₀ 7: There is no significant difference between the performance of the low achievers (LAs) of urban school taught through BBL and conventional teaching methods.

Table 35: Significance of difference on mean achievement scores for LAs of urban school

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	<i>p</i>	<i>t</i>	df	<i>p</i>	SE _D
Mean Achievement score	Equal variances assumed	.882	.360	4.373	18	.000	2.7667
	Equal variances not assumed			4.373	14.459	.001	2.7667

It is obvious from table 35 that the measurements of *t*, *df*, *p* and SE_D were 4.373, 18, .000 and 2.7667 respectively. A significant difference was observed between mean achievement scores of LAs of experimental and LAs of control groups in urban school at .05 alpha level, $t(18) = 4.373, p < .005$ (Appendices M and R). So the null hypothesis H₀ 7 was also rejected in favour of BBL teaching method for the above mentioned category of the students. So the research hypothesis “H₀ 7: There is a significant difference between the performance of the low achievers (LAs) of urban school taught through BBL and conventional teaching methods” was accepted.

Table 36: Group statistics of mean achievement scores of LAs of rural school

Score	Group	N	M	SD	SEM
	Experimental	10	23.3000	3.3015	1.0440
	Control	10	11.2000	2.7406	.8667

In table 36, the measurements for mean, standard deviation and standard error of mean for LAs of the experimental group in the urban area were 23.300, 3.3015 and 1.0440 respectively. The same values for LAs of control group in the urban area were 11.200, 2.7406 and .8667 respectively. The table indicated a difference between mean achievement scores of both of the groups in the rural area.

H₀ 8: There is no significant difference between the performance of the low achievers (LAs) of rural school taught through BBL and conventional teaching methods.

Table 37: Significance of difference on mean achievement scores for LAs of rural school

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	P	t	df	p	SE D
Mean Achievement score	Equal variances assumed	.618	.442	8.918	18	.000	1.3569
	Equal variances not assumed			8.918	17.41	.000	1.3569

According to the table 37, the measurements of t, df, p and SE_D for LAs of the rural school were 8.918, 18, .000 and 1.3569 respectively. A significant difference was found between mean achievement scores of LAs of experimental and control groups in the rural school at .05 alpha level, $t(18) = 8.918, p < .005$ (Appendices P and R). So the null hypothesis H₀ 8 was rejected and the alternative hypothesis “H₁ 8: There is no significant difference between the performance of the low achievers (LAs) of rural school taught through BBL and conventional teaching methods” was accepted for the stated category of the students.

Since a 2×3 factorial design was used for this experimental study in which two teaching methods (BBL and Conventional) were comparatively tested over three levels of achievement (HAs, AAs, LAs). The statistical test of two-way Between-Groups (Independent Groups) ANOVA was applied. The results of ANOVA and the group statistics for the students of the urban and the rural schools are given as follows.

Table 38: Group statistics for students of experimental and control groups of urban school

Levels of Achievement→ Methodologies↓	HAs	AAs	Las
BBL teaching method	$M=64.50,$ $SD= 3.37,$ $N=10$	$M= 48.80,$ $SD=5.90,$ $N= 10$	$M=24.10,$ $D=7.56,$ $N= 10$
	$M= 45.80, SD=17.84, N=30$ (For overall experimental group)		
Conventional teaching method	$M=57.60,$ $SD=5.27,$ $N= 10$	$M= 22.80,$ $SD= 10.33,$ $N= 10$	$M= 12.00,$ $SD= 4.40,$ $N= 10$
	$M= 30.80, SD=20.96, N=30$ (For overall control group)		

Table 38 indicates cell-wise values of means (M) and standard deviations (SD) of experimental and control groups of the urban school. It is obvious from above table that values of M and SD for the HAs, AAs and LAs in experimental group were 64.50 and 3.37; 48.80 and 5.90; 24.10 and 7.56 respectively. Similarly, values of M and SD of overall experimental group were 45.80 and 17.84 respectively. Table 36 also indicates that values of M and SD for HAs, AAs and LAs in control group were 57.60 and 5.27; 22.80 and 10.33; and 12.00 and 4.40 respectively. Similarly, values of M and SD of overall control group were 30.83 and 20.96 respectively.

Table 39: Results of ANOVA for students of experimental and control groups at the urban school

Source	Type III Sum of Squares	Df	Mean Square	Observed F value	Critical F value	<i>p</i> value
Methodology	3375.00	1	3375.00	78.73	$F_{.05}(1, 54) = 4.02$.000*
Levels of Achievement	18677.50	2	9338.75	217.84	$F_{.05}(2, 54) = 3.17$.000*
Methodology* Levels of Achievement (Interaction)	975.10	2	487.55	11.37	$F_{.05}(2, 54) = 3.17$.000*

df total =59; df between treatment =5; df within treatment = 54; df methodology = 1;
df achievement levels = 2; df interaction = 2

It is obvious from table 39 that in the urban school:

- 1 For methodology, the obtained F ratio, $F = 78.73$, exceeding the related critical F ratio, lied in the critical region. Hence, it was inferred that the students taught through BBL teaching method performed significantly better as compared to the students taught through conventional teaching method, $F(1, 54) = 78.73$, $p < .005$, $SL = .05$. Hence the null hypothesis H_0 “The mean achievement score of the students selected from urban school, taught through BBL teaching method, is not significantly different than the mean achievement score of the students selected from urban school, taught through conventional teaching method” was rejected in favour of the BB teaching method. Hence the alternative hypothesis “ H_1 :The mean achievement score of the students selected from urban school, taught through BBL teaching method, is significantly different

than the mean achievement score of the students selected from urban school, taught through conventional teaching method” was accepted.

- 2 For levels of achievement, the obtained F ratio, $F = 217.84$, exceeding the related table value of F, also lied in the critical region. Consequently, it was held that the main effect of three levels of achievement was also highly significant, $F(2, 54) = 217.84, p < .005, SL = .05$. Hence the researcher rejected the null hypothesis $H_0 11$: “There is no significant difference among the mean achievement scores of the students selected from urban school who are placed in any of the three levels of achievement, namely high achievers, average achievers and low achievers”. Thus the alternative hypothesis “ $H_1 11$: There is a significant difference among the mean achievement scores of the students selected from urban school who are placed in any of the three levels of achievement, namely high achievers, average achievers and low achievers” was accepted.
- 3 The interaction between methodology and levels of achievement was noted as highly significant, $F(2, 54) = 11.37, p < .005, SL = .05$ because the obtained F ratio, $F = 11.37$, exceeding the related table value of F, lied in the critical region. So the null hypothesis “ $H_0 13$: There is no interaction between teaching methodology and the levels of achievement (based on 8th class annual examination score) in the selected urban school” was also rejected. So the alternative hypothesis “ $H_1 13$: There is an interaction between teaching methodology and the levels of achievement

(based on 8th class annual examination score) in the selected urban school”
 was accepted (Appendix S).

Table 40: Results of Post Hoc Tests for Multiple Comparisons of mean differences among three levels of achievement by Tukey HSD in urban school

Levels of achievement (1)	Levels of achievement (2)	Mean Difference (1)-(2)	Standard. Error of Mean (SEM)	<i>P</i> values
HA	AA	25.25	2.07	.000
	LA	43.00	2.07	.000
AA	HA	-	-	-
	LA	17.75	2.07	.000

Table 40 summarizes the results of mean differences in the academic achievement found between any two categories of students out of HAs, AAs and LAs. It was found that the performance of the stated HAs is significantly different from that of AAs ($p < .005$, $SE_M = 2.07$, $SL = .05$). It was also noted that AAs of the urban school performed significantly different than LAs of the same urban school ($p < .005$, $SE_M = 2.07$, $SL = .05$). The results also reflected the significantly different performance of HAs from LAs in the selected school at urban area.

The table indicated that the largest mean difference was found between the performances of HAs and LAs (43). Similarly the mean difference between HAs and AAs (25.05) was noted as greater than the mean difference between AAs and LAs (17.75) in the urban school.

Table 41: Group statistics for students of experimental and control groups of rural school

Levels of Achievement→ Methodologies↓	Has	AAs	Las
BBL teaching method	$M=64.00,$ $SD= 5.66,$ $N=10$	$M= 40.90,$ $SD=4.46,$ $N= 10$	$M=23.30,$ $SD=3.30,$ $N= 10$
		$M= 42.73, SD=17.52, N=30$ (For whole experimental group)	
Conventional teaching method	$M=40.20,$ $SD=7.70,$ $N= 10$	$M= 31.20,$ $SD= 3.52,$ $N= 10$	$M= 11.20,$ $SD= 2.74,$ $N= 10$
		$M= 27.53, SD=13.29, N=30$ (For whole control group)	

Table 41 summarizes cell-wise values of means (M) and standard deviations (SD) for achievement scores of experimental and control groups at the rural area. It is obvious that values of M and SD for HAs, AAs and LAs in experimental group were 64.00 and 5.66; 40.90 and 4.46; and; 23.30 and 3.30 respectively. Similarly, values of M and SD of overall experimental group were 42.73, 17.52 respectively. Table 39 also gave the values of M and SD for HAs, AAs and LAs in control group as 40.20 and 7.70; 31.20 and 3.52; and; 11.20 and 2.74 respectively. Similarly, values of M and SD of overall control group were observed as 27.53 and 13.29 respectively.

Table 42: Results of ANOVA for students of experimental and control groups in rural school

Source	Type III Sum of Squares	Df	Mean Square	Observed F value	Critical F value	p value
Methodology	3465.60	1	3465.60	146.46	$F_{.05} (1, 54) = 4.02$.000
Levels of Achievement	12170.43	2	6085.22	257.16	$F_{.05} (2, 54) = 3.17$.000
Methodology* Levels of Achievement (Interaction)	569.10	2	284.55	12.03	$F_{.05} (2, 54) = 3.17$.000

df_{total} = 59; df_{between treatment} = 5; df_{within treatment} = 54; df_{methodology} = 1; df_{achievement levels} = 2; df_{interaction} = 2

It is obvious from table 42 that:

- 1 For methodology, the obtained F ratio, $F = 146.46$, exceeding the related table value of F, lied in the critical region. Hence, it was inferred that the students taught through BBL teaching method performed significantly better as compared to the students taught through conventional teaching method, $F (1, 54) = 4.02$, $p < .005$, $SL = .05$, at the rural school. Hence the null hypothesis H_0 “The mean achievement score of the students selected from the urban school, taught through BBL teaching method, is not significantly different than the mean achievement score of the students selected from rural school, taught through conventional teaching method” was rejected in favour of the BB teaching method. So the alternative hypothesis “ H_1 10: The mean achievement score of the students selected from the urban school, taught through BBL teaching method, is

- significantly different than the mean achievement score of the students selected from rural school, taught through conventional teaching method” is accepted.
- 2 For levels of achievement, the obtained F ratio, $F = 257.16$, exceeding the related table F value, also lied in the critical region. Consequently, it was held that the main effect of three levels of achievement was also highly significant, $F_{.05} (2, 54) = 3.17$, $p < .005$, $SL = .05$. Hence the researcher rejected the null hypothesis $H_0 12$: “There is no significant difference among the mean achievement scores of the students selected from rural school who are placed in any of the three levels of achievement, namely high achievers, average achievers and low achievers”. Hence the alternative hypothesis “ $H_1 12$: There is no significant difference among the mean achievement scores of the students selected from rural school who are placed in any of the three levels of achievement, namely high achievers, average achievers and low achievers” was accepted.
 - 3 The interaction between methodology and levels of achievement was noted as highly significant, $F. (2, 54) = 3.17$, $p < .005$, $SL = .05$ because the obtained F ratio, $F = 12.03$, exceeding the table value of F, lied in the critical region. So the null hypothesis $H_0 14$ “There is no interaction between teaching methodology and the levels of achievement (based on 8th class annual examination score) in the selected rural school” was also rejected. Thus the alternative hypothesis “ $H_1 14$: There is an interaction between teaching methodology and the levels of achievement (based on 8th class annual examination score) in the selected rural school” was accepted (Appendix T).

Table 43: Results of Post Hoc Tests for Multiple Comparisons of mean differences among three levels of achievement by Tukey HSD in rural area

Levels of achievement (1)	Levels of achievement (2)	Mean Difference (1)-(2)	Standard. Error of Mean (SEM)	<i>p</i> -value
HA	AA	16.05	1.54	.000*
	LA	34.85	1.54	.000*
AA	HA	-	-	-
	LA	18.80	1.54	.000*

Table 43 summarizes the results of mean differences in the academic achievement found between any two categories of students out of HAs, AAs and LAs. It was found that the performance of the stated HAs is significantly different from that of AAs ($p < .005$, $SE_M = 1.54$, $SL = .05$). It was also noted that AAs of the rural school performed significantly different than LAs of the same rural school ($p < .005$, $SE_M = 1.54$, $SL = .05$). The table indicates that the mean difference between HAs and LAs (34.85) is greater than the other two differences. Similarly the mean difference between HAs and AAs (16.05) is lesser than the mean difference (18.80) between AAs and LAs.

DISCUSSION

The study was conducted to compare effectiveness of BBL and conventional teaching methods in teaching mathematics at secondary school level of rural and urban areas. The objectives of the study were to compare impact of BBL teaching method versus conventional teaching method on the academic achievement of the 9th graders. A school each from rural and urban areas was selected to conduct the experiment of the study. An overall 120 students of both the schools were selected as sample of the study. Sixty of the students were taken from the urban school and 60 of the students were taken from the rural school. In each of the selected schools, the sample of 60 students was selected on normal distribution of their annual examination scores in the previous 8th class centralized examination. Then the 60 students were divided equally into two groups through systematic random sampling. In this way, two groups of students were formed and each group contained of 30 students. The stated two groups were named randomly as experimental and control groups. Each group was further divided into high, average and low achievers through systematic random sampling, comprising 10 each of HAs, AAs and LAs. Both of experimental and control groups were taught through BBL and conventional teaching methods respectively. Three chapters were selected from 9th class mathematics textbook as content for the experiment of the study. The two groups were taught for 8 months through specified 38 lesson plans developed by the researcher. An academic achievement test was administered as pre-test and post-test to collect the data of the study.

The researcher formulated 14 null hypotheses as well as 14 alternative or research hypotheses in the light of objectives of the study. The hypotheses were either accepted or

rejected during analysis of the data. The data of the study contained 8th class annual examination score (AES), pre-test score and academic achievement score. Statistical tests of Pearson correlation 'r', independent sample t test and two-way ANOVA were applied with the help of SPSS 12. Mean, standard deviation and standard error of mean were also calculated and reported accordingly. The researcher gathered following facts from the analysis and interpretation of data.

The researcher checked the consistence of overall distribution of rural and urban school students in experimental and control groups on the basis of pre-test scores as well as on AES through 'Pearson correlation r'. The correlation results showed that the stated groups were significantly equivalent with respect to pre-test scores and the statistical establishment of groups. Consequently, the researcher retained the distribution of students into two groups on the normal distribution of their 8th class annual examination scores. The pretest scores of the selected students were consistently matched with the normal distribution of grouping of the students. In this way, the overall experimental and control groups were equated prior to the start of the experiment. Moreover, the same procedure enabled the researcher to equate HAs, AAs and LAs of the experimental group with their respective HAs, AAs and LAs of the control group. It was also concluded that the academic performance of the students in the previous departmental examination of 8th class was maintained by them in the next grade as well (Tables 6-9). The correlation between AES and pre-test scores of the students, named as HAs, AAs and LAs, selected from the rural and urban schools, were also investigated. A significant correlation between the AES and pre-test scores for each stated category of the concerning students was found. The statistical formation of three categories of students remained consistent

with the pre-test scores. So the grouping of each category of students on achievement levels was retained. The above-mentioned tests proved equivalence of each category of the selected students within their concerning level of achievement. It was concluded that HAs, AAs and LAs, belonging to control group and HAs, AAs and LAs, belonging to experimental groups, selected from rural as well as urban schools were nearly equal with respect to achievement levels prior to start of experiment of the study (Tables 10-15).

Prior to offer treatments of the study, the group equivalence, on pre-test scores of all of the selected students was also investigated. The results of independent sample t test proved that HAs, AAs and LAs of experimental and control groups in the rural and urban schools were almost equivalent mutually on pre-test scores prior to receive treatments of BBL and conventional teaching methods respectively. It was inferred that the students of both experimental and control groups were performing nearly at same academic levels and it established a justified baseline for the performance of the above mentioned students (Tables 16-23).

The results of independent sample t tests on mean achievement scores of rural and urban schools' students belonging to experimental and control groups (Tables 24-25) proved the effectiveness of BBL teaching method as compared to lecture method. Resultantly, the null hypotheses H_01 and H_02 were rejected in favor of the BBL teaching method and H_11 and H_12 were accepted. The same result was already reported in findings of the research study of Ozden and Gultiken (2004). So the objective (i) of the research study was achieved. Both Ozden and Gultiken (2004) studied the impact of BBL teaching method in the subject of science for the 5th graders but this research study investigated the effectiveness of BBL theory in the subject of mathematics for the 9th

graders. In this way, the findings of the study corroborate the results of Ozden and Gultiken (2004). Moreover, the results of statistical tests on mean achievement scores for high achievers, studying in urban and rural schools helped to reject the null hypotheses $H_0 3$ and $H_0 4$ and accept their respective alternative hypotheses $H_1 3$ and $H_1 4$. So BBL teaching method was found to be more effective than the conventional teaching method for the stated HA category of the students (Tables 27 and 29). The significantly better performance of the HAs of experimental group than HAs of the control group can be attributed to effective utilization of the faculties of brain like parallel processing, innate search of meaning etc. by the students of experimental group. The stated high achievers created deep understanding through interacting with meaningful content, peer tutoring sessions, quick formation of patterns, unfolding riddles based on realistic situations etc. Thus objective (ii) of the research study was achieved.

