

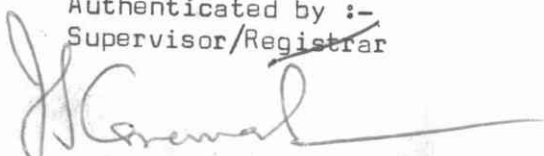
CERTIFICATE OF AUTHENTICATION

I do hereby declare that the copy of the thesis submitted to the ICSSR is an authenticated copy of my thesis approved for the award of degree of Doctor of Philosophy by the University of \_\_\_\_\_

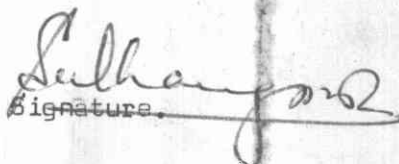
BHOPAL - UNIVERSITY

Date : 26/9/1983

Authenticated by :-  
Supervisor/Registrar



**Dr. J. S. GREWAL**  
Reader in Education, & Ph. D. Supervisor  
Regional College of Education,  
BHOPAL-462013



Signature.

(S. N. L. BHARGAVA)

Lecturer in Education,  
Regional College of Edu.,  
Bhopal

**A Study of Some Conitive Processes  
in Science Learning With Reference to Physics  
for Students of Higher Secondary Classes**



A THESIS SUBMITTED TO  
The BHOPAL UNIVERSITY, BHOPAL  
FOR  
The Degree of Doctor of Philosophy in Education



**Dr. J. S. Grewal**  
Guide

**S. N. L. Bhargava**  
Investigator

**MARCH, 1982**

**C E R T I F I C A T E**

Certified that Shri S.N.L.Sharma, candidate for the Ph.D. Degree in Education, has executed his research work under my guidance. The title of his study was "A Study of Some Cognitive Processes in Science Learning with Reference to Physics for Students of Higher Secondary Classes."

Further certified that

- (a) the thesis embodies the work of the candidate himself;
- (b) the candidate worked under me for the required period; and
- (c) in my opinion the thesis fulfils the requirements of the Ordinance relating to the Ph.D. Degree of Bhopal University, Bhopal.

*J. S. Grewal*

(Dr. J.S.Grewal)  
Supervisor and  
Reader in Education  
Regional College of Education  
Bhopal

March 31, 1982.

## CONTENTS

	Page
ACKNOWLEDGMENTS	i
LIST OF TABLES	i
LIST OF FIGURES	vii
CHAPTER I. INTRODUCTION	1-97
1.1 INTRODUCTION	1
1.2 NEED AND IMPORTANCE OF THE STUDY	12
1.3 STATEMENT OF THE PROBLEM	15
1.4 OBJECTIVES OF THE STUDY	15
1.5 PARAMETER OF THE STUDY	17
1.6 CONCEPTS CENTRAL TO THE STUDY	20
1.6.1 Concept of Processes of Science.	22
1.6.2 Concept of Achievement.	41
1.6.3 Achievement Tests	42
1.6.4 Concept of Intelligence.	45
1.6.5 Concept of Socio Economic Status	47
1.7 BACKGROUND OF RESEARCH ON THE PROGRESS OF SCIENCE AND OTHER VARIABLES UNDER STUDY.	48
1.7.1 Experimental and Developmental Studies.	49
1.7.2 Studies on Cognitive Variables.	59
1.7.3 Studies on Achievement in Science, Performance on Science Processes and Demographic Dimensions.	75

	Page
1.8 OPERATIONAL DEFINITIONS OF THE VARIABLES.	88
1.8.1 Independent Variables.	88
1.8.2 Dependent Variables.	90
1.9 HYPOTHESES OF THE STUDY	92
1.10 DELIMITATIONS OF THE PROBLEM	96
1.11 SUMMARY	96
<b>CHAPTER II THEORETICAL FRAMEWORK OF THE STUDY</b>	<b>98-128</b>
2.1 INTRODUCTION	98
2.2 SUBJECT MATTER-CENTRED APPROACH OF BURNER.	101
2.3 LEARNER-CENTRED APPROACH OF GAGNE	107
2.4 ECLECTIC MODEL OF MISHKEL AND SHULMAN	117
2.4.1 Ausubel's Theory of Advance Organisers.	117
2.4.2 Shulman's' Highway Approach.	119
2.5 DEVELOPMENTAL THEORY OF PIAGET AND HIS COLLEAGUES.	122
2.6 EVALUATION-CENTRED APPROACH OF BLOOM AND HIS COLLEAGUES.	128
2.7 SUMMARY	132
<b>CHAPTER III METHODOLOGY</b>	<b>134-145</b>
3.1 THE SETTING	134
3.2 THE SAMPLE	136
3.2.1 Age Level of the Pupils.	140
3.3 TOOLS OF THE STUDY.	141