Similarly the significantly better performance of the AAs and the LAs belonging to experimental groups than the AAs and the LAs of the control groups of rural and urban schools proved the effectiveness of BBL method (Tables 31,33,35 and 37) as compared to the conventional teaching method. This was inferred from rejection of null hypotheses $H_0 5$ to $H_0 8$ and acceptance of the alternative hypotheses $H_1 5$ to $H_1 8$ in favour of BBL teaching method. Resultantly, the objectives (iii) and (iv) of the study were also achieved. The stated groups enhanced academic achievement levels through functioning of brains in enriched environment which was threat-free, highly challenging, friendly to individual differences, smile promoting, psychologically and physically safe etc. The students of each level of achievement inculcated information by utilizing the faculties of their brains which were sharpened under the umbrella of the twelve principles of BBL theory. The

role of brain friendly activities in the form of presentation of meaningful content, exploration of concepts, content bearing aspects of familiarity and novelty, unfolding riddles, creation of parts- wholes-parts, solving real-life situations of lesson sets, working in small groups, formation and identification of patterns, unique assignments, quizzes, pinpointing similarities and differences between two different concepts, physical movements, solution of textbook exercises by themselves, working in a cheerful environment, displaying the assigned tasks in the classroom, availing full liberty of discussion with peers or teacher etc remained effective in inhibiting rote memorization of ideas.

The results of statistical tests provided sufficient proof to reject null hypothesis H_0 9 and H_0 10 and alternative hypothesis H_1 9 and H_1 10 in favour of BBL teaching method. So the BBL teaching method remained more effective than the conventional teaching method for the selected students of both rural and urban area schools (Tables 39 and 42). Thus main effect of teaching method was observed significantly in favor of BBL teaching method. The effectiveness of BBL teaching method confirmed the findings given by Soonthornrojana (2007), Duman (2006), VanDevender (1984) and Waters (2005). The objective (i) of the study was achieved through rejection of null hypotheses H_0 11 to H_0 14 and acceptance of the alternative hypotheses H_1 11 to H_1 14. The study work of Soonthornrojana (2007), Duman (2006), VanDevender (1984) and Waters (2005) reported the effectiveness of BBL teaching method and this study concluded the same result. In all of the stated research work of some researchers, intact classes were taken as sample for the experimental purposes but this research study, contrarily, has a contrasting aspect with respect to sample of the study. The test items included in the research tool do

not resemble with the nature of test items which were administered by the stated researchers and the author's work may be considered as an addition to the knowledge of BBL theory. Similarly, the distribution of students into three categories on the basis of their ability, statistical tests of Pearson Correlation r and ANOVA; sample size of 120 students, 2-month duration of the study and separate study at rural as well as urban areas may distinguish the author's study work from majority of the contemporary research work in the area of BBL theory. Unlike to some of the studies on the topic, the researcher did not use questionnaires to probe into the social life, family background, health problems etc of the learners as well and evaluated the academic achievement of the learners through an academic achievement test.

The effectiveness of BBL teaching method maybe attributed to the learners' involvement of natural tendencies of their brains during classroom teaching learning sessions into the process of storing, processing and retrieving of information in accordance with the biological functioning of the brain. The students created deep understanding of different mathematical concepts by following natural mechanism of information handling by the brain. The result supports the findings given by Avaci and Yagbasani (2005) in the research study. So the BBL method enhances academic achievement of fast learners, mediocre and slow learners. The orchestrated immersion, relaxed alertness and active processing created conceptual understanding of different mathematical concepts among learners of each level of achievement.

It was concluded that threatening atmosphere of the classrooms, rote-learning and text-book based teaching and learning should be replaced by enriched environment of the classrooms, meaningful presentation of content and concept-based teaching learning

activities respectively. Such paradigm shift of teaching methodology enhances the academic achievement of the learners significantly in the subject of mathematics at the secondary level. Unless the content is presented in consistence with the physiology of the human brain; the receiving, processing and retrieval of the input data occurs at a poor rate and vice versa.

CHAPTER 5

SUMMARY, FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

The study was conducted to compare effectiveness of BBL and conventional teaching methods in the subject of mathematics at secondary level. Three chapters were selected from 9th grade mathematics text-book, 2007 to teach the students of 9th class included in the sample of the study. To do this, the researcher developed 38 lesson plans for the selected chapters based on the BBL teaching method and then developed 38 lesson plans on the same topics of the stated chapters based on the conventional teaching method. These lesson plans were validated through expert opinions, consultation with working teachers and pilot testing.

The tool of the study was an academic achievement test, in the subject of mathematics, which was constructed in the perspective of five in-built faculties of human brain i.e. parallel processing, innate search of meaning, learning through patterning, perception and creation of parts and wholes; and uniqueness of thinking which are also implied in the five principles of BBL theory. The researcher while constructing unseen items of an academic achievement test followed the themes of mathematical problems given in 9th class mathematics text-book, GRE and O level. The tool of the study was validated through table of specification, experts' opinions, consultation with working teachers and item analysis. Split-half method confirmed the reliability of the tool of study.

All the 9th class students studying mathematics in the secondary schools were the population of the study. Two FG boys model secondary schools working under FDE

Islamabad were selected through purposive sampling to conduct the experiments of the study. One of the schools was taken from rural area and the other was taken from the urban area of District Islamabad.

An overall sample of 120 students was taken from the two secondary schools by selecting 60 students each from the two selected schools. The sample 60 students was divided equally into experimental and control groups through statistical procedures. Each of the experimental and the control groups were further divided equally into high, average and low achievers through systematic random sampling. Prior to start of experiment of the study, the tool of study was administered as pre-test on control and experimental groups of both the selected schools to determine the self-concept of the learners about the content.

Experimental groups in rural and urban schools were taught through BBL teaching method whereas the control groups were taught through conventional teaching method i.e. lecture method. Teaching method was independent variable and academic achievement was dependent variable. The 3×2 factorial design was followed for the purpose of the study. The design includes two factors i.e. teaching method (factor A) and academic achievement (factor B). Further, the factor A consisted of BBL teaching method and conventional teaching method and the factor B (academic achievement) had three levels i.e. high, average and low achievers. At the immediate end of 2-month experiment of the study, the same pretest was administered as a posttest by changing the arrangements of the items. The mean achievement score of each of the student was calculated by taking difference between post- test and pre-test scores.

The data were analyzed to find out the significance of correlations at significance level (SL) of 0.05 between pre-test scores and annual examination scores of 8th class. Similarly independent sample t test was applied to calculate significant difference at significance level of 0.05 between the mean achievement scores of both the experimental and control groups in rural and urban schools. Two-way ANOVA was applied to check effectiveness of teaching methodology, impact of methodology on three levels of achievement as well as the interaction between both teaching methods. The stated statistical tests were applied with the help of SPSS 12 and the following findings of the study were drawn.

5.2 Findings of the Study

Following findings were obtained from the analyses of the data of the study.

1. The mean (M) and standard deviation (SD) of pre-test scores for 30 students of experimental group in the urban school were 13.90 and 3.88 respectively whereas M and SD of AES for the stated group were 354.07 and 89.97 respectively. A significant correlation exists between AES and pre-test scores of the students of the stated group, $r(30) = .88$, $**p < .005$, SL= .05 (Table 6).
2. The mean (M) and standard deviation (SD) of pre-test scores for 30 students of experimental group in the rural school were 13.60 and 2.75 respectively whereas M and SD of AES for the stated group were 309.30 and 81.76 respectively. A significant correlation exists between AES and pre-test scores of the students of the stated group, $r(30) = .89$, $**p < .005$, SL= .05 (Table 7)

3. The mean (M) and standard deviation (SD) of pre-test scores for 30 students of control group in the selected school at urban area were 14.77 and 3.86 respectively whereas M and SD of AES for the same group were 357.33 and 87.59 respectively. A significant correlation exists between AES and pre-test scores of the students of the stated group, $r(30) = .86$, $**p < .005$, $SL = .05$. (Table 8)
4. The mean (M) and standard deviation (SD) of pre-test scores for 30 students of control group in the selected school at rural area were 13.47 and 3.15 respectively whereas M and SD of AES for the same group were 311.40 and 82.46 respectively. A significant correlation exists between AES and pre-test scores of the students of the stated group, $r(30) = 0.84$, $**p < .005$, $SL = .05$. (Table 9)
5. The correlation between pretest scores ($M = 17.95$, $SD = 1.91$, $N = 20$) of the HAs belonging to experimental as well as control groups and their AES ($M = 459.95$, $SD = 60.81$, $N = 20$) in urban school was highly significant, $r(20) = .64$, $**p = .003$, $SL = .05$ (Table 10)
6. The correlation between pretest scores ($M = 16.15$, $SD = 1.46$, $N = 20$) of the HAs belonging to experimental as well as control groups and their AES ($M = 410.95$, $SD = 17.49$, $N = 20$) in the rural secondary school was also highly significant, $r(20) = .81$, $**p < .005$, $SL = .05$, (Table 11).
7. A significant correlation exists between pretest scores ($M = 15.15$, $SD = 2.03$, $N = 20$) of the HAs belonging to experimental as well as control groups and their AES ($M = 338.85$, $SD = 17.05$, $N = 20$) in urban school, $r(20) = .64$, $**p = .002$, $SL = .05$ (Table 12).

8. There is a significant correlation between pretest scores ($M = 16.15$, $SD = 1.46$, $N = 20$) of the AAs belonging to experimental as well as control groups and their AES ($M = 410.95$, $SD = 17.49$, $N=20$) in the rural school, $r(20) = .81$, $**p < .005$, $SL = .05$ (Table 13).
9. The correlation between pretest scores ($M = 9.90$, $SD = 1.83$, $N = 20$) of the LAs belonging to experimental as well as control groups and their AES ($M = 268.30$, $SD = 17.46$, $N = 20$) in urban school was highly significant, $r(20) = .85$, $**p < .005$, $SL = .05$ (Table 14).
10. A significant correlation exists between pretest scores ($M = 10.40$, $SD = 1.57$, $N = 20$) of the LAs belonging to experimental and control groups and their AES ($M = 218.25$, $SD = 7.19$, $N = 20$) in the rural school $r(20) = .63$, $**p = .003$, $SL = .05$ (Table 15).
11. There is no significant difference between the mean pretest score of students belonging to the experimental group ($M = 13.90$, $SD = 3.88$, $SE_M = .71$) and the mean pretest score of students belonging to the control group ($M = 14.77$, $SD = 3.86$, $SE_M = .70$) in urban school at alpha level of 0.05, $t(58) = .87$, $p > .05$. It was also found that the values of SD and SE_M for the experimental group are nearly equal to those for the control group on pre-test scores in the stated two groups of the selected students (Table 16).
12. There is no significant difference between the mean pretest score of students belonging to the experimental group ($M = 13.60$, $SD = 2.75$, $SE_M = .50$) and the mean pretest score of students belonging to the control group ($M = 13.47$, $SD = 3.15$, $SE_M = .57$) of the rural school at an alpha level of .05, $t(58) = .18$, $p > .05$.

- The values of SD and SE_M for the experimental group are slightly less than those for the control group on the pre-test scores in the stated two groups (Table 17).
13. There is no significant difference between mean pretest score of HAs belonging to the experimental group ($M = 17.70$, $SD = 2.06$, $SE_M = .65$) and mean pretest score of HAs belonging to control group ($M = 18.20$, $SD = 1.81$, $SE_M = .57$), located in urban area, at alpha level of .05, $t(18) = -.58$, $p > .05$. The values of SD and SE_M for the experimental group are slightly more than those for the control group with respect to pre-test scores in the stated two groups (Table 18).
 14. There is no significant difference between mean pretest score of HAs belonging to the experimental group ($M = 16.20$, $SD = 1.32$, $SE_M = .42$) and mean pretest score of HAs belonging to the control group ($M = 16.10$, $SD = 1.66$, $SE_M = .53$) at .05 alpha level, $t(18) = .15$, $p > .05$. The values of SD and SE_M for the experimental group are slightly less than those for the control group on pre-test scores in the stated two groups (Table 19).
 15. There is no significant difference between the mean pretest score of AAs belonging to the experimental group ($M = 14.40$, $SD = 1.78$, $SE_M = .56$) and the mean pretest score of AAs belonging to control group ($M = 15.90$, $SD = 2.08$, $SE_M = .66$) at .05 alpha level, $t(18) = 1.74$, $p > .05$. The values of SD and SE_M for the experimental group are slightly less than those for the control group with respect to pre-test scores in the stated two groups (Table 20).
 16. There is no significant difference between the mean pretest score of AAs belonging to the experimental group ($M = 13.90$, $SD = 1.91$, $SE_M = .60$) and the mean pretest score of AAs belonging to control group ($M = 14.2$, $SD = 2.30$, SE_M

- = .73) at alpha level of .05, $t(18) = -.32$, $p > .05$. The table indicates that the values of SD and SE_M for the experimental group are slightly less than those for the control group with respect to pre-test scores in the stated two groups (Table 21).
17. There is no significant difference between the mean pretest score of LAs belonging to the experimental group ($M = 9.60$, $SD = 2.07$, $SE_M = .65$) and the mean pretest score of LAs belonging to the control group ($M = 12.20$, $SD = 1.62$, $SE_M = .51$) at 0.05 level of significance, $t(18) = -.72$, $p > .05$. It is also clear from the result that the values of SD and SE_M for the experimental group are slightly more than those for the control group on pre-test scores in the stated two groups (Table 22).
 18. There is no significant difference between the mean pretest score of LAs belonging to the experimental group ($M = 10.70$, $SD = 1.42$, $SE_M = .45$) and the mean pretest score of LAs belonging to the control group ($M = 10.10$, $SD = 1.73$, $SE_M = .55$) with 0.05 alpha level, $t(18) = .85$, $p > .05$. The values of SD and SE_M for the experimental group are slightly less than those for the control group with respect to pre-test scores in the stated two groups (Table 23).
 19. There is a significant difference between the mean achievement score of students belonging to the experimental group ($M = 45.80$, $SD = 17.84$, $SE_M = 3.26$) and the mean achievement score of students belonging to the control group ($M = 30.80$, $SD = 20.96$, $SE_M = 3.83$) at alpha level of .05, $t(58) = 2.99$, $p = .004$. It was found that the values of SD and SE_M for the experimental group are slightly less than

- those for the control group with respect to mean achievement scores in the stated two groups (Table 24).
- 20.** There is a significant difference between the mean achievement score of students belonging to the experimental group ($M = 42.73$, $SD = 17.52$, $SE_M = 3.20$) and the mean achievement score of students belonging to the control group ($M = 27.53$, $SD = 13.29$, $SE_M = 2.43$) in rural school with alpha level at .05, $t(58) = 3.79$, $p < .005$. The value of SD for the experimental group is more than that for the control group and value of SE_M of the experimental group is slightly more than that for the control group with respect to pre-test scores in the stated two groups (Table 25).
 - 21.** The measurements for mean, standard deviation and standard error of mean for HAs of the experimental group of the urban school were 64.5000, 3.3747 and 1.0672 respectively. The same values for HAs of control groups of the urban school were 57.6000, 5.2747 and 1.6680 respectively. It was found that the values of SD and SE_M for the experimental group are less than those for the control group with respect to mean achievement scores in the stated two groups (Table 26).
 - 22.** The values of t , df , p and SE_D for HAs of urban school were 3.485, 18, .003 and 1.9802 respectively at .05 level of significance. A significant difference between mean achievement scores of HAs of experimental and those of control groups was found in the urban school at .05 alpha level, $t(18) = 3.485$, $p = .003$ (Table 27).
 - 23.** The measurements for mean, standard deviation and standard error of mean on mean achievement score for HAs of the experimental group of the rural school

were 64.0000, 5.6569 and 1.7889 respectively. The same values for HAs of control group of the rural school were 40.2000, 7.6999 and 2.4349 respectively. It indicated that the values of SD and SE_M for the experimental group are slightly less than those for the control group with respect to mean achievement scores in the stated two groups (Table 28).

24. The measurements of t , df , p and SE_D for HAs of rural school were 7.877, 18, .000 and 23.8000 respectively. A significant difference was found between mean achievement scores of HAs of experimental and those of control groups in the rural school at alpha level of .05, $t(18) = 7.877$, $p < .005$ (Table 29).
25. The measurements for mean, standard deviation and standard error of mean on mean achievement score for AAs of the experimental group in the urban school were 48.8000, 5.9029 and 1.8667 respectively. The same values for AAs of control group in the urban school were 22.8000, 10.3258 and 3.2653 respectively. It was found that mean achievement score for AAs of experimental group is greater than that of control group. The values of SD and SE_M for the experimental group are less than those for the control group on mean achievement scores in the stated two groups (Table 30).
26. The measurements of t , df , p and SE_D on mean achievement score for AAs of urban school were 6.913, 18, .000 and 3.7612 respectively. A significant difference was found between mean achievement score of AAs of experimental group and AAs of control groups in urban school at .05 alpha level, $t(18) = 6.913$, $p < .005$ (Table 31).

27. The measurements for mean, standard deviation and standard error of mean on mean achievement score for AAs of the experimental group belonging to rural school were 40.9000, 4.4585 and 1.4099 respectively. The same values for AAs of control groups were 31.2000, 3.5214 and 1.1136 respectively. The values of SD and SE_M for the experimental group are slightly more than those for the control group with respect to mean achievement score in the stated two groups. It was also found that mean achievement score for AAs of experimental group is greater than that for AAs of control group for the stated groups of the students (Table 32).
28. The measurements of t , df , p and SE_D on mean achievement score for AAs of rural school were 5.399, 18, .000 and 1.7966 respectively. A significant difference was found between mean achievement scores of AAs of experimental group and the AAs of the control groups in the rural school at .05 alpha level, $t(18) = 5.399$, $p < .005$ (Table 33).
29. In urban school, the measurements for mean, standard deviation and standard error of mean on mean achievement score for the 10 LAs belonging to experimental group were 24.100, 7.5638 and 2.3919 respectively. The same values for the same number of LAs of control groups were 12.0000, 4.3970 and 1.3904 respectively. The values of SD and SE_M for the experimental group are more than those for the control group on mean achievement scores in the stated two groups. It was found that mean achievement score for LAs of experimental group is greater than that of control group in the rural school (Table 34).

30. The measurements of t , df , p and SE_D on mean achievement scores for LAs of urban school were 4.373, 18, .000 and 2.7667 respectively. A significant difference was found between mean achievement scores of LAs of experimental and LAs of control groups in urban school at .05 alpha level, $t(18) = 4.373$, $p < .005$ (Table 35).
31. The measurements for mean, standard deviation and standard error of mean on mean achievement score for 10 LAs of this experimental group in the rural school were found to be 23.300, 3.3015 and 1.0440 respectively. The same values for LAs of control groups in the rural school were 11.200, 2.7406 and .8667 respectively. It was found that mean achievement score for LAs of experimental group is greater than that of control group. The values of SD and SE_M for the experimental group are slightly more than those for the control group on mean achievement score in the stated two groups (Table 36).
32. The measurements of t , df , p and SE_D on mean achievement scores for LAs of rural school were 8.918, 18, .000 and 1.3569 respectively. The significant difference existed between mean achievement scores of LAs of experimental and those of control groups in the rural school at .05 alpha level, $t(18) = 8.918$, $p < .005$ (Table 37).
33. The values of M and SD for the students named as HAs, AAs and LAs in experimental group of the urban school are 64.50 and 3.37; 48.80 and 5.90; 24.10 and 7.56 respectively. Similarly, values of M and SD of the overall experimental group of the urban school were 45.80 and 17.84 respectively. Similarly, the values of M and SD for HAs, AAs and LAs in control group are 57.60 and 5.27; 22.80

- and 10.33; 12.00 and 4.40 respectively whereas the values of M and SD for the overall control group of the urban school were 30.83 and 20.96 respectively (Table 38).
34. A significant difference was found between mean achievement scores of experimental ($M= 45.80$, $SD=17.84$, $N=30$) and control ($M= 30.80$, $SD=20.96$, $N=30$) groups in the urban school, $F(1, 28) = 78.73$, $p < .005$, $SL=.05$ (Table 39).
 35. It was found that the main effect of three levels of achievement is highly significant in the urban school, $F(2, 28) = 217.84$, $p < .005$, $SL=.05$ (Table 39).
 36. A significant interaction was observed between teaching methodology and the levels of achievement (based on 8th class annual examination score) in the urban school, $F(2, 58) = 11.37$, $p < .005$, $S=.05$ (Table 39).
 37. The significant mean differences were found between HA, LA; HA, AA; and AA, LA ($p < .005$, $SE = 2.07$, $SL=.05$) in the urban school. It was also found that the mean difference (of 43) between HA and LA is largest. Similarly the mean difference (of 25.05) between HA and AA is greater than the mean difference (of 17.75) between AA and LA in the urban school (Table 40).
 38. The values of M and SD for HAs, AAs and LAs in experimental group of the rural school were found to be 64.00, 5.66; 40.90, 4.46; and 23.30, 3.30 respectively. Similarly, values of M and SD of the stated overall experimental group were 42.73 and 17.52 respectively. The values of M and SD for HAs, AAs and LAs in the control group of the rural school were 40.20, 7.70; 31.20, 3.52; and 11.20, 2.74 respectively whereas the values of M and SD of overall control group of the rural school were 27.53 and 13.29 respectively (Table 41).

39. There is a significant difference between mean achievement scores of experimental ($M= 42.73$, $SD=17.52$, $N=30$) and control ($M= 27.53$, $SD=13.29$, $N=30$) groups in rural school, $F(1, 28) = 146.46$, $p < .005$, $SL = .05$ (Table 42).
40. The main effect of three levels of achievement is highly significant in the rural school, $F(2, 28) = 257.16$, $p < .005$, $SL = .05$ (Table 42).
41. The interaction between teaching methodology and the levels of achievement (based on 8th class annual examination score) in the rural school was highly significant, $F(2, 58) = 12.03$, $p < .0005$ (Table 42).
42. The significant differences were found between mean achievement scores of HA, LA; HA, AA; and AA, LA ($p < .005$, $SE = 1.54$, $SL = .05$) in the rural school. The mean difference (of 34.85) between HA and LA is greater than the differences between HA and AA; or LA and AA whereas the mean difference (of 16.05) between HA and AA is lesser than the mean difference (of 18.80) between AA and LA (Table 43).

5.3 Conclusions

Following conclusions have been drawn on the basis of findings of the study:

1. BBL teaching method is more effective than conventional teaching method to teach mathematics at secondary level in the urban area due to utilization of different faculties of human brain like parallel processing, innate search of meaning, perception through simultaneous creation of parts and wholes etc.
2. BBL teaching method is more effective than conventional teaching method to teach mathematics at secondary level in the rural area as well because BBL

teaching method ensures maximization of neurotic connections of human brain to solve mathematical problems in a logical sequence.

3. The achievement level of high achievers in the experimental group is significantly more than that of high achievers belonging to control group in the urban school. This edge was due to interaction of the concerning learners with meaningful content, peer tutoring, group discussions, quick formation of patterns, unfolding riddles etc.
4. BBL teaching method is more effective than conventional teaching method to teach mathematics to high achievers in the rural school at secondary level. Factors like building up the storage of spatial memory, individual as well as group work of students, exploration of mathematical concepts through open discussions, brain energizers, physical movements of the students etc resulted in the effectiveness of BBL teaching method.
5. Another important aspect was noted that BBL teaching method remained effective equally for the high achievers belonging to the schools situated in rural as well as urban areas, unlike the conventional teaching method which had been more effective for the high achievers studying in the rural school.
6. The performance of average achievers taught through BBL teaching method was better than those taught through conventional teaching method in the urban school. This difference in performance was a result of working in small groups, individual assignments considering uniqueness of each brain, exploration of ideas through real-life problems, physical activities, relating previous knowledge to the

fresh mathematical concepts, solving by themselves most of the mathematical problems given in the mathematics textbook etc.

7. The BBL teaching method proved to be more effective for average achievers of rural school as compared to conventional teaching method to teach mathematics at secondary level. It happened due to an enriched environment which resulted in improving the slow functioning of their brains as well as step-wise inculcation of mathematical concepts which helped learners to create meaningful wholes.
8. BBL teaching method is more effective as compared to the conventional teaching method for the low achievers of urban area schools in teaching the subject of mathematics. The effectiveness is attributed to the factors like formation of groups having mixed abilities, peer learning, working in a brain-friendly environment, solution of unseen mathematical problems, solving by themselves problems given in the exercises of the mathematics text-book, interacting with the real life situations of lesson set etc.
9. Low achievers of rural area school, taught through BBL teaching method, performed well as compared to the low achievers taught through conventional teaching method because the better performers were provided a low-threatening and high-challenging environment. Moreover, the upper handed (i.e. better performers) low achievers retained information efficiently through effective use of spatial memory rather than rote memory. The role of having say in the class, competition with the quick learners within the group, peer help, learning by thinking etc were also important factors in making the noted difference.

10. Main effect of teaching methodology on the three levels of academic achievement was found to be significantly different for the students of rural as well as urban secondary schools.
11. A significant difference was noted among the mean achievement scores of the students selected from urban as well as rural secondary schools who were placed in any of the three levels of achievement, namely high achievers, average achievers and low achievers.
12. As the achievement level of the students studying in urban schools increases, the BBL teaching method gradually becomes more effective because the rich environment of the classroom and the resultant interest and involvement of the students were matching with the natural functioning of brain.
13. BBL teaching method becomes more effective as the level of achievement of students decreases in rural area schools. This effectiveness is due to availability of choices, having say in classroom, enhanced confidence level due to solving mathematical problems of textbook by themselves, individual student-teacher interaction, self-efficacy and stress free environment for the students in the classroom.
14. An interaction between teaching methodology and the levels of achievement (based on 8th class annual examination score) was observed for the students included in the rural and urban secondary schools. Thus mean differences between the teaching methods conditions were not what would be predicted from the overall main effects of both of the factors.

5.4. Recommendations

In light of the study, following recommendations are given.

1. The teachers may introduce the homogeneous subject-wise grouping of students on the basis of their academic achievement levels within classrooms for peer learning in the light of the study. For the purpose, such groups may be formed which comprise equal number of high, average and low achievers.
2. The concept-based mathematical problems related to real-life situations of learners may also be twinned by the mathematics teachers with the relevant textbook-based mathematical problems. In this way, the abstract textbook-based mathematical problems may be taught through a meaningful way.
3. The orchestrated immersion, relaxed alertness and active processing based on the twelve principles of BBL theory should be practiced by the teachers in the classrooms to create effective understanding of mathematical concepts among students.
4. Personal health problems of the students may be addressed by the teachers instantly so that learners may engage their whole physiology in the complex task of learning which is impaired during physical illness.
5. The mathematical problems in exercises of text-book may be constructed in accordance with the five out of twelve principles of the BBL theory i.e. parallel processing, innate search of meaning, patterning, creation of parts & wholes and uniqueness.

6. The BBL theory is effectiveness for mathematics; therefore further studies may be carried out to investigate its effectiveness for other subjects at elementary, secondary and higher levels as well.
7. The effectiveness of BBL teaching method may be investigated by comparing the performance of male and female learners as well as learners of rural and urban areas.
8. Such financial and academic resources may be provided within each secondary school in light of the classrooms of the experimental groups of the study whereby the BBL teaching method may be effectively implemented by the teachers
9. Teachers of mathematics may be trained on pattern of brain-friendly teaching learning activities which have been organized in the study so that conceptual understanding of mathematical concepts may be developed by the teachers through BBL teaching method.
10. Further research studies may be conducted to investigate the impact of innate faculties of human brain i.e. parallel processing; innate search of meaning; pattern formation; perception through parts and wholes; and uniqueness on the performance of learners at any level and in any discipline. The comparative studies between male-female, rural-urban etc may also be conducted in the context of BBL theory.

BIBLIOGRAPHY AND REFERRANCES

- Apple Learning Interchange, (2003). Opening Classrooms Doors, Teaching Methods, Cooperative Learning, Retrieved from [http:// newali.apple.com](http://newali.apple.com) on January, 21, 2008
- Armstrong, T. (1994). Multiple intelligences in the classroom. Alexandria, Virginia: Association for Supervision and Curriculum Development. Retrieved from http://www.ascd.org/ed_topics/cl200011_jacobsconnell.html on September10, 2008
- Avaci, D.E. & Yagbasani, R. (2005). A Study on Impact of Brain Based Learning Approach on Students' Achievement of Knowledge about "Work-Energy". Retrieved from [http:// www.ffri.hr/GE2/abstractsub.php?open=97&sign=0](http://www.ffri.hr/GE2/abstractsub.php?open=97&sign=0) on August 25, 2007
- Barbara, k. (2002). Teaching to the Brain's Natural Learning Systems, ASCD, Alexandria, VA. PY.
- Baron, B.A. (2006). Psychology (5th ed.), Pearson education, Inc. Pearson Prentice Hall, London, p 7
- Best, J.W. & Kahn, J.V. (1996). Research in Education (7th ed.), New Delhi, Prentice Hall, pp 275, 320-329
- Biller, L. (2007). Brain Friendly and Traditional Classrooms. Taken from: "Creating Brain Friendly Classrooms". Retrieved from <http://xnet.rrc.mb.ca/glenh/newpage124.htm> on February 22, 2008, & The Brain-Compatible Classroom - General Characteristics. Retrieved from <http://ontheroad.northantsstudycentres.org/files/2008/07/brain-friendly-classroom.doc> on February 22, 2008
- Bruer, T. & James, S. (1999). Education and the Brain: A Bridge Too Far. McDonnell Foundation. Excerpt: Retrieved from <http://ucalgary.ca> on March 17, 2005
- Bruer, T. & James, S. (1999). Put Brain Science on the Back Burner. McDonnell Foundation. Excerpt: Retrieved from [http://http://mysite.verizone.net](http://mysite.verizone.net) on March 17, 2005
- Bruer, J.T. (1999). In Search of ... Brain-Based Education. Retrieved from <http://www.pdkintle.org> on March 17, 2005.
- Caine, R. & Caine, G. (1991). Making Connections, Teaching and The Human Brain. Association for Supervision and Curriculum Development 1250N. Pitt Street Alexandria, VA 22 314. pp 8-9, 80-87, 124
- Caine, R. & Caine, G. (1995, 1997). Understanding a Brain Based Approach to Learning and Teaching, Educational Leadership, 1990, retrieved from www.mainesupportnetwork.org, on July 12, 2007 & on December 23, 2007
- Caine, R. & Caine, G. (1995). Reinventing Schools Through Brain Based Learning. Journal of Educational Leadership Association for Supervision and Curriculum Development 1250N. Pitt Street Alexandria, April. p 44

- Caine, R. & Caine, G. (1990). *Understanding a Brain-Based Approach to Learning and Teaching*, Educational Leadership, 1990. Retrieved from <http://www.mainesupportnetwork.org/handouts/html/Approach.htm> on July 12,2007)
- Cangelosi, (2003). Quoted by National Science Foundation, Vol. 1, No. 1 (2006) pp. 62 – 82, *Applications and Applied Mathematics (AAM): An International Journal*
- Cengelci (2005), *Elementary Education Online*, 6(1), pp 62-75, 2007, retrieved from <http://ilkogretim-online.org> on September 12, 2007.
- Cohen, P. A. Kulik, J. A. & Kulik, C. C. (1982). Educational outcomes of peer tutoring: A meta-analysis of findings. *American Educational Research Journal*, 19(2), pp 237-248. EJ 272 101
- Connell, D.J. (2000). *Brain-Based Teaching: Integrating Multiple Intelligences and Emotional Intelligence*. *The Science of Learning*. November 2000, Volume 4, Number 3. Retrieved from http://www.ascd.org/ed_topics/cl200011_jacobsconnell.html on September10,2008
- Cooperative Learning, (2007). Retrieved from <http://edtech.kennesaw.edu/intech/cooperativelearning.com> on September 12, 2007
- Craig, D.I. (2003), *Brain-Compatible Learning: Principles and Applications in Athletic Training Journal of Athletic Training*, December 2003;38(4)
- Crossroads Institute, 2009. *Types of Memory*, Retrieved from [http:// www.crossroadsinstitute.org](http://www.crossroadsinstitute.org) on January 12, 2009
- Crow, L.D. & Crow, (1999) *Educational Psychology*, Eurasia Publishing House (P) Ltd. Ram Nagar, New Delhi- 55 (India), p 21
- Davenport Community School, (2008). *We Have Brain-Friendly Classrooms*. Retrieved from <http://davenport.k12.ia.us/default.asp> on September 11, 2008.
- Davenport Community School, (2007). Retrieved on September 1, 2007 from <http://davenport.k12.ia.us/default.asp>)
- Davis, A. (2004). *The Credentials of Brain-Based Learning*. *Journal of Philosophy of Education*, Vol. 38, No. 1, 2004
- DePaulo, et al. (1989). Age differences in reactions to help in a peer tutoring context. *Child Development*, 60(2), April, pp 423-439. EJ 387 666
- Duman, B. (2006). *The Effect of Brain-Based Instruction to Improve on Students' Academic Achievement in Social Studies Instruction*. 9th International Conference on Engineering Education. July 23 – 28, 2006
- ERIC Database, Record 1-14, (2003). Retrieved on February 6, 2009 from www.eduref.org
- Erlauer, L. (2003). *The Brain-Compatible Classroom: Using What We Know About Learning to Improve Teaching*. Virginia: Association for Supervision and Curriculum Development. pp 1-2
- Ertmer, P.A. & Newby, T.J. (1993). *Behaviorism, Cognitivism, Constructivism, Performance Improvement Quarterly*, 1973, 6(4), pp 50-72

- Felder, R. M. (2002). Matters of Style, *ASEE Prism*, vol. 6, no. 4, pp. 16-23. Retrieved from <http://www2.ncsu.edu/unity/lockers/users/f/felder/public/Papers/LS-Prism.htm> on 23rd July 2002.
- Feldman, R.S., (1999). *Understanding Psychology*. 5th Edition, The McGraw-Hill Companies, Inc. p 15
- Fitness Channel, (2009). Types of Memory. Retrieved from <http://bfc.positscience.com> on January 17, 2009
- Gardner, H. (1983). *Frames of mind: The theory of multiple intelligences*. New York: Basic Books. Retrieved from http://www.ascd.org/ed_topics/cl200011_jacobsconnell.html on September10,2008
- Gardner, H. (1991). *The unschooled mind*. New York: Basic Books. Retrieved from http://www.ascd.org/ed_topics/cl200011_jacobsconnell.html on September10,2008
- Gardner, H. (1993). *Multiple intelligences: The theory in practice*. New York: Basic Books. Retrieved from http://www.ascd.org/ed_topics/cl200011_jacobsconnell.html on September10,2008
- Gardner, H. (1995). Reflections on multiple intelligences: Myths and messages. *Phi Delta Kappan*, 77 (3), pp 200–208. Retrieved from http://www.ascd.org/ed_topics/cl200011_jacobsconnell.html on September10,2008
- Gardner, H. (1998). Keynote Presentation, Fourth International Teaching for Intelligence Conference, NYC, NY. Retrieved from http://www.ascd.org/ed_topics/cl200011_jacobsconnell.html on September10,2008
- Gay, L.R. (2000). *Educational Research: Competencies for Analysis and Application*, 5th edition, National Book Foundation Islamabad. pp 170,371-374
- Goleman, D. (1994). *Emotional intelligence*. New York: Bantam Books. Retrieved from http://www.ascd.org/ed_topics/cl200011_jacobsconnell.html on September10,2008
- Goleman, D. (1998). *Working with emotional intelligence*. New York: Bantam Books. Retrieved from http://www.ascd.org/ed_topics/cl200011_jacobsconnell.html on September10,2008
- Gould, (2007). Retrieved on February 12, 2007 from www.howstuffwork.com
- Gravetter, F.J. and Wallvau, L.B., (2004). *Statistics for the Behavioral Sciences*. Wadsworth/Thomas Learning, USA. 6th Edition, p 504
- Gulpinar, M.A. (2005). The Principles of Brain-Based Learning and Constructivist Models in Education. *Educational Sciences: Theory & Practice* 5 (2), November 2005, pp 299-306
- Haghighi, A.M., Vakil, R.& Weitba, J.K. (2005): Reverse-Traditional/ Hands-on: An Alternative method of Teaching Statistics. *Application and Applied Mathematics (A.A.M.)*, Vol. 1, No. 1 (2006).
- Harburger, L. et al. (2007). *Behavioral Neuroscience*, Vol 121(4)
- Haris, V.W. & Sherman, J.A. (1973). Effects of peer tutoring and consequences on the math performance of elementary classroom students. *Journal of Applied Behavior Analysis*. 1973, winter, 6(4), pp 587–597

Hayes, N. (1999). Foundations of Psychology, an Introductory text. New York. pp. 2-9, 20, 994

Hendrix, M.M. (2008). Brain-Compatible Teaching and Learning. Retrieved from <http://en.wikibooks.org> on 12 August, 2008.

http://edtech.tennessee.edu/~bobannon/lesson_plan.html. Retrieved on December 12, 2006

http://en.wikipedia.org/wiki/Action_learning, retrieved on May 13, 2008.