	Page
3.3.1 Tools used in the study Constructed by Others.	142
3.3.2 Tools used in the study Constructed by the Investigator.	143
3.4 SUMMARY	144
<b>CHAPTER IV CONSTRUCTION OF TOOLS AND DATA COLLECTION</b>	<b>145-210</b>
4.1 INTRODUCTION	145
4.2 TOOLS CONSTRUCTED FOR THE STUDY.	146
4.2.1 The Construction of Battery of 147 Process Based Tests in Science. (PBT6)	147
4.2.2 The Construction of Objec- tive Based Tests of Achievement in Physics (OBTP).	151
4.2.3 Socio Economic Status Scale.	202
4.3 DATA COLLECTION	202
4.4 SCORING PROCEDURES FOR THE INSTRUMENTS.	203
4.5 STATISTICAL TECHNIQUES USES	208
4.6 SUMMARY	210
<b>CHAPTER V INTERACTIONAL AND DIFFERENTIAL STUDIES</b>	<b>211-242</b>
5.1 DESCRIPTION OF DATA	211
5.2 INTERACTIONAL STUDIES	223
5.2.1 Interaction Effects on the Process of Observing.	225
5.2.2 Interaction Effects on the Process of Measuring.	228
5.2.3 Interaction Effects on the Process of Drawing	230

	Page
	Inferences and Making Predictions.
5.2.4	Interaction Effects on the Process of HIA(Flex) 232
5.2.5	Interaction Effects on the Process of HIA(Flex) 234
5.2.6	Interaction Effects on the Process of HTA(Flex) 236
5.2.7	Interaction Effects on the Process of HTA(Flex) 237
5.3.	DIFFERENTIAL STUDIES 238
5.4	SUMMARY 240
<b>CHAPTER VI</b>	<b>CORRELATIONAL AND FACTOR ANALYTICAL STUDIES, 240-280</b>
6.1	INTRODUCTION 240
6.2	TESTING HYPOTHESES ABOUT THE STUDY OF RELATIONSHIPS, 240
6.2.1	Treatment of Data by Hypotheses. 240
6.2.2	Conclusions About the Study of Relationships. 240
6.3	FACTOR ANALYSIS OF SCIENCE PROCESSORS
6.3.1	Factor Analysis-Introduction 252
6.3.2	The Correlation Matrix 254
6.3.3	Original Factor Matrix 256
6.3.4	Varimax Rotated Factor Matrix 258
6.3.5	Analysis and Discussion of Rotated Factor Matrix. 272
6.4	SUMMARY 280