<http://en.wikipedia.org/wiki/Neuroplasticity>, Retrieved on June 2, 2006.

<http://fcit.usf.edu/assessment/selected/responsec.html>. Classroom Assessment. Retrieved on August 17, 2011

<http://www.freewebs.com/taol/biengthere.html>. Retrieved On March 16, 2008

<http://www.funderstanding.com>, 1998-2001. Retrieved on November 21, 2006

<http://www.journeytoexcellence.org/practice/instruction/theories/iti>. Retrieved on October 9, 2007

<http://www.kovalik.com/founder.htm>. Retrieved on April 15, 2008

<http://www.myshelf.com/writing/05/fivefingeressay.htm> Retrieved on January 17, 2008

<http://www.poweroften.ca/consulting/consultants.html>, Retrieved on 13 November, 2006

<http://www.smartforkids.com>/Retrieved on September 2, 2007

http://www.thefivefingerparagraph.com/what's_ffp.htm Retrieved on April 17, 2008

Huitt, W. (2000). Individual differences: The 4MAT system. Educational Psychology Interactive. Valdosta, GA: Valdosta State University. Retrieved on June 28, 2008 from <http://chiron.valdosta.edu/whuitt/col/instruct/4mat.html>

Human Brain, Human Learning, quoted by Robertson, C. (2008). Retrieved from academic.evergreen.edu/r/robcai22/sem7wolfe.doc on December 28, 2008, p 2

Hunter et al. (1987). Mastery Learning. Notes from Benjamin Bloom lecture. Retrieved from <http://www.humboldt.edu/~tha1/mastery.html> retr on March 17, 2008.

Jensen, E. (2000). Journal of Educational Leadership, April, Association for Supervision and Curriculum Development 1250N. Pitt Street Alexandria, VA 22 314, pp 76-78.

Jensen, E. (2005). Teaching with the Brain in Mind, 2nd Edition. Association for Supervision and Curriculum Development. Retrieved from <http://www.ascd.org/publications> on January 20, 2008

Jorgenson, O. (2003). Brain Scam? Why educators be careful about embracing brain research. The Educational Forum, 2003. Vol. 67. No.4, pp 364-69

Kagan, S.(2001), Kagan Structures are Brain-Based, Retrieved from <http://www.kaganonline.com> on January 12, 2009, Kagan Online Magazine, Winter 2001.

- Karen (2005). Brain Based Learning, 1998-2008, retrieved from www.funderstanding.com on May 22, 2006.
- Koch, 2005, Santa Cruz Style Entertainment: Retrieved from <http://www.heartmath.org/press-room/pr-whole-brain-learning-is-a-new-frontier> on January 12, 2009.
- Kolb (1984), *Experiential Learning*. Prentice Hall, Englewood Cliffs, New Jersey.
- Kovalik (2008), Retrieved on March 16, 2008 from <http://www.kovalik.com/overview.htm>
- Lackney (2008). 12 Design Principles based on Brain-based learning research, retrieved from www.designshare.com on June 12, 2008
- Lucas, R. W. (2004). *The creative training idea book: Inspired tips and techniques for engaging and effective learning*. New York: AMACOM.
- Lee, I. (2003). University of Brain education. Retrieved on November 26, 2007 from www.brainfrontier.or.k
- Lucas, R.W. (2004). *The creative training idea book: Inspired tips and techniques for engaging and effective learning*. New York, AMACON
- Lunenburg & Ornstein (2004), *Educational Administration*, 4th ed., Thomson WADSWORTH, USA. p 536
- Madigan, K., (2001). Buyer Beware: Too Early To Use Brain-Based Strategies Basic Education (Council on Basic Education), April 2001. Excerpts. Retrieved from <http://www.c-b-e.org> on July 15, 2006
- 4MAT System, Retrieved on April 19, 2008 from <http://www.usd.edu/~ssanto/4mat.html>
- McCarthy, B. & McCarthy, D. (2006). *Teaching Around the 4MAT Cycle: Designing Instruction for Diverse Learners*, Corwin Press, ISBN: 1412906393, Amazon.com. 2006
- McEwen, B. & Magarinos, A. (2001). *Human Psycho- pharmacology Clinical & Experimental*, Vol 16(1), pp S7-S19.
- McIntosh N. (1996). *Why Do We Lecture?* JHPIEGO Strategy Paper #2. JHPIEGO Corporation, Baltimore, Maryland.
- Melton, L. (2009). Brain-based education: A viable option for struggling readers. Retrieved from <http://www.helium.com> on March 2, 2009.
- Metropolitan Omaha Educational Consortium (MOEC), Omaha, NE: University of Nebraska at Omaha, (1999), <http://coe.unomaha.edu/moec/brainbased.php> on 12-2-2009
- Meyer, M. (1997). The greening of learning: Using the eighth intelligence. *Educational Leadership*, 55 (1), pp 32–34. Retrieved from http://www.ascd.org/ed_topics/cl200011_jacobsonnell.html on September 10, 2008
- Milham, M. et al. (2005). *Biological Psychiatry*, Vol 57(9), pp 961-66.

- Munson L.S. (1992). *How to Conduct Training Seminars: A Complete Reference Guide for Training Managers and Professionals*. McGraw-Hill. New York.
- Nunley (2006), K.F., *Layered Curriculum*. Retrieved from <http://help4teachers.com/layeredcurriculum.htm> on June 14, 2006
- Ozden, M., & Gultekin, M. (2004). The Effects of Brain-Based Learning on Academic Achievement and Retention of Knowledge in Science Course. *Electronic Journal of Science Education*. (Southwestern University) Vol. 12, No. 1 (2008). Retrieved from <http://ejse.southwestern.edu> on September 14, 2008.
- Paglin, C. (2000). A Cautionary Note on Brain Research, Northwest Regional Education Laboratory, Northwest Education Magazine, Fall 2000. Retrieved from <http://www.nwrel.org> on October 2, 2007
- Palombo, W.R. (2000). Brain based Learning, Training and Development, Vol 54 No. 7, July 2000, pp 20-24
- Pithers, R. & Mason, M. (1992). Learning Style Preferences: Vocational Students and Teachers, *Australian Education Researcher*, vol. 19, no. 2, pp. 61-71.
- Politano and Paquin, (2000). quoted by Avaci, D.E. and Yagbasani, R. (2004), A Study On Impact Of Brain Based Learning Approach On Students' Achievement Of Knowledge About "Work-Energy". Retrieved on August 25, 2007 from <http://www.ffri.hr/GE2/abstractsub.php?open=97&sign=0>
- Power Of Ten, A Brain Compatible Learning System For Numeracy Skills: Retrieved from <http://www.poweroften.ca/pot.html> on October 11, 2007.
- Prigge, D.J. (2002). Promote Brain-Based Teaching and Learning Vol. 37, No. 4, March 2002, pp 237-41
- Reardon, M. (1999). The Brain. Navigating the new reality: An exploration of brain-compatible learning, *Adult learning*, vol 10, No. 2, winter 1998-1999, pp 10-17
- Reber, A. (1995). *The Penguin dictionary of Psychology* (2nd ed.), Penguin books limited, England
- Reifschneider, T. J. (1983). Concrete Operations as "Natural" Thinking. Retrieved from <http://www.eduref.org> on December 31, 2008. A Paper presented at the Annual Meeting of the Northern Rocky Mountain Educational Research Association 1st, Jackson, WY, October, 1983. pp 13-15
- Ruyle, K. (1995). Group training methods, in *The ASTD Technical and Skills Training Handbook*. Kelly L (ed). McGraw-Hill: New York
- Seith, R. (2000). Brain Based Learning an attempt to break classroom blues, retrieved on July 16, 2007 from www.connectwithkids.com
- Solso, R. I. (2005). *Cognitive Psychology*. 6th ed. Pearson Education (Singapore) Pte.Ltd. Indian Branch, 482 F.I.E.Patparganj, Delhi 110 092, India.
- Soonthornrojana, W. (2007). A Teaching Model Development for Reading Comprehension by Brain-Based Learning Activities. The 1st International Conference on Educational Reform 2007 November 9-11, 2007 Mahasarakham University, THAILAND 310

- Steinhorst & Keeler, (1995), quoted by Reverse-Traditional/ Hands-on: An Alternative method of Teaching Statistics. *Application and Applied Mathematics (A.A.M.)*, Vol. 1, No. 1 (2006), pp 62-82.
- Strauss, V. (2001). Brain Research Oversold, Experts Say. *Washington Post*, retrieved on March 13, 2001 from <http://teachers.net/gazette>
- Teacher tap, (2008). Brain based (compatible) learning. Retrieved on February 4, 2009 from www.eduscapes.com
- Tomlinson, C. & Kalbfleisch (1998). Teach me; Teach my brain, A call for differentiated classrooms. *Educational Leadership*, 56(3), pp 52–55. Retrieved from http://www.ascd.org/ed_topics/cl200011_jacobsconnell.html on September 10, 2008
- Tommerdahl, J. (2008). Educational neuroscience: where are we? Retrieved from <http://teachingexpertise.com> on December 12, 2008.
- Tompkin, A.W., (2007), Retrieved on September 20, 2007 from digitalcommons.liberty.edu/doctrol/22/
- VanDevender, E.M. (1984). The Effect of Three Types of Brain-Based Instruction on the Mathematics Achievement and Attitudes of Second Grade Students. Retrieved from www.eric.ed.gov. ED250155 on January 14, 2007
- Vella, F. (1992). Medical education: Capitalizing on the lecture method. *FASEB Journal* 6(3), pp 811–12.
- Wagmeister, J. & Shifrin, B., 2000, Thinking Differently, Learning Differently, *Educational Leadership*, November, pp 45-48
- Waters, N. (2005). The realities of brain research strategies. Retrieved on July 16, 2007 from www.anderson1.k12.sc.us
- Webb, R. et al (2007). *Journal of Educational Psychology*, Vol 99(2), pp 397-420.
- Weber E. (2006). Brain Based Business. Retrieved from <http://brainbasedbusiness.com> on December 23, 2007.
- Weeks (2003). Retrieved from http://content.library.ccsu.edu/cdm4/item_viewer.php?CISOROOT=/ccsutheses&CISOPTR=1149&CISOBX=1&REC=2 on January 21, 2006
- Wikipedia, the free encyclopedia (2007). Triune Brain, Decade of brain, retrieved on November 29, 2007 from Wikipedia.com
- Willingham, D.T. (2006). Brain-Based Learning: More Fiction than Fact, *American Federation of Teachers*, Fall 2006. Retrieved from <http://www.aft.org> on November 12, 2008.
- Willis, J. & Crowder, J. (1974). Does tutoring enhance the tutor's academic learning? *Psychology in the Schools*, 11(1), January, pp 68-70. EJ 092 500
- Wilson, L. O. (2005). Using Brain-based education to optimize learning, Retrieved on January 16, 2007 from <http://www.uwsp.edu/Education/lwilson/brain/bboverview.htm>

- Wolfe, P. & Brandt, R. (1998). Brain science, brain fiction. *Educational Leadership*, 56(3),14–18. Retrieved from http://www.ascd.org/ed_topics/cl200011_jacobsconnell.html on September10,2008
- Woolfolk, A. (2005). *Educational psychology*. 9th ed. Pearson Education (Singapore) Pte.Ltd, Indian Branch, 482 F.I.E.patparganj, Delhi 110 092, India, p 40
- Zagranski, R. (2008). *Understanding Standard Based Education*, crown press, amazon.com p 132, retrieved from [www. crownpress.com](http://www.crownpress.com) on February 5, 2009, p 132

APPENDIX A**THE 9TH CLASS STUDENTS SELECTED AS SAMPLE FROM
FGBMS I-8/4 (URBAN AREA)**

Names of HAs	Section (S)	AES	Names of AAs	S	AES	Names of LAs	S	AES
1.Awais	B	382	21.Salih	A	316	41.Farhan	B	243
2. Adeel	A	393	22.Hannan	A	319	42.Nabeel	A	248
3.Qasim	B	400	23.Muzamal	B	320	43.Rehan	A	250
4.Asad	B	405	24.Aftab	A	320	44.Danial	B	250
5.Mudasar	A	416	25.Fasih	A	321	45.Rehman	A	250
6.Shiraz	A	421	26.Obaid	B	323	46.Umar	A	252
7.Fawad	B	443	27.Khizar	B	327	47.Zain	B	253
8.Tayab	A	443	28.Nabeel	B	328	48.Zahid	A	254
9.Afzaal	A	416	29.Atif	B	330	49.Junaid	B	261
10.Kamran	A	456	30.Shoaib	A	336	50.Umar	B	263
11.Tauqir	A	458	31.Saad	A	341	51.Zishan	A	272
12.Azaz	A	425	32.Asad	A	347	52.Noman	B	274
13.Ayaz	A	421	33.Bilal	B	348	53.Usama	B	279
14.Kashif	A	575	34.Mohsin	A	349	54.Ahsan	A	283
15.Sjawal	A	500	35.Saad	A	349	55.Aftab	A	288
16.Atif	B	497	36.Tariq	B	349	56.Samad	A	288
17.Amir	A	506	37.Zubair	A	357	57.Usman	B	289
18.Zishan	A	502	38.Zaid	B	363	58.Shahid	A	290
19.Faisal	A	561	39.Mehran	B	364	59.Bilal	B	290
20.Jamal	A	575	40.Khurm	B	370	60.Bilawal	B	290

APPENDIX B

**THE 9TH CLASS STUDENTS SELECTED AS SAMPLE FROM
FGBMS HUMMAK (RURAL AREA)**

Names of HAs	Section (S)	AES	Names of AAs	S	AES	Names of LAs	S	AES
1.Amir	D	395	21.Zulfiqar	D	235	41.Ahsan	A	210
2.Wahid	D	396	22.Talat	A	306	42. shakoore	E	210
3.Sana	E	399	23.Asim	B	306	43.Umar	B	210
4.Waqas	B	401	24.Wahab	C	306	44.Usman	B	210
5.Fasil	C	402	25.Imran	A	307	45.Irfan	B	210
6. Khan	E	403	26.Ahsan	A	307	46.Noman	A	211
7.Noman	C	408	27.Aqib	A	307	47.Noman	A	212
8.Ahmed	E	410	28.Usman	D	308	48.Ijaz	A	215
9.Usama	E	411	29.Amanat	E	309	49.Babar	B	215
10.Faisal	D	414	30.Jibran	C	309	50.Tauqeer	B	218
11.Imran	C	416	31.Waqar	D	309	51.Zain	A	219
12.Rafay	A	420	32.Asif	E	310	52.Habib	B	220
13.Amir	A	424	33. Jahan	A	311	53.Usman	E	221
14.Zishan	C	426	34.Kashif	C	312	54..Kamran	B	221
15.Rabi	C	441	35.Kamran	A	312	55.Tariq	E	224
16.Hasnan	B	442	36. Ferhaj	D	313	56.Farooq	B	228
17.Adib	B	442	37.Adnan	E	313	57.Zubair	D	228
18.Asim	B	442	38.Tayyab	C	314	58. Fahad	B	228
19.Irfan	B	446	39.Yasir	A	317	59.Umar	B	229
20.Umar	B	462	40.Merhan	C	322	60.Zameer	A	230

APPENDIX C

**PRE TEST, POST TEST AND ACHIEVEMENT SCORES OF THE
SELECTED STUDENTS OF FGBMS I-8/4 (URBAN AREA)**

S.No.	Scores of Experimental Group			Scores of Control Group			Levels of Achievement
	pretest	posttest	achievement	pretest	posttest	achievement	
1	15	85	70	16	76	60	High Achievers
2	15	82	67	15	79	64	
3	19	86	67	20	84	64	
4	16	84	68	17	72	55	
5	18	83	65	17	73	56	
6	17	80	63	20	75	55	
7	20	82	62	19	73	54	
8	17	88	61	20	73	53	
9	21	81	60	19	84	65	
10	19	91	62	19	69	50	
11	13	72	59	12	57	45	Average Achievers
12	12	64	52	13	42	29	
13	13	65	52	16	43	27	
14	14	64	50	18	45	27	
15	16	72	56	16	43	27	
16	15	61	46	16	34	18	
17	14	59	45	17	35	18	
18	13	56	43	15	28	13	
19	17	59	42	18	30	12	
20	17	60	43	18	30	12	
21	6	49	43	7	23	16	Low Achievers
22	8	34	26	8	23	15	
23	7	30	23	10	28	18	
24	9	32	23	10	24	14	
25	10	31	21	11	24	13	
26	11	32	21	10	23	13	
27	10	30	20	11	23	12	
28	11	40	29	12	21	9	
29	12	31	19	11	16	5	
30	12	28	16	12	17	5	

APPENDIX D

**PRE TEST, POST TEST AND ACHIEVEMENT SCORES OF
THE SELECTED STUDENTS OF FGBMS HUMMAK TOWN
(RURAL AREA)**

S.No.	Scores of Experimental Group			Scores of Control Group			Levels of Achievement
	pretest	posttest	achievement	pretest	posttest	achievement	
1	15	81	66	14	55	41	High achievers
2	16	94	78	15	70	55	
3	15	76	61	14	62	48	
4	14	78	64	16	61	45	
5	16	78	62	17	60	43	
6	16	84	68	16	51	35	
7	17	78	61	15	49	34	
8	17	77	60	18	50	32	
9	18	79	61	17	48	31	
10	18	77	59	19	57	38	
11	10	59	49	10	43	33	Average achievers
12	13	57	44	10	41	31	
13	12	59	47	14	46	32	
14	15	56	41	15	55	40	
15	14	53	39	16	46	30	
16	13	52	39	15	44	29	
17	15	52	37	16	46	30	
18	16	51	35	15	46	31	
19	15	53	38	15	44	29	
20	16	46	40	16	43	27	
21	8	37	29	6	17	11	Low achievers
22	9	36	27	9	24	15	
23	10	31	21	10	23	13	
24	12	35	23	10	23	13	
25	10	34	24	11	26	15	
26	11	38	27	12	22	10	
27	12	32	20	10	20	10	
28	12	33	21	11	19	8	
29	11	32	21	10	17	7	
30	12	32	20	12	22	10	

RESEARCH TOOL OF THE STUDY, ADMINISTERED
AS PRE-TEST & POST-TEST

NAME OF STUDENT:----- ROLL NO: -----

Maximum Time Allowed: 75 minutes

Total marks: 100

NOTE:- Simplify the following problems at spaces given for each question. Please use back side of the page for rough work or calculations.

ITEM NO. 1: (i). If $a*b = \sqrt{a} \times \sqrt{b}$ (e.g. $7*11 = \sqrt{7} \times \sqrt{11} = \sqrt{77}$)

Look at the table carefully and fill in following blanks by applying $a*b = \sqrt{a} \times \sqrt{b}$:

		b	
	*	3	5
a	13	-----	-----
	7	-----	-----

(ii). Now fill in the following blanks by applying $a*b = \sqrt{a} \times \sqrt{b}$:

		b	
a	*	----	----
	-----	$\sqrt{6}$	$\sqrt{21}$
	-----	$\sqrt{10}$	$\sqrt{35}$

(Please turn over)

ITEM NO.2: There are three types of decimal fractions; Terminating (T), Recurring and non-terminating (R) and Non-recurring and non-terminating (N). Write T or R or N whichever is correct under each decimal fraction in second row:

Decimal fractions	3.654601---	3.6549032---	3.654654---	3.654444---	3.6518---	0.1
Types	-----	-----	-----	-----	-----	-----

ITEM NO 3: Look at the products given in the following blocks and calculate the answers of parts i,ii and iii with the help of these blocks:

$$8 \times 8 \times 8 \times 8 = 4096$$

$$25 \times 25 = 625$$

$$15 \times 15 \times 15 = 4475$$

i) ${}^3\sqrt{4475} =$ -----

ii) $\sqrt{4096} =$ -----

iii) ${}^4\sqrt{625} =$ -----

ITEM NO.4: Different values of A, B and C are given in the following blocks below:

$$A = 2^{1/3}$$

$$B = 6^{1/2}$$


$$C = 9^{1/4}$$


Simplify $A^6 \times B^2 \div C^8$ by putting the above values of A, B, and C, Write answer in fractional form.


(Please turn over)


ITEM NO.5: Write your name in English: -----.


Now fill in the following blocks as directed below:


a) Write the total number of alphabets of your name? 

b) Multiply this number by 4. 

c) Now take square root of answer of part (b). 

d) Then divide the answer of part (c) by 2^{-3} . 

e) Hence multiply the answer of part (d) with $(256)^{-1/2}$. 

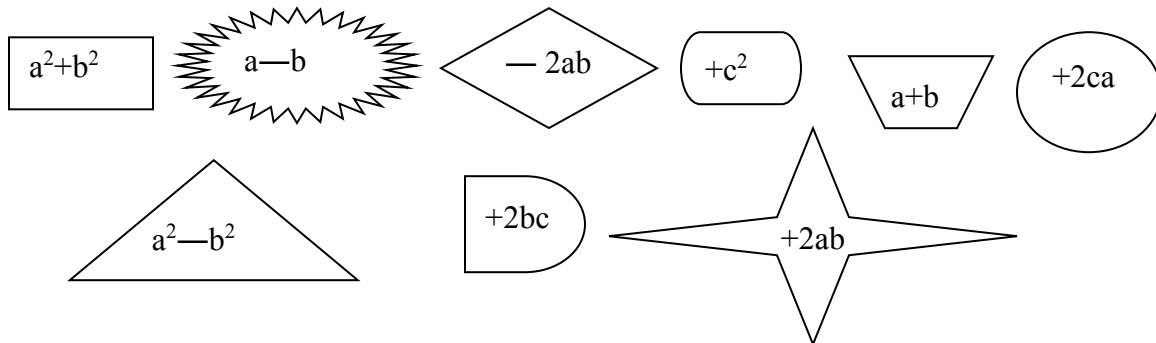
f) Finally, take the square of answer of part (e). 

Tick with **YES / NO** which makes the following result correct.

Result: Answer of part (a)= Answer of part (f)	YES / NO
---	-----------------

(Please turn over)

ITEM NO.6: Look at the following shapes in which some algebraic expressions are given.



Complete the following formulae by taking algebraic expressions from above shapes.

- $(a+b)^2 = \text{-----}$
- $(a-b)^2 = \text{-----}$
- $(a+b+c)^2 = \text{-----}$
- $a^2-b^2 = \text{-----}$

ITEM NO.7: A student claims “If $(2x)^3$ is subtracted from the product of $2x-3$ and $4x^2+6x+9$, the answer is 27.” Find after simplification whether he is right or wrong?

ITEM NO.8: Rewrite following incorrect words (underlined> by replacing them with correct ones.

- i) $9xy$ is an algebraic expression which contains three variables.
- ii) $\sqrt{3}y^3 - \sqrt{6}y + \sqrt{7}$ is a polynomial of natural numbers.
- iii) $t^3 + 7xy - 8$ contains five terms.
- iv) Degree of algebraic expression $6x^3 + 3x^2 - 8x + 10$ is six.

(Please turn over)

ITEM NO.9: Simplify the following expressions by showing calculations and write their answers at specified places:

- $64^{1/2} = \text{-----}$

- $64^{2/3} = \text{-----}$

- $64^{-1} = \text{-----}$

Hence, with the help of above calculations, find the value of P (64)

$$\text{If } P(t) = 2t^{1/2} - 4t^{2/3} + 32t^{-1} + 2$$

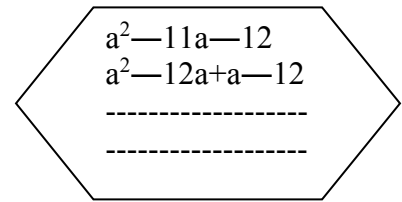
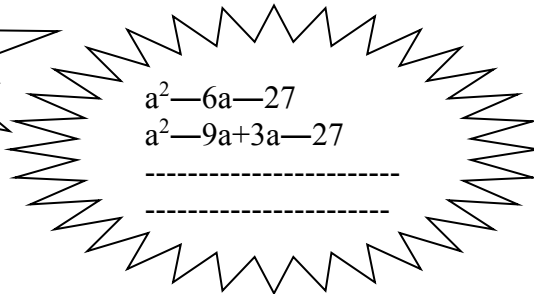
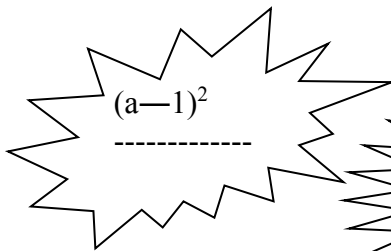
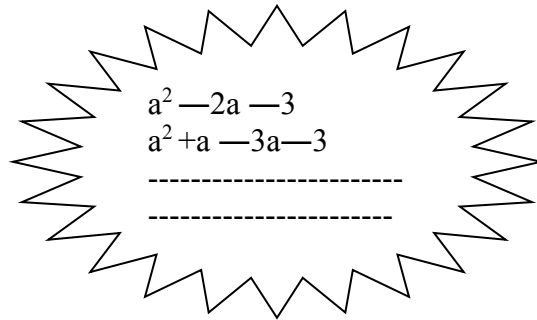
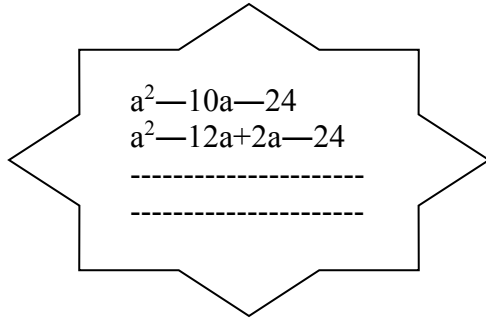
ITEM NO.10: (a). Fill in the blanks with any four different integers of your choice:

$$P(x) = (\text{---})x^4 + (\text{---})x^3 - (\text{---})x^2 - (\text{---})x + 5$$

(b). Now verify whether $x+1$ is a factor of $P(x)$ or not?

(Please turn over)

ITEM NO.11: (a). Complete the blanks by factorizing algebraic expressions given in the following shapes:



(b). By using the factorization of above algebraic expressions, simplify the following algebraic fraction:

$$\frac{a^2 - 10a - 24}{a^2 + 2a - 3} \div \frac{a^2 - 11a - 12}{a^2 - 6a - 27} \times \frac{a - 9}{(a - 1)^2}$$

(Please turn over)

ITEM NO.12: (a). Fill in the blanks of following two blocks first.

$$4x^2 = (\text{-----})^2$$

$$25y^4 = (\text{-----})^2$$

Hence, by using a suitable formula, factorize $4x^2 - 25y^4$

(b). Now fill in the following blanks:

- $1000^2 - 999^2 = \text{-----}$
- $151^2 - 149^2 = \text{-----}$

ITEM NO.13: If A, B, C and D four algebraic expressions which have the following characteristics:

A= Algebraic expressions which can be factorized by using the formula of $a^3 - b^3$

B= Algebraic expressions which can be factorized by using the formula of $a^3 + b^3$

C = Algebraic expressions which can be factorized by using the formula of $a^3 + b^3 + c^3 - 3abc$

D = Algebraic expressions which cannot be factorized by using any of the above three formulae

Some algebraic expressions are given in second column. Tell the types of these expressions by ticking under A or B or C or D whichever is correct.

S.Nos.	Algebraic Expressions	A	B	C	D
1	$125c^3 + 64d^3$				
2	$a^3 - 9b^3$				
3	$x^3 - y^3 - z^3 - 3xyz$				
4	$2t^3 + 54$				
5	$a^3 + b^3 - c^3 - 3abc$				
6	$8a^3 - 343f^3$				

(Please turn over)

ITEM NO.14: Look at the solution of square root of an algebraic expression below. Here are some blanks, shown by ----- and some mistakes in calculations. Complete all such blanks and correct all such mistakes.

$$\begin{array}{r}
 2x^2+6x \text{ -----} \\
 \hline
 \text{-----} \quad 4x^4-20x^3+x^2+60x+36 \\
 \quad \underline{4x^4} \\
 \hline
 4x^2 \text{ -----} \quad -20x^3+x^2+60x+36 \\
 \quad \quad \quad \underline{-20x^3+-----x^2} \\
 \quad \quad \quad + \\
 \hline
 4x^2-10x+6 \quad -20x^2+60x+36 \\
 \quad \quad \quad \underline{-24x^2+70x+36} \\
 \quad \quad \quad + \quad \quad \quad \underline{\quad \quad \quad}
 \end{array}$$

Hence $\sqrt{4x^4-20x^3+x^2+60x+36} = \pm (\text{-----})$

ITEM NO 15: Write any two different natural numbers of your own choice in the following blanks.

If first polynomial = $(x+4)(x- \text{-----})$

Second polynomial = $(x- \text{-----})(x+4)$

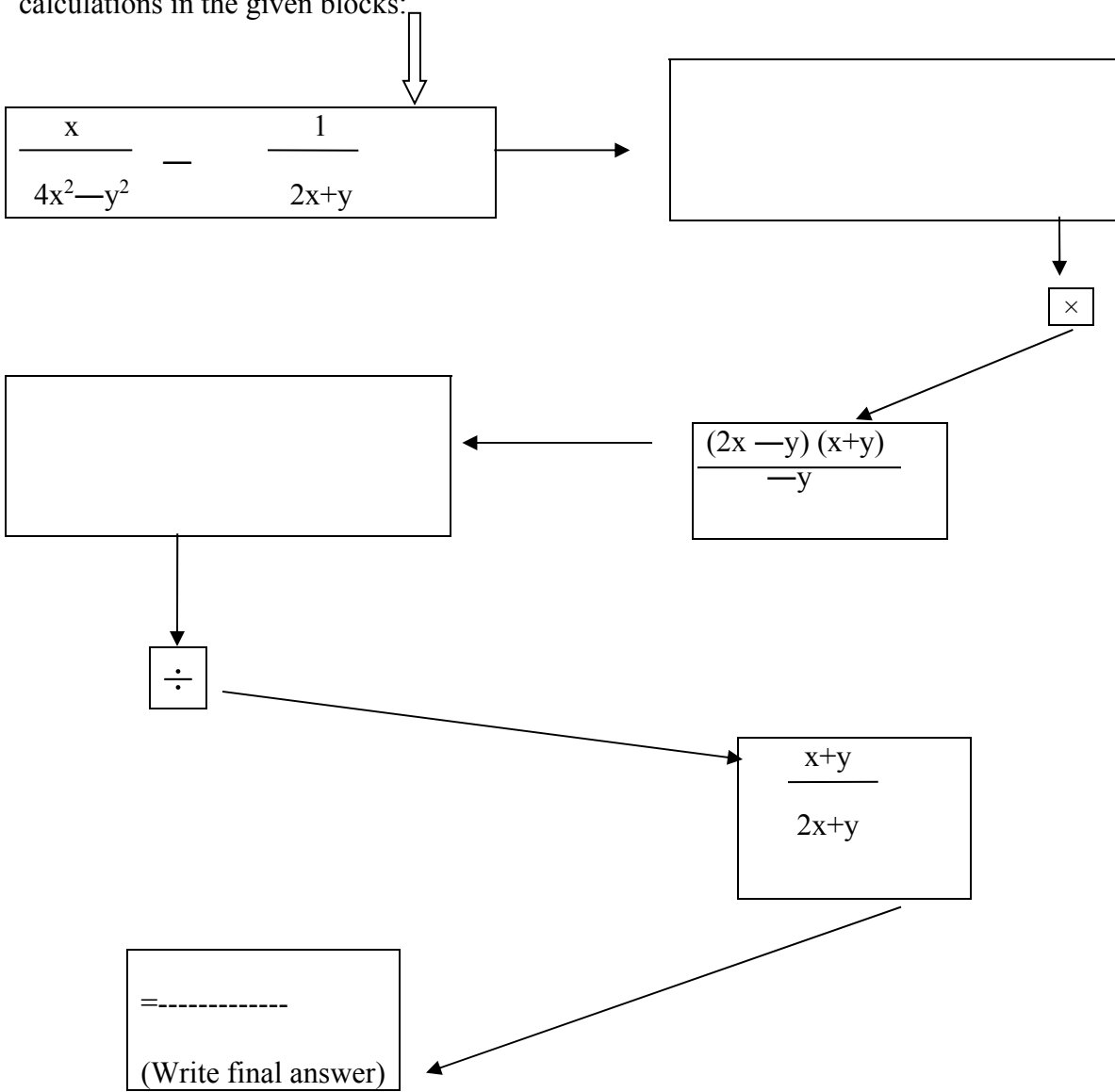
Calculate H.C.F and L.C.M of above polynomials and write the answers in the following blocks.