	Page
<b>CHAPTER VII. DEVELOPMENTAL AND QUALITATIVE STUDIES</b>	<b>281-304</b>
<b>7.1. INTRODUCTION</b>	<b>281</b>
<b>7.2 DEVELOPMENTAL STUDIES BY HYPOTHESES</b>	<b>281</b>
<b>7.3 QUALITATIVE ANALYSIS OF SAMPLE RESPONSES</b>	<b>288</b>
<b>7.3.1 Range of Responses of Items of IMAT</b>	<b>289</b>
<b>7.3.2 Range of Responses of Items of HTAT</b>	<b>301</b>
<b>7.4 SUMMARY.</b>	<b>303</b>
<b>CHAPTER VIII. SUMMARY, CONCLUSION AND TRENDS EMERGED FOR FURTHER RESEARCH.</b>	<b>305-346</b>
<b>8.1. NEED AND RATIONALE OF THE STUDY.</b>	<b>308</b>
<b>8.2 OBJECTIVES OF THE STUDY</b>	<b>308</b>
<b>8.3 HYPOTHESES OF THE STUDY</b>	<b>310</b>
<b>8.4 METHODOLOGY.</b>	<b>313</b>
<b>8.5 DESIGN OF THE STUDY</b>	<b>321</b>
<b>8.6 STATISTICAL TREATMENT</b>	<b>322</b>
<b>8.7 MAJOR FINDINGS AND CONCLUSIONS</b>	<b>323</b>
<b>8.8 IMPLICATIONS OF THE STUDY</b>	<b>326</b>
<b>8.8.1 Specific Implications of the study.</b>	<b>326</b>
<b>8.8.2 General Implications of the study.</b>	<b>340</b>
<b>8.9 TRENDS EMERGED FOR FURTHER RESEARCH</b>	<b>345</b>
<b>BIBLIOGRAPHY</b>	<b>367</b>
<b>APPENDIX :</b>	
<b>A. Final Form of PETS</b>	<b>1-xiii</b>
<b>B. Final Form of OBT</b>	<b>xiv-xviii</b>
<b>C. Final Form of SES Scale</b>	<b>xix-xxii</b>
<b>D. A Sample of Responses on IMA</b>	<b>xxiii- xxvi</b>
<b>E. A Sample of Responses on HTA</b>	<b>xxvii - xxxi</b>

## A C K N O W L E D G E M E N T S

I take the privilege of expressing my sincere gratitude to Dr. J. S. Grewal, Reader in Education, Regional College of Education, Bhopal for his ever inspiring guidance, encouragement and affectionate care in the completion of my research work. His interest in academic work and deep study proved to be an asset to me. I owe my hearty thanks to him for the help extended by him at all stages of this study.

I am indebted to Dr. J. S. Rajput, Principal, and Prof. S. N. Tripathi, Professor of Education, Regional College of Education, Bhopal for their whole hearted support and encouragement in this professional venture and for extending all possible facilities to me in this research work. The initiation to work in this area of educational research came from Prof. N. Vaidya, for which I am grateful to him and also to my employer, the N. C. E. R. T., for giving me financial assistance for undertaking this research work.

I am grateful to Dr. A. B. Saxena, Shri S. C. Arya and Mrs. Avinash Grewal who helped me in developing the tools and in many other ways. I am also thankful to Shri A. B. Saxena, my colleague, whose cooperation was always available throughout my work.

My sincere thanks are due to Shri P. S. Shah and Mrs. R. Trivedi of Physical Research Laboratory Ahmedabad and Shri Das Gupta, Incharge, Computer Centre IITL Bhopal.

for their cooperation in the data processing; to Shri G.N. Vyas, Librarian, Regional College of Education, Bhopal and his staff for the assistance rendered by them; and to the Principals and students of various schools who have actively cooperated at the data collection stage.

To my father who, till his end, aroused in me a soul and undoubted spirit to work hard with a sense of commitment. His blessings will ever remain a motivating force for me in my life. I also cherish the way my wife, Vinia Bhargava, and my children continuously worked and sacrificed their personal time for the completion of this study.

Bhopal  
March 25, 1982.

  
(S.N.L. BHARGAVA)

LIST OF TABLES

S.No.	Table No.	Description	Page
1	2.1	The number of higher secondary schools and enrolment of students in Bhopal Division.	135
2	3.2	The number of pupils selected for the sample of the study.	137
3	3.3	The type of schools and enrolment of pupils.	138
4	3.4	Universe and Sample of the study.	139
5	4.1	Showing the response infavour of the processes in science at higher secondary level.	140
6	4.2	Distribution of the sub-test items for the various processes included in the study.	161
7	4.3	Number of participating students in the try-out of the PHTS.	162
8	4.4	Average responses of the various categories of items of PHTS.	165
9	4.5	Specification of retained items on PHTS.	167
10	4.6	Validity of the various sub-tests of science processes against the criterion of intelligence.	174
11	4.7	Coefficient of reliability and standard error of measurement of the sub-tests of PHTS.	179
12	4.8	The number of participating students in the try-out of OHTS.	180
13	4.9	Item difficulty and discriminating power of the test items	182
14	4.10	't' - values and correlations with the whole test for the retained items of the test.	185