H.C.F=-----

L.C.M=-----

(Please turn over)

ITEMNO.16: Complete the flow chart by moving along the arrow (\rightarrow). Show all calculations in the given blocks:



THE END

APPENDIX F

RUBRICS FOR PRE/POST TEST (TOOL OF STUDY)

Item No.	Details of marking scheme	Total marks	Time Required in minutes
1	For parts i and ii, award 1 mark for each correct fill in blank	8	6
2	For each true response, award 1 mark	6	4
3	Each true filling= 1 mark Each true calculation= 1 mark	6	4
4	Putting correct values= 3 marks Calculation of answer = 2 marks Writing answer in lowest fraction= 1 mark	6	4
5	Writing name= 1 mark Calculation of parts a, b, c, d and f = 1 mark each Calculation of part e = 2 marks Showing correct result= 1 mark	8	6
6	Filling each blank correctly= 1 mark	4	3
7	Calculation of product= 2 marks Finding product by formula= 1 mark Subtracting correctly= 2 marks Writing right/ wrong correctly= 1 mark	6	4
8	Correcting each underlined word= 1 mark	4	3
9	Each of three calculations= 2 marks Finding P (64)= 2 marks	8	6
10	(a). Writing four different integers= 2 marks (b). Verifying for factor by any method= 4 marks	6	4
11	(a). Completing each blank of each of five blocks= 1 mark (b). Simplification= 3 marks	8	6
12	(a). Filling each of two blocks= 1 mark each, Factorizing with help of formula= 2 marks (b). Filling each of two blanks= 1 mark each	6	5
13	Each correct ticking= 1 mark	6	5
14	Filling each of five blanks= 1 mark each Correcting each of three mistakes= 1 mark each	8	6
15	Writing each natural number correctly= 1 mark each Finding H.C.F.= 1 mark Finding L.C.M.= 1 mark	4	3
16	Calculation for each of three blocks= 2 marks each	6	6
		Total score = 100	Total time = 75 minutes

APPENDIX G

LIST OF EXPERTS

Prof. Dr Maqsood Alam Bokhari, Principal College of Liberal arts and Sciences, Foundation University, New Lalazar, Rawalpindi

Mr. Mushtaq Ahmad, Vice Principal FGBMS F-8/3 Islamabad & PhD (Education) Research scholar, IER Punjab University, Lahore.

Mr. Javed Awan, Principal Govt. Muslim Higher secondary school, Rawalpindi, Head examiner, Sub examiner in Board of Intermediate & secondary Education, Sargodha and Rawalpindi

Mr. Mushtaq Ahmad Sial Senior Subject Specialist, Govt. College of elementary teachers, Rawalpindi, Head examiner & Sub examiner in Board of Intermediate and secondary Education, Sargodha and Rawalpindi

Mr. Sher Zaman, vice Principal FG Boys Higher Secondary School, Rawat Islamabad, PhD (Education) Research scholar, IER Punjab University, Lahore

Mr. Sultan Sikandar, Subject Specialist (Mathematics), Govt. higher secondary school Kundian (Mianwali), Punjab, working teacher, Head examiner & Sub examiner in Board of Intermediate and secondary Education, Sargodha

Mr. Shafqat Hussain, Senior Subject Specialist, Govt. College of elementary teachers, Mianwali (Punjab), PhD (scholar), Paper setter, Head Examiner, Board of intermediate and secondary education, Sargodha, Working with University of Education, Lahore

**A LESSON PLAN IN THE PERSPECTIVE OF BRAIN-BASED
LEARNING (BBL) METHOD**

Unit name	<p>CHAPTER 2</p> <p>“SYSTEM OF REAL NUMBERS”</p> <p>Sub-topics: 1.Properties of real, rational and irrational numbers 2.Square root & qth root, 3. Surds, 4.Exponents and its laws, 5. Rational exponents</p>
Lesson Title	2.Square Root & q th Root
Lesson Author	Aziz-ur-Rehman
Grade Level / Subject Area	Grade / Level: 9/ secondary Subject: Mathematics
Time Allotted For Lesson	120 Minutes. The complete lesson will be taught in 3 periods. Each period has a duration of 40 minutes.
Short Description of Lesson	<p>Under this second sub-topic of the unit, following concepts are included:</p> <p>Calculation of square root</p> <p>Addition, subtraction and multiplication of expressions involving square root</p> <p>Radicands and indices</p> <p>Cube, 4th, 5th, 6th and 7th root</p>
Classroom Layout and Grouping of Students	<p>1). There are 30 students in the class. This is an experimental group which contains 10 students each taken from high (HAs), average (AVs) and low achievers (LAs).</p> <p>2). The 30 students will be divided into 5 small groups. Each group comprises of 6 members such that two students will be taken randomly each from HAs, AVs and LAs. In this way, 5 heterogeneous groups of mixed abilities will be formed. The groups are named randomly as A, B, C, D, E and F.</p> <p style="text-align: center;">(Continued) (Please turn over)</p>

<p>Classroom Layout and Grouping of Students</p>	<p>3). Teaching learning sessions will take place in the specified room designed for the purpose and maximum space of the classroom is utilized for learning purposes.</p> <p>4). For most of the time, the teacher will conduct teaching learning sessions in groups with the help of posters, worksheets, pictures, diagrams, flowcharts and printed material. Self-exploring capability of students will be encouraged at maximum. To propagate general rule or a fundamental formula, instruction may be imparted collectively.</p>
<p>Instructional Objectives</p>	<p><u>General objectives:</u> The general objectives of this lesson will be to:</p> <ul style="list-style-type: none"> ○ Organize a brain drill for the students to create an enriched environment consistent with the principles of Brain-Based Learning (BBL) method ○ Develop “low threat and high challenge” states of brain among learners studying at secondary level ○ Minimize the role of rote-learning and maximize benefiting from thinking brain for inculcation of mathematical concepts ○ Design a brain compatible modus operandi to teach mathematics <p><u>Specific objectives:</u> After going through this lesson , the students will be able to:</p> <ul style="list-style-type: none"> ➤ Understand the concepts and fundamental laws related to square root & q^{th} root in a brain friendly teaching learning environment ➤ Solve mathematical & real-life problems concerning with properties of square root & q^{th} root by using principles of BBLtheory ➤ Apply brain-based teaching-learning techniques to explore problems related to square root & q^{th} root given in the exercises of mathematics text-book for 9th graders
<p>Materials</p>	<p>Textbook, charts containing balanced diet and diagram of human brain , posters and different sizes and colors, classroom worksheets, classroom notice board, displaying materials, colorful markers, plants, aromas, water bottles</p> <p>(Please turn over) (Continued)</p>

**Optimal
Brain-
Compatible
Environment
For
Classroom**

i). Following strategies show how five principles of BBL theory will be applied during cognitive exercise of teaching-learning session by the teacher.

S.Nos.	Principles (BBL theory)	Teaching learning Strategies
1	P ₁	Solving by diagrams, Finding mistakes, Doing corrections, Judging similarities and differences between mathematical concepts etc
2	P ₃	Making use of familiarity of students, Creating novelty in teaching materials, Reflecting previous knowledge of students during classroom teaching, Exploring by fitting new content into previously related concept etc
3	P ₄	Encouraging students to explore, Ensuring students to have says in the classrooms, Praising innovative approaches, Unfolding riddles, Solving real-life problems, Conducting discussions, Concretizing abstract concepts etc
4	P ₆	Breaking mathematical problem into parts, Integrating parts into wholes, inductive and deductive reasoning etc
5	P ₁₂	Individual tasks, Availability of choices, Incorporating related reflections of students into teaching content etc

P₁: The brain is a parallel processor.

P₃: The search for meaning is innate.

p₄: The search for meaning occurs through “patterning”.

P₆: Every brain simultaneously perceives and creates parts and wholes.

P₁₂: Every brain is unique.

ii). The remaining seven principles were applied either strategically or through generation of enriched environment. Following table depicts different strategies organized by the teacher to apply the seven principles.

(Please turn over)

(Continued)

**Optimal
Brain-
Compatible
Environment
For
Classroom**

S. Nos.	Principle (BBL theory)	HOW TO APPLY IN CLASSROOMS
1	P ₂	Displaying balanced diet chart, Encouraging students to bring water bottles with them, Giving hygienic tips periodically
2	P ₅	Creating cheerful environment within classroom through brain energizers & jokes, Using soothing colors like green, blue & brown, Playing music if students feeling boredom, Reflection of students' interests in lesson, Using praising words, etc
3	P ₇	Home assignments, Relating mathematical concepts with real-life situations, individual tasks, group discussions, Solving problems given in lesson sets, Exploring similarities and differences between two mathematical concepts, Assuring students of having says in the classroom etc
4	P ₈	Appreciating innovation, Acknowledging ambiguities of students, Giving adequate down time & pauses to process information, Organizing group discussions, Arranging suitable breaks, Motivating students to self-explore, Displaying accomplished assignments of each group in classrooms, Encouraging students to ask questions & facilitating other students to answer them etc
5	P ₉ & P ₁₀	Generation of safe & friendly environment (Details are given in part iii), Presenting meaningful content, Fitting new ideas into already relevant existing ideas, Reflecting familiarity and novelty in teaching learning materials, Encouraging students to form own patterns, Acknowledging individual differences of students, Keeping smiles on face & allowing students' laughter, Promoting critical thinking etc.
6	P ₁₁	Reducing threats through friendly environment, Daily agendas, physical activities, sarcasms free jokes and teacher's friendly attitude towards students; exploration of ideas, home assignments, unfolding riddles, solving problems related to real life situations & appreciation of innovative thinking of students, classroom competition of various kinds, Quizzes etc.

**Optimal
Brain-
Compatible
Environment
For
Classroom**

iii). Teacher uses BBL techniques of orchestrated immersion, relaxed alertness and active processing to facilitate brains of the learners with an environment where brains can function naturally. To do so, an enriched environment will be generated with the help of plants, colours, music, air fresheners, oxygenated classrooms, water facilitation, balanced diet charts, notice boards, typical seating arrangement and humor in the following ways:

- ❖ Classroom is decorated with vases of plants and flowers which are placed at scattered places of the whole classroom so that Students would enjoy the soothing impact of plants and flowers. The plants and flowers may be helpful in reduction of threat and negative stress levels of learners.
- ❖ Air fresheners will be used periodically as and when required to refresh the students and create a brain-compatible, relaxed and threat free environment.
- ❖ Particular colors shape students' attitudes and behaviors and promote learning. To enhance students' attention span and promote positive feelings about school, a multicolored classroom is arranged with brain-compatible colours i.e. green, blue and brown, where greens and blues are calming colours and shades of brown are reassuring and helpful in learning.
- ❖ A light music (in the form of "*daff*") maybe played on few occasions only during teaching-learning interactive session to facilitate human brain with a soothing taste and catalyze the learning mechanism. This maybes done by the help of a mobile phone which is set at an audible tone within the classroom only.
- ❖ Classroom is airy and properly ventilated. Such oxygenated room will be helpful in casting positive influence on learning.
- ❖ The brain needs maximum amount of water comparatively than all other parts of human body and it inhibits its normal functioning in dehydrated states. To serve need of water, students were encouraged to bring water bottles with them and use them instantly to quench thirst. For the first day, such bottles were provided by the teacher.
- ❖ Balanced diet charts and notice boards are displayed in classroom at a readable height. Diet chart would guide students to take such food which may maintain

	<p>their physical health and notice board is used to write classroom agendas, individual or group comments, announcements, reflections of students and complaints about anyone in the classroom.</p> <ul style="list-style-type: none"> ❖ The 30 students were divided into five groups such that every group comprised of two members each taken from high achievers, average and low achievers. These five groups were arranged to sit in U-shaped form facing one another and the teacher as well. ❖ Humor helps in creating a positive environment and minimizes the teacher-student distance. Such sober and sarcasm free humor, in the form of jokes and funny stories, will be encouraged which would keep the environment cheerful.
<p>Pre-Requisites For a Brain-Compatible Classroom</p>	<ul style="list-style-type: none"> ➤ U-shaped seating arrangements are arranged in BBL classroom and students would sit in their respective groups. ➤ Classroom agenda should be written on notice board by students after discussing with each other during first five minutes or the same maybe written by the teacher with the help of suggestions of the class. Students will be encouraged to give suggestions in preparing agenda. ➤ Feedback is taken through on-the-spot assignments, question-answer sessions, quizzes, homework and individual & group work. ➤ First five minutes of every period is reserved for a simple physical activity and students' visit to notice board and giving suggestions to teacher standing nearby. Each student would submit home assignments to the teacher soon after entering classroom and teacher returns them on next day with suitable guidance.

PERIOD 1

Following teaching-learning activities & strategies will be introduced in the brain-based teaching learning classroom by the teacher to accomplish this lesson plan.

Instructional Procedures

a. Lesson Set: Teacher will present following two real life situations written on five colored placards.

“A teacher asks a class to sit in 6 rows and each row must contain 6 students. What is total number of students in that class?”

$$\begin{array}{l} \boxed{6 \times 6 = 36} \\ \Rightarrow \boxed{6^2 = 36} \end{array}$$

“Length, breadth and height of a cubical room is 15 ft each. Find volume of this room?”

$$\begin{array}{l} \boxed{15 \times 15 \times 15 = 3375 \text{ ft}^3} \\ \Rightarrow \boxed{15^3 = 3375 \text{ ft}^3} \end{array}$$

Each group will be asked to read placard carefully and note information which each group gets through reading of solution. The teacher will announce a time of 5 minutes after which he gathers group reflections. With that he will actively put students on thinking and discussing within groups about the poster. Students will be encouraged to explore the following conclusions.

❖ **6 is square root of 36**

❖ **15 is cube root of 3375**

Teacher will encourage students to give identical ideas, prepare other real life situations, share critical remarks and criticize positively on points of views given by any student of any group. The teacher will sum up the discussion and let students turn to the direction of the topic of lesson.

(13 minutes)P₁,P₃,P₁₂

b. Individual task: After ensuring the focus of students on the topic of the day, teacher will further distribute worksheets to all students on which the following table will be given. Each student will be assigned to develop three such examples, by

Instructional Procedures

multiplying any number by 4 times and another number by 5 times and write the solution just like the pattern of given worksheet. Students will display their tasks on walls. **(10 minutes) P₁,P₃,P₁₂**

$$4 \times 4 \times 4 \times 4 \times 4 \times 4 = 4^6$$

$$\Rightarrow 4096 = 4^6$$

$$\Rightarrow (4096)^{1/6} = 4$$

$$\Rightarrow \mathbf{4 \text{ is } 6^{\text{th}} \text{ root of } 4096.}$$

c). Brain energizer(3):

Each group will be provided with 15 slips of paper. Numbers 2,3,4,5 and 6 will be written on five of the slips of paper whereas 9, 16,25, 27,36, 64, 81, 125,216 and 256 will be written on other ten slips of paper. A draw competition will be conducted within each group. For this purpose, each group will be required to pick ten slips out of 15. the rest of slips will be taken back immediately. Now students will be encouraged to count as maximum relations as possible between the numbers written on 10 picked papers with respect to root of a number. Teacher will announce the best performance of a particular group on the basis of maximum number of such relations at the end.

(7 minutes) P₄

d. Each student will be provided with two cards on which following problems will be given. One of the cards will contain a solved problem. Its solution will be explored by the teacher with the help of class collectively. The students will be encouraged to solve the problem given on the second card.

(4minutes) P₁,P₆,P₁₂

Instructional Procedures

$$\begin{aligned}\sqrt{72} &= \sqrt{(2.2.2.3.3)} \\ &= 2.3. \sqrt{2} \\ &= 6 \sqrt{2}\end{aligned}$$

$$\begin{aligned}\sqrt{135} &= \text{-----} \\ &= \text{-----} \\ &= \text{-----}\end{aligned}$$

e. Individual home assignments:

Students will be assigned to solve Q.Nos. 1-10 of Exercise 2.1 on separate pages and bring the pages tomorrow with them. **(1 minute)P₁₂**

END OF FIRST LESSON PLAN

START OF SECOND LESSON PLAN

PERIOD 2

Following teaching-learning activities & strategies will be introduced in the brain-based teaching learning classroom by the teacher to accomplish this lesson plan.

f. Lesson set: Teacher will distribute a worksheet in each group of the class containing following riddle and encourage them to solve and then paste its solution at the specified places of the room with a challenging voice of “Who solves and pastes first.” **(3 minutes) P₃**

“If $\sqrt{25}$ men, $(64)^{1/3}$ children and $32^{1/5}$ women are sitting in a bus, how many persons are there in the bus altogether”

Instructional Procedures

Continued on next page

= -----persons

g. Teacher will relate the above riddle with the coming concept and elaborate the importance of such surds in practical life. To do so, teacher will organize following activities:

The basic rules for multiplication, addition and subtraction of algebraic expressions involving square root will be explored with the help of previous knowledge of the students. Discussion method will be applied. Teacher will anchor the situation and will conclude each rule by solving one or two examples for each concept.

After creating understanding of the stated concepts, each student will be given a worksheet and teacher will write three simple problems on whiteboard related to the three stated concepts and motivate students to apply those rules and solve them on given worksheets.

Students will be asked to hand over their solved worksheets in clock-wise order within the group during a maximum time of 3 minutes. Now teacher will distribute the solution chart and rubric in each group and ask all students to start scoring solved answer sheets and return back to concerned student after scoring (each example carries 3 marks). In this way, each student will know about his performance instantly. At the end, teacher will encourage comments or reservations of any of the students about the said practice and listen to the viable objections. **(12minutes) P₆,P₁₂**

Brain energizer(4): Teacher will ask all students to stand up and take long breath for 4-5 times. **(1 minute)**

Instructional Procedures

h. Peer tutoring session: Teacher will distribute following chart that contains five mathematical problems about the stated concepts. The chart depicts the nature of responsibilities of each group. Each group has to select its best representative to perform the assigned peer tutoring task in the form of presentation on the whiteboard of the classroom. Each group will be encouraged to prepare a comprehensive solution of the assigned task prior to present it. All other students will also be requested to note down their observations or suggestions about presentations of other groups and hand over their reflections to teacher who will be busy in doing so during the presentations.

(18 minutes) P₃,P₁₂

ASSIGNMENT OF GROUP B

Send your one representative who solves the following problem and explains each step with the help of rules involved in the solution.

(Time: 2 minutes)

$$6\sqrt{7} + 5\sqrt{7} + 11\sqrt{7}$$

Instructional Procedures

ASSIGNMENT OF GROUP E

Send your one representative who solves the following problems and explains each step with the help of rules involved in the solution.