S.No.	Table No.	Description	Page
15	4.11	Testing session of the study and the order of administering the various tools.	203
16	5.1	Original and percent frequency distribution along with the measures of mean, median, SD, SK and KU based on the observing process scores of boys (N = 944) and girls (N= 403) and the total sample (N= 1347).	212
17	5.2	Original and percent frequency distribution along with the measures of mean, median, SD, SK and KU based on the measuring process scores of boys (N=944) and girls (N=403) and the total sample (N=1347).	213
18	5.3	Original and percent frequency distribution along with the measures of mean, median, SD, SK and KU based on the drawing inferences and making predictions process scores of boys, girls and the total sample.	214
19	5.4	Original and percent frequency distribution along with the measures of mean, median, SD, SK and KU based on the HMA (fluency) scores of boys, girls and the total sample.	215
20	5.5	Original and percent frequency distribution along with the measures of mean, median, SD, SK and KU based on the HMA (flexibility) of boys, girls and the total sample.	217
21	5.6	Original and percent frequency distribution along with the measures of mean, median, SD, SK and KU based on the HTA (fluency) scores of boys, girls and the total sample.	219

S.No.	Table No.	Description	Page
22	5.7	Original and percent frequency distribution along with the measures of mean, median, SD, SK and KU based on the HTA (flexibility) of boys, girls and the total sample.	220
23	5.8	Original and percent frequency distribution along with the measures of mean, median, SD, SK and KU based on the achievement in Physics scores of boys, girls and the total sample.	222
24	5.9	Summary of ANOVA for the variables of SES, intelligence and achievement in Physics for 2x2x2 factorial design for the process of observing.	226
25	5.10	Summary of ANOVA for the variables of SES, intelligence and achievement in Physics for 2x2x2 factorial design for the process of measuring.	228
26	5.11	Summary of ANOVA for the variables of SES, intelligence and achievement in Physics for 2x2x2 factorial design for the process of drawing inference and making predictions.	230
27	5.12	Summary of ANOVA for the variables of SES, intelligence and achievement in Physics for 2x2x2 factorial design for the process of HMA (Fluency) scores.	232
28	5.13	Summary of ANOVA for the variables of SES, intelligence and achievement in Physics for 2x2x2 factorial design for the process of HMA (Flexibility) scores.	234
29	5.14	Summary of ANOVA for the variables of SES, intelligence and achievement in Physics for	235

S.No.	Table No.	Description	Page
30	5.15	Summary of ANOVA for the variables of SES, intelligence and achievement in Physics for 2x2x2 factorial design for the process of HTA (flexibility) scores.	237
31	5.16	Difference between rural and urban pupils on the various processes of science.	239
32	5.17	Difference between the urban boys and urban girls on the various processes of science.	240
33	5.18	Difference between the rural boys and rural girls on the various processes of science.	242
34.	5.19	Difference between the boys and girls on the various processes of science.	243
35.	5.20	Difference between the pupils of rural and urban areas on achievement in Physics.	244
36	5.21	Difference in the achievement in Physics scores of urban boys and girls.	245
37	5.22	Difference in the achievement in Physics scores of rural boys and girls.	246
38	5.23	Difference in the achievement in Physics scores of boys and girls.	247
39	6.1	Correlation Matrix (14x14) for the variables of the study.	250
40	6.2	Relationship of age with the scores obtained on seven processes of science.	251
41	6.3	Relationship of SES (SEC) with the	252

S.No.	Table No.	Description	Page
		scores obtained on seven processes of science.	
42	6.4	Relationship of SES(Education) with the scores obtained on seven processes of science.	264
43	6.5	Relationship of SES(Occupation) with scores obtained on seven processes of science.	265
44	6.6	Relationship of SES(Income) with scores obtained on seven processes of science.	266
45	6.7	Relationship of intelligence with the scores obtained on seven processes of science.	267
46	6.8	Relationship of achievement in Physics with the scores of seven processes of science.	268
47	6.9	Correlation matrix (14x14) for the variables of the study.	269
48	6.10	Original Principal Component Factor Matrix (14x5).	270
49	6.11	Rotated Factor Matrix(14x5)	270
50	6.12	Variance of significant factors and the variance of individual variables.	271
51	6.13	Loading on Varimax Factor I.	272
52	6.14	Loading on Varimax Factor II.	273
53	6.15	Loading on Varimax Factor III.	273
54	6.16	Loading on Varimax Factor IV.	273
55	6.17	Loading on Varimax Factor V.	273
56	7.1	Scores on the process of observing of 13 to 16 years old boys (B), girls(G) and the total (T) sample.	274