(Time: 5 minutes)

1. $\sqrt{t} \times \sqrt{t}$
2. $\sqrt{6} \times 2\sqrt{8} \times \sqrt{2}$

ASSIGNMENT OF GROUP C

Send your one representative who solves the following problem and explains each step with the help of rules involved in the solution.

(Time: 5 minutes)

$$(4\sqrt{6} + 5\sqrt{6} - 7\sqrt{6}) \times 5\sqrt{3}$$

ASSIGNMENT OF GROUP D

Send your one representative who solves the following problem and explains each step with the help of rules involved in the solution.

(Time: 2 minutes)

$$6\sqrt{11} - 5\sqrt{11} - \sqrt{11}$$

ASSIGNMENT OF GROUP A

Send your one representative who solves the following problem and explains each step with the help of rules involved in the solution.

(Time: 4 minutes)

$$(2\sqrt{9} + 5\sqrt{9}) \times \sqrt{10}$$

i. The individual task will be assigned to each student from the textbook. Students will be motivated to solve Q.Nos. 11-20 of exercise 2.1 on assignment pages and submit them tomorrow. **(1minute) P₁₂**

END OF 2ND LESSON PLAN
START OF 3RD LESSON PLAN

PERIOD 3

The teacher will facilitate the students with the following brain friendly activities.

Instructional Procedures

j. Lesson set: Students know that a bicycle has different parts like wheels, seat, handle, paddle etc. Students will explore that sum of the stated parts is named as a cycle. Students will be encouraged to reflect on the same sense for algebraic expressions containing qth root of surds. He will disclose the terms radicand and index by linking them with the stated expressions. Teacher will further explain the concept of radicand and index with the help of three examples and thereafter each group will be assigned to construct two such expressions from themselves and write radicand and index of each on worksheet. Teacher will rotate in groups to monitor the assigned task.

(4minutes) P₆

k. Teacher will elaborate square root, cube root, 4th, 5th, 6th, 7th, 8th and 9th roots of real numbers and for algebraic expressions by adopting following instructional strategies.

- ❖ Exemplifications for simple and easy-to-calculate expressions
- ❖ Actual multiplication methods: Teacher will assign multiplication task to some students and thereupon explore the concept of roots.

e.g. $18 \times 18 = \text{-----}$, $12 \times 12 \times 12 = \text{-----}$, $7 \times 7 \times 7 \times 7 = \text{-----}$ etc

- ❖ By prime factorizations: Teacher will assign task of making prime factorization to some students randomly and collect true response from them.

e.g. prime factorization of 4096 to give concept of 4th or 6th root etc

(11 minutes) P₃

Brain energizer(5): Teacher will invite each group to write name of the favourite character on notice board and motivate each group to imitate their favourites.

(2 minutes)

Instructional Procedures

l. Teacher will distribute 30 brown posters to each student. Each poster will contain the two blocks in which complex algebraic expressions are given. Students will be encouraged to complete the solution of the problems of blocks given below:

(10 minutes) P₁, P₄, P₆, P₁₂

$$(m^8)^{1/4} = (\underline{m.m.m.m.m.m.m.m})^{1/4} = \text{-----} = \text{-----}$$

$$(n^{12})^{1/4} = (\underline{n.n.n.n.n.n.n.n.n.n.n.n})^{1/4} = \text{-----} = \text{-----}$$

$$16^{1/4} = (2.2.2.2)^{1/4} = (2^4)^{1/4} = \text{-----}$$

$$81^{1/4} = \text{-----} = \text{-----} = 3$$

Using solutions of above given blocks, simplify the following algebraic expressions in simplified form:

(7 minutes) P₁, P₄, P₃, P₆

$$\left(\frac{16 n^{12}}{81 m^8} \right)^{1/4}$$

m. Homework: Solve Q.Nos. 6-12 of exercise 2.2 on assignment pages and submit on tomorrow. _

(1minute) P₃, P₁₂

**Students'
Products**

1. Self-exploring textbook exercises 2.1 and 2.2 on the basis of classroom performances done in group or individual work
2. Unfolding riddles
3. Group discussions and Individual reflections
4. Various physical activities
5. Displaying a variety of mathematical tasks
6. Exploring real life situations of lesson sets
7. Maintaining classroom notice board
8. Preparation of daily agenda
9. Tasks done on worksheets

**Classroom
Layout and
Grouping of
Students**

treated as a single group.

3). Teaching learning sessions will take place in a classroom like other classrooms of school and whole room will not be utilized for learning purposes. In stead, whiteboard and space for seating of students is utilized for teaching purpose. Teacher would write on whiteboard and coerce students to write it verbatim on their notebooks.

4). For maximum of the time, the instruction is delivered collectively with the help of whiteboard. Individual instruction is rarely given.

**Instructional
Objectives**

General objectives:

The general objectives of this lesson will be to:

- ❖ Develop skill of solving mathematical problems among students through memorization
- ❖ Create capability among students to reproduce problems given in mathematics text-book at secondary level in the subject of mathematics
- ❖ Enable students to go through annual examination held under federal board of intermediate and secondary education, Islamabad
- ❖ Habituate students to listen a teacher and understand information under the instruction of teacher

Specific objectives:

After going through this lesson , the students will be able to:

- ❖ Understand and reproduce the concepts and fundamental laws related to Square Root & q^{th} Root through solution of problems by the teacher
- ❖ Solve the problems/examples included in textbook exercise about properties of Square Root & q^{th} Root by using conventional lecturing approach

	<p>❖ Finish the portion of syllabus given in scheme of studies</p>
Materials	Textbook, worksheets and writing instruments
Optimal Conventional Environment For Classroom	<ol style="list-style-type: none"> 1). A neat classroom is required which would be airy and well-lit. 2). Walls of classroom were already decorated with charts of different subjects which were pasted at a height out of reach for students. 3). There should be a lecture dice, seating chair for the teacher and a whiteboard. 4). There are fixed seating arrangements for the students.
Pre-Requisites For a Conventional Classroom	<ul style="list-style-type: none"> • Row wise seats are arranged in a conventional classroom and students are to sit at their fixed or teacher-allotted positions in a back to back posture. • The agenda of class is never discussed with students. In stead, teacher decides himself the plan of action. • First five minutes of every period are reserved for roll call and collection of notebooks for checking purposes.
Instructional Procedures	<p style="text-align: center;"><u>PERIOD 1</u></p> <p>Following teaching-learning activities are introduced in the conventional classroom by the teacher to accomplish the lesson plan.</p> <p><u>Lesson Set:</u> Teacher will ask students to open mathematics textbook at page No. 29 where examples/deducted rules are given. Teacher will explain all the same by writing solutions on blackboard. He will also perform following activities.</p>

Instructional Procedures

- Asking forcibly all students to copy one by one all solutions written on whiteboard
- Writing on whiteboard all concerning rules as they are given in text-book
- Explanation with the help of some examples and students writing them on whiteboard
- Showing resentment/anger/displeasure on
 - a) poor attention
 - b) copying slowly/ imperfectly/ differently
 - c) talking/laughing with one another
 - d) making mistakes
 - e) questioning during teaching or writing sessions
 - f) Seeking permission to have water during teaching session by the students. **(20 minutes)**

Teacher will ask all students to give a tight look to above solved examples/rules within 5 minutes. After 5 minutes, teacher will order all class to be attentive to note down the solution of problems given in text-book. Teacher will solve most of problems given in textbook at page No. 29. **(15 minutes)**

At the end, teacher will assign students to reproduce classroom tasks in written form on notebooks. **(1 minute)**

PERIOD 2

Following activities and strategies are introduced in the conventional teaching learning classroom by the teacher to complete this lesson plan.

Lesson set: Teacher will ask about difficulties or confusions related to previous topic. But if students pinpoint some of actual difficulties faced by them at home, teacher will adopt following techniques to resolve them:

Instructional Procedures

- Solving the problem on whiteboard hastily at the name of time saving
- Solving such questions either incompletely or through oral guidance
- Rejecting some easy looking problems sarcastically
- Denying to solve such problems which had already been solved yesterday
- Realizing students about consumption of time of period in mere previous task
- Punishing on asking problems, having remote resemblance with the topic **(5 minutes)**

a). Teacher will ask students to open books at page No. 30. (Pause) Teacher will start solving exercise 2.1 from page No. 30. Following activities will be performed by him:

1. Writing, one by one, solutions of all the problems 1-21 on whiteboard
2. Explaining main steps of each question only
3. Tallying answers of each problem with the text- book at specified page
4. Discouraging harshly to all such students who aren't reproducing from whiteboard, who are talking with one another, laughing or smiling, wanting to go out for drinking water or for some other genuine reasons etc
5. Encouraging and hailing all students who copy solutions of problems verbatim from whiteboard. **(29 minutes)**

b). Homework: i) Teacher will ask all students to rewrite solutions of all problems of exercise 2.1 on neat notebooks and submit them tomorrow.

ii) Teacher will assign a test of exercise which will be administered by him on tomorrow. **(1 minute)**

Instructional Procedures

PERIOD 3

a). Teacher will administer a test during this period by performing following activities.

1. Including such items in the test which were given within relevant exercises of textbook only or in examples
2. Threatening students on showing bad performance in the test
3. Discouraging physical movement of the students during solving test items **(10 minutes)**

b). Soon after the test is over, teacher will give a brief introduction of q th root of x with the help of page No. 30 of textbook. **(5 minutes)**

c). After explaining about q th root of x , teacher will ask students to open textbooks at page No. 31. (pause) Teacher will start solving exercise 2.2 with the help of following activities.

1. Writing solutions of maximum of problems 1-14 himself on whiteboard
2. Bounding students to take notes of all solutions
3. Explaining main steps of each problems only
4. Tallying answers of each problem with the text- book at specified page
5. Discouraging harshly to all such students who aren't reproducing from blackboard, who are talking with one another, laughing or smiling, wanting to go out for drinking water or for some other genuine reasons etc
6. Encouraging and hailing all students who copy questions verbatim from blackboard. **(19 minutes)**

Homework: Teacher will ask all students to write solutions of problems

	of exercise 2.2 on neat notebooks and submit them tomorrow. (1 minute)
Student Products	Copying textbook exercises 2.1 and 2.2 on notebooks with the help of classroom note-taking

APPENDIX J

SUMMARY OF THE STATISTICAL MEASUREMENTS PERFORMED

S. Nos	Statistical measurements performed	Why to apply	How to apply	What to infer
1	Pearson Correlation r	<ul style="list-style-type: none"> ➤ To check consistence between AES and pre-test scores ➤ To observe groups equivalence prior to start of experiment 	Through SPSS 12	<ul style="list-style-type: none"> ○ To validate the distribution of students into different groups
2	Independent sample t test	<ul style="list-style-type: none"> • To use data of two separate samples to infer mean difference between performance of students taught through BBL and Conventional teaching methods 	Through SPSS 12	<ul style="list-style-type: none"> ▪ Whether the results accept or fail to accept null hypotheses H_0 1 to H_0 8. ▪ To find out Comparative effectiveness of BBL or Conventional teaching method ▪ Whether objectives i, ii and iii of the study are achieved or not?
3	A Two-Way ANOVA	<ul style="list-style-type: none"> ❖ To observe the main effect of first factor i.e. teaching methods ❖ To observe main 	Through SPSS 12	<ul style="list-style-type: none"> ▪ Whether the results accept or fail to accept null hypotheses H_0 9 to H_0 14?

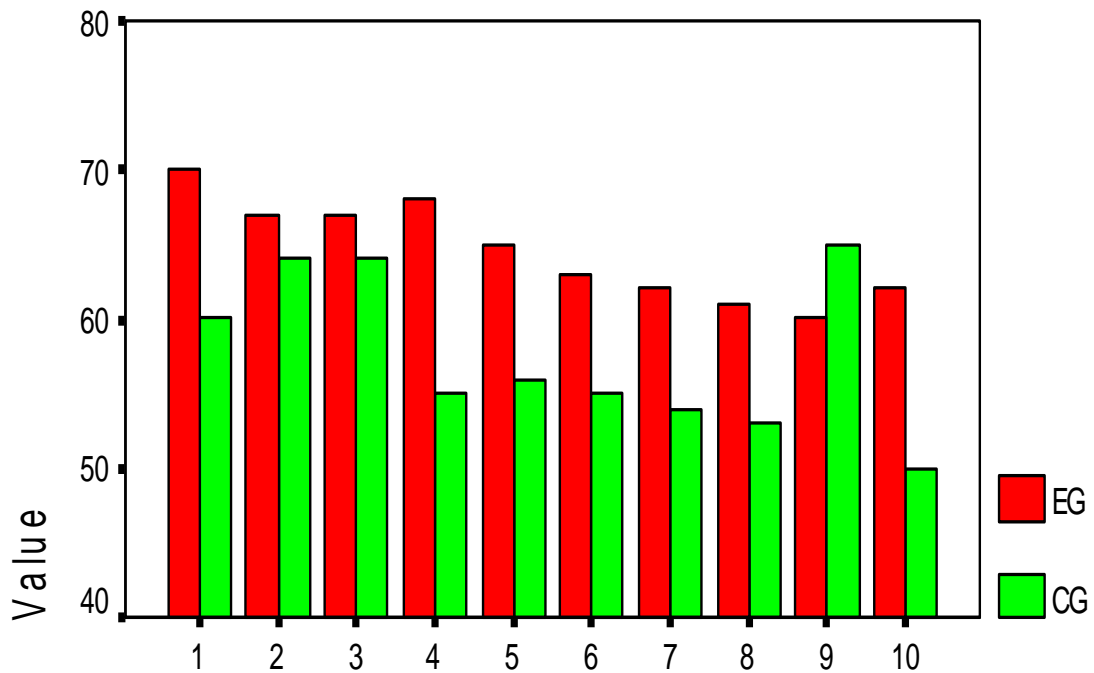
		<p>effect of second factor i.e. academic achievement</p> <p>❖ To investigate about any interaction between the two stated factors</p>	<ul style="list-style-type: none"> ▪ Comparative effectiveness of BBL or Conventional teaching method ▪ Whether objective iv of the study is achieved or not?
--	--	---	---