<b>S.No.</b>	<b>Table No.</b>	<b>Description</b>	<b>Page</b>
57	7.2	Scores on the process of measuring of 13 to 16 years old boys(B),girls(G) and the total (T) sample.	284
58	7.3	Scores on the process of drawing inferences and making predictions of 13-16 years old boys(B), girls(G) and the total (T) sample.	287
59	7.4	Scores on the process of HMA (Fluency) of 13 to 16 years old boys (B),girls(G) and the total (T) sample.	289
60	7.5	Scores on the process of HMA (Flex.)of 13 to 16 years old boys (B),girls (G) and the total (T) sample.	292
61	7.6	Scores on the process of HMA (Flue) of 13 to 16 years old boys(B),girls(G) and the total (T) sample.	294
62	7.7	Scores on the process of HTA (Flex) of 13 to 16 years old boys (B),girls(G) and the total (T) sample.	296
63	7.8	Fluency,flexibility and ratio between these two on HMA responses.	299
64	7.9	Fluency,flexibility and ratio between these two on HTAT responses.	301

LIST OF FIGURES

S.No.	Fig.No.	Description	Page
1	5.1	Smoothed Frequency Polygons of Observing Process Scores of Boys, Girls and Total Sample.	212a
2	5.2	Smoothed Frequency Polygons of Measuring Process Scores of Boys, Girls and Total Sample.	213a
3	5.3	Smoothed Frequency Polygons of Drawing Inferences and Making Predictions Scores of Boys, Girls and Total Sample.	215a
4	5.4	Smoothed Frequency Polygons of HMA(Fine) Scores of Boys, Girls and Total Sample.	216a
5	5.5	Smoothed Frequency Polygons of HMA(Flex) Scores of Boys, Girls and Total Sample.	218a
6	5.6	Smoothed Frequency Polygons of HTA(Fine) Scores of Boys, Girls and Total Sample.	219a
7	5.7	Smoothed Frequency Polygons of HTA (Flex) Scores of Boys, Girls and Total Sample.	221a
8	5.8	Smoothed Frequency Polygons of Achievement of Physics Scores of Boys, Girls and Total Sample.	222a
9	5.9	Interaction (BXC) of Intelligence (B) and Achievement (C) for the process of Measuring.	223a
10	6.10	Interaction (AXB) of SES(A) and Intelligence(B) for the Process of HMA(Fine).	224a
11	5.11	Interaction (AXB) of SES(A) and Intelligence(B) for the Process of HMA(Flex).	224a
12	5.12	Interaction (AXB) of SES(A) and	225a

S.No.	Fig.No.	Description	Page
		Intelligence (B) for the Process of HTA(Flue).	
13	6.1	Pie Diagram Showing Original Principal Component Factor Matrix.	287a
14	6.2	Pie Diagram Showing Rotated Factor Matrix by Varimax Method.	288a
15	7.1	Showing the Trend of Mean Scores Obtained on the Process of Observing at age Levels 13 to 16 years.	282a
16	7.2	Showing the Trend of Mean Scores Obtained on the Process of Measuring at age Levels 13 to 16 years.	285a
17	7.3	Showing the Trend of Mean Scores Obtained on the Process of Drawing Inferences and Making Predictions at age Levels 13 to 16 years.	288a
18.	7.4	Showing the Trend of Mean Scores Obtained on the Process of HTA (Flue) at age Levels 13 to 16 years.	290a
19	7.5	Showing the Trend of Mean Scores Obtained on the Process of HTA(Flex) at age Levels 13 to 16 years.	293a
20	7.6	Showing the Trend of Mean Scores Obtained on the process of HTA(Flue) at age Levels 13 to 16 years.	286a
21	7.7	Showing the Trend of Mean Scores Obtained on the process of HTA(Flex) at age Levels 13 to 16 years.	297a