APPENDIX K

PLOT OF COMPARISON OF THE ACHIEVEMENT SCORES OF HIGH ACHIEVERS IN THE URBAN SCHOOL

comparison of achievement scores

high achievers of urban school



Case Number

eg=experimental group

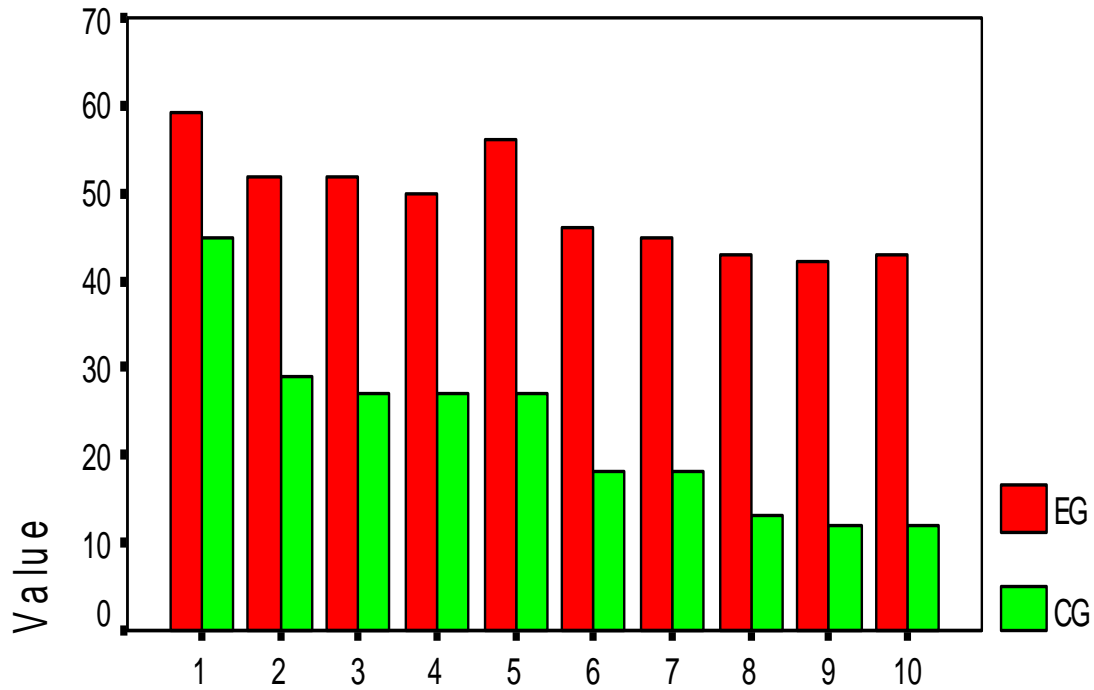
cg=control group

APPENDIX L

**PLOT OF COMPARISON OF THE ACHIEVEMENT SCORES OF AVERAGE
ACHIEVERS IN THE URBAN SCHOOL**

comparison of achievement scores

average achievers of urban school



Case Number

eg=experimental group

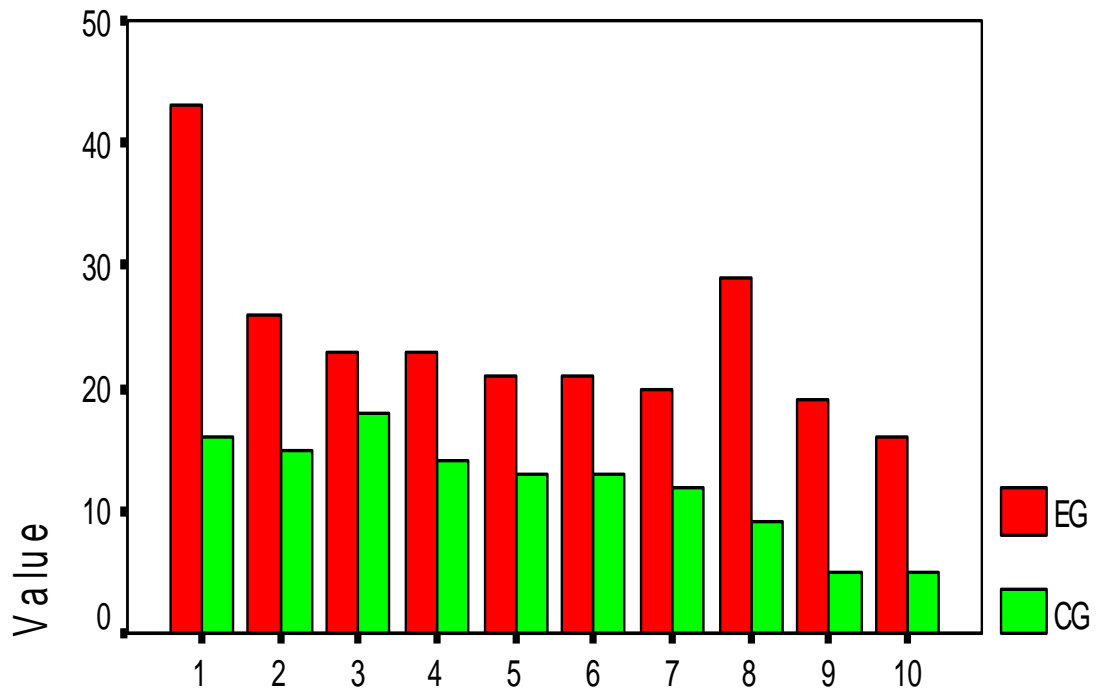
cg=control group

APPENDIX M

**PLOT OF COMPARISON OF THE ACHIEVEMENT SCORES OF LOW
ACHIEVERS IN THE URBAN SCHOOL**

comparison of achievement scores

low achievers of urban school



Case Number

eg=experimental group

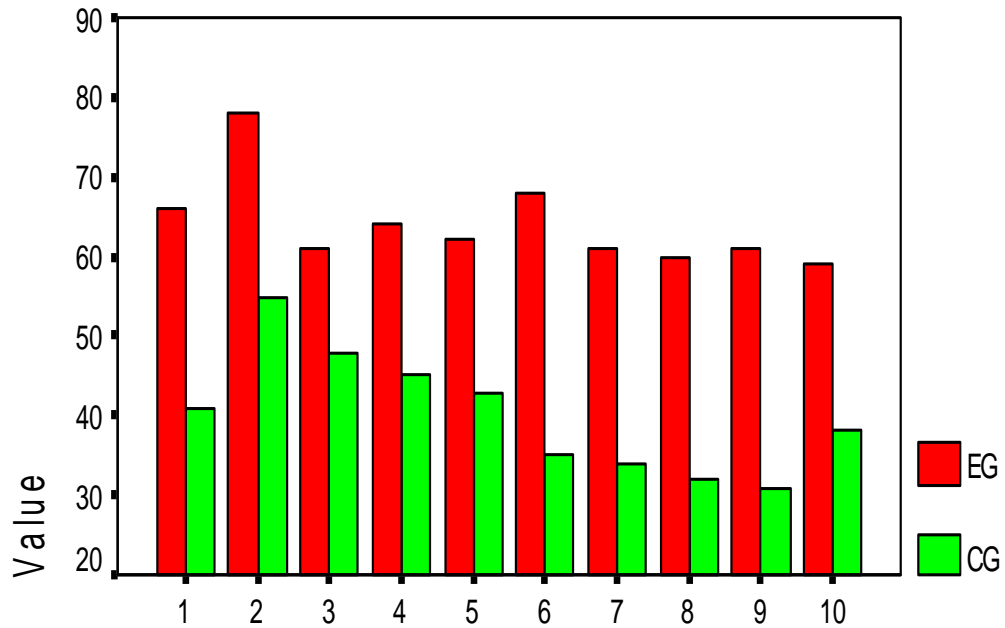
cg=control group

APPENDIX N

**PLOT OF COMPARISON OF THE ACHIEVEMENT SCORES OF HIGH
ACHIEVERS IN THE RURAL SCHOOL**

comparison of achievement scores

high achievers of rural school



Case Number

eg=experimental group

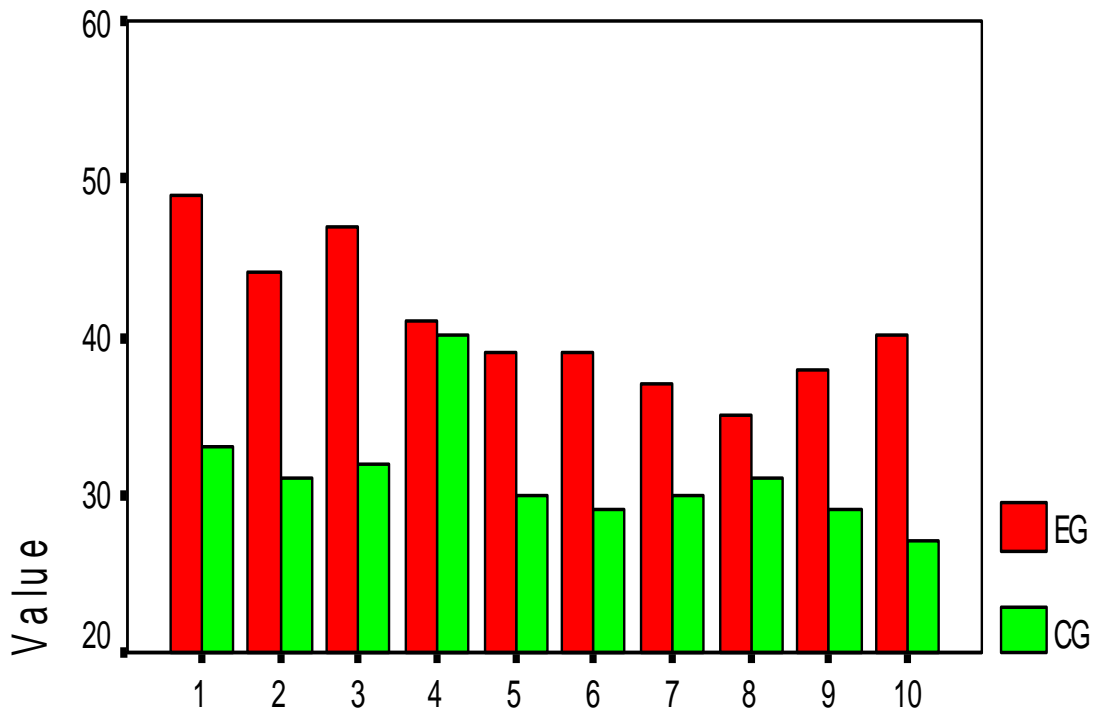
cg=control group

APPENDIX O

**PLOT OF COMPARISON OF THE ACHIEVEMENT SCORES OF AVERAGE
ACHIEVERS IN THE RURAL SCHOOL**

comparison of achievement scores

average achievers of rural school



Case Number

eg=experimental group

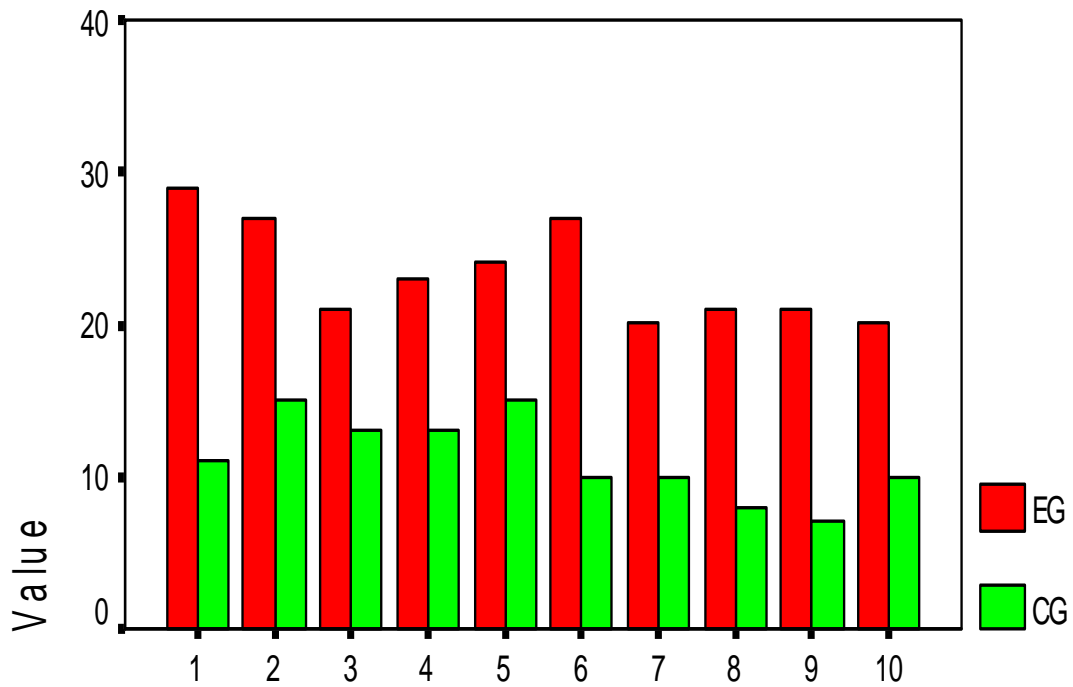
cg=control group

APPENDIX P

**PLOT OF COMPARISON OF THE ACHIEVEMENT SCORES OF LOW
ACHIEVERS IN THE RURAL SCHOOL**

comparison of achievement scores

low achievers of rural school



Case Number

eg=experimental group

cg=control group

APPENDIX Q

**SUMMARY OF DESCRIPTIVE STATISTICS ON PRE-TEST SCORES FOR
THE SELECTED STUDENTS OF RURAL AND URBAN AREAS**

LOCATION	URBAN SCHOOL				RURAL SCHOOL			
	N	M	SD	SE _M	N	M	SD	SE _M
GROUPS OF → STUDENTS								
OVERALL EG ↓	30	13.90	3.8805	.7085	30	13.60	2.7493	.5020
OVERALL CG	30	14.7667	3.8568	.7041	30	13.4667	3.1484	.5748
HAs of EG	10	17.70	2.06	.65	10	16.20	1.32	.42
HAs of CG	10	18.20	1.81	.57	10	16.10	1.66	.53
AAs of EG	10	14.40	1.78	.56	10	13.90	1.91	.60
AAs of CG	10	15.90	2.08	.66	10	14.2	2.30	.73
LAs of EG	10	6.60	2.07	.65	10	10.7	1.4181	.4485
LAs of CG	10	12.20	1.62	.51	10	10.1	1.7288	.5467

HA s= high achievers
 AAs= average achievers
 Las= low achievers
 EG= experimental group
 CG= control group

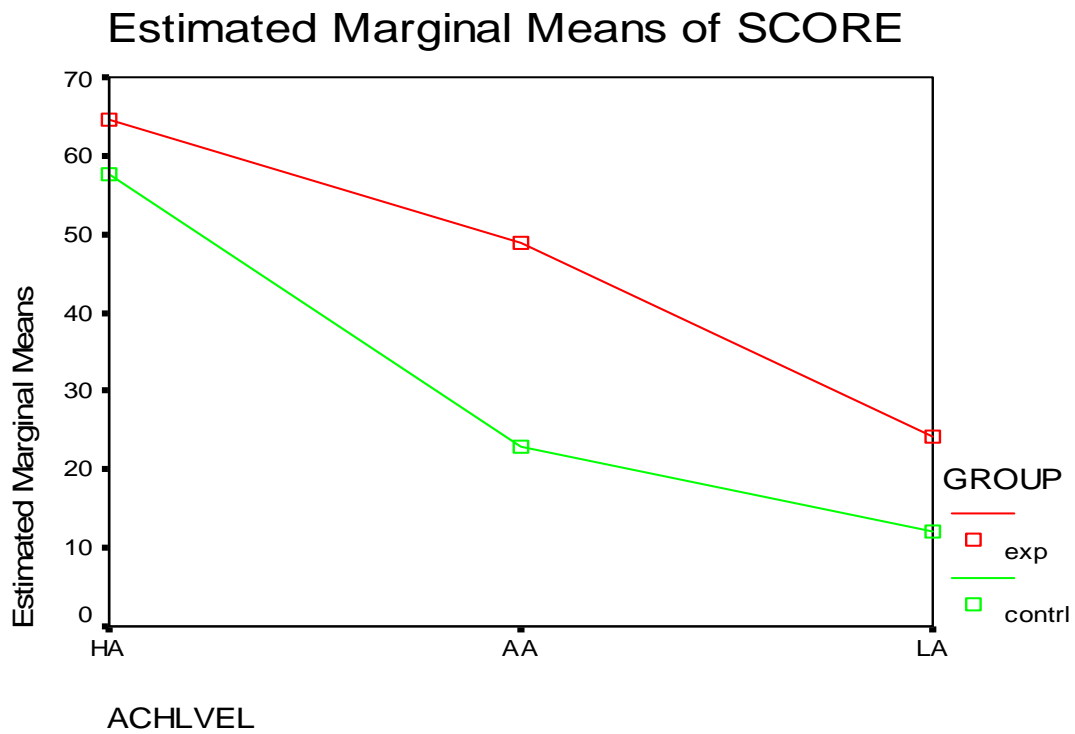
APPENDIX R

**SUMMARY OF DESCRIPTIVE STATISTICS ON ACHIEVEMENT SCORES
FOR THE SELECTED STUDENTS OF RURAL AND URBAN AREAS**

LOCATION	URBAN SCHOOL				RURAL SCHOOL			
	N	M	SD	SE _M	N	M	SD	SE _M
GROUPS OF STUDENTS →								
OVERALL EG ↓	30	45.80	17.84	3.26	30	42.73	17.52	3.20
OVERALL CG	30	30.80	20.96	3.83	30	27.53	13.29	2.43
HAs of EG	10	64.5000	3.3747	1.0672	10	64.0000	5.6569	1.7889
HAs of CG	10	57.6000	5.2747	1.6680	10	40.2000	7.6999	2.4349
AAs of EG	10	48.8000	5.9029	1.8667	10	40.9000	4.4585	1.4099
AAs of CG	10	22.8000	10.3258	3.2653	10	31.2000	3.5214	1.1136
LAs of EG	10	24.1000	7.5638	2.3919	10	23.3000	3.3015	1.0440
LAs of CG	10	12.0000	4.3970	1.3904	10	11.2000	2.7406	.8667

HA s= high achievers
 AAs= average achievers
 Las= low achievers
 EG= experimental group
 CG= control group

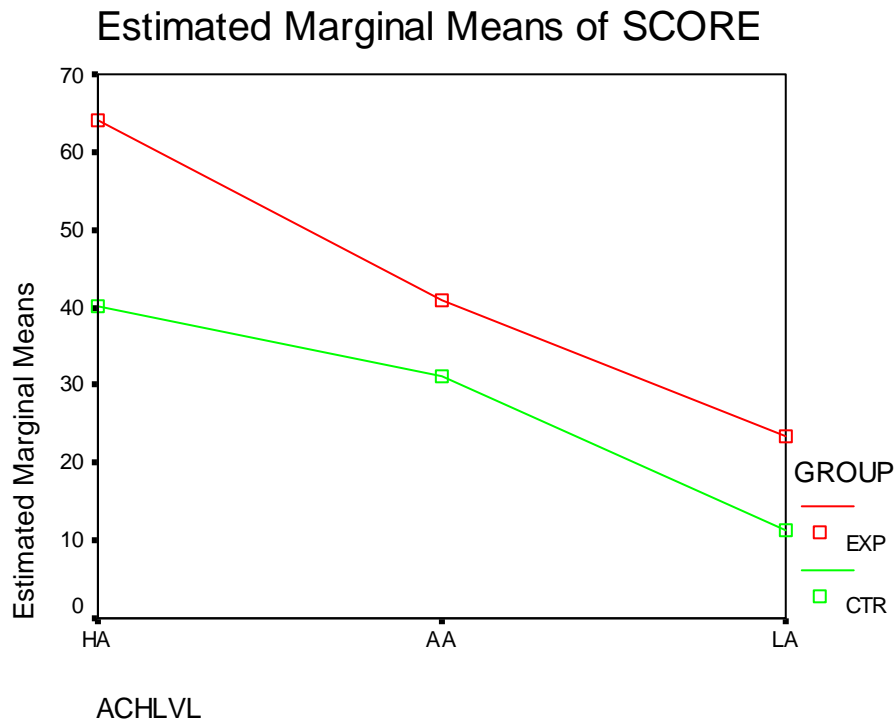
INTERACTION BETWEEN TEACHING METHODOLOGY AND THE LEVELS OF ACHIEVEMENT FOR THE SELECTED STUDENTS AT THE URBAN SCHOOL



SCORE	Academic Achievement Score
ACHIENEM	Achievement Score
ACHLEVL	Achievement Levels
HA	High Achievers
AA	Average Achievers
LA	Low Achievers
exp	Experimental Group
contrl	Control Group

APPENDIX T

INTERACTION BETWEEN TEACHING METHODOLOGY AND THE LEVELS OF ACHIEVEMENT FOR THE SELECTED STUDENTS AT THE RURAL SCHOOL



SCORE	Academic Achievement Score
ACHLEVL	Achievement Levels
HA	High Achievers
AA	Average Achievers
LA	Low Achievers
exp	Experimental Group
contrl	Control Group