Cognitive preferences and academic achievement in students of science

Suhasini Bajpai* and P.C. Shukla**

*School of Education, Mahatma Gandhi Antarrashtriya Hindi Vishwavidyalaya, Wardha
**Faculty of Education, Banaras Hindu University, Varanasi

ABSTRACT

The present study is an attempt to identify the cognitive preferences of secondary school science students and its relationship with academic achievement. For this purpose a 'Cognitive Preference Test' and an 'Achievement Test in Science' were developed and administered to 500 eleventh grade science students subsequent to their study of tenth grade science subject. The finding suggests that secondary school science students have a strong bias for 'Principle' and that their general order of preference is 'Principle-Recall-Application-Questioning'. A strong dependence of cognitive preference orientation on 'Academic Achievement' in science was observed. High achiever group of students were found to exhibit a high preference for 'Questioning' and a strong discontentment for 'Recall' mode. Exactly an opposite trend of preferences among low achiever group has been reported, as having highest preference for 'Recall' and lowest preference for 'Questioning' mode.

Keywords: Cognitive preferences, cognitive style, academic achievement, learning experiences

The challenges of modern times characterised by rapid advances in science and technology have necessitated adoption of new outlook and orientation in content and methodologies in education. Dynamic adaptations and adjustments in the teaching learning process will be required for optimal learning outcomes. In recent years matching instruction to the needs and preference of individual learners has been advocated and it has become the focus of major research efforts. No wonder that this trend has led to an extensive search after means for extending the description of individual differences beyond the ubiquitous and crystallized notion of I.Q. - One such characteristic is cognitive style. To understand cognitive style in a more general manner we can say that 'cognitive style' is the term used to describe different ways in which people process information, including perception, storage, transformation and utilization of information from the environment. It describes the habitual process of perceiving and thinking which are qualitatively distinct.

Address for correspondence

School of Education, Mahatma Gandhi Antarrashtriya Hindi Vishwavidyalaya, Wardha

E-mail: sunbajpai9@gmail.com

Cognitive preferences as suggested by Heath constitute a kind of cognitive style which is acquired as a result of certain life and learning experiences. The acquired cognitive preference style, in turn, interacts with other individual characteristics such as abilities, thus influencing further outcomes in subsequent learning under specific mode of instruction.

The concept of cognitive preferences was introduced by Heath (1964) in an attempt to "assess *not whether the students can identify correct or incorrect information*" but rather "*what they are likely to do with information intellectually*". He suggested four different modes of cognitive preferences of learners in actually dealing with the scientific information received during instruction. Being a variant of cognitive style, Heath's conceptualization of cognitive preference resulted in a series of investigations in the area. Not only measures of cognitive preferences were refined (Atwood, 1971; Kempa and Dube, 1973), but investigations also revealed a strong dependence of students' academic achievement on cognitive preferences in science subjects (Tamir, 1975; Kempa and Dube, 1973; Rathore & Singh, 1987; Day, 1995; Bagchi, 2002; Sotayo ,2007). The purpose of the present study is to further validate and investigate:

1. Cognitive Preference orientations of Secondary School Science Students.

2. The relationship between 'Cognitive Preference' and 'Academic Achievement' of Secondary School Science Students.

Cognitive preferences: Cognitive preference is the characteristic way in which an individual prefer to learn a new material (Jungwirth , 1980).This implies an individual's learning modes. Heath (1964) points out that *"the interest is not in whether the students can identify correct or incorrect information, but rather what they are likely to do with information intellectually."* The four modes of *"attending to scientific information"* originally suggested by Heath and are given here as reformulated by Van den Berg *et al*. (1978):

1. **Recall**: Acceptance of scientific information for its own sake, i.e. without consideration of its implication, or limitations.

2. **Principles**: Acceptance of scientific information

because it exemplifies or explains some fundamental scientific principle or relationship.

3. **Questioning**: Critical questioning of scientific information as regards its completeness, general validity or limitations.

4. **Application:** Acceptance of scientific information in view of its usefulness and applicability in a general, social or scientific context.

Thus, "*cognitive preference suggests how a learner process information intellectually*". This method of processing information (learning modes) could depend on learning experiences (Tamir, 1976).

Hypotheses

To meet the objectives of the study following hypotheses were formulated and tested:

1. The Secondary school students do not differ significantly within themselves in respect of their modes of cognitive preference in science.

2. The secondary school science students categorized as 'high' and 'low achievers' in Science, do not differ significantly in respect of their 'Cognitive preferences'.

Procedure

Sample

The sample of the study consisted of 500 students of secondary school of Varanasi city selected through cluster random sampling. The selection of the schools situated in urban areas of Varanasi city was made on random bases. Further sections of maths and biology group of class XI students were also selected randomly and tools were administered on all the students present in the class on that particular day.

Instruments

The Cognitive preference test

Science Cognitive Preference Test (SCPT) designed and validated by the investigator has been used for assessing the cognitive preferences of the students. The four cognitive preference areas suggested by Heath

were accepted as such for construction of cognitive preference test in the present study. In its operational form, the test comprised 20 items covering all major areas of current secondary level science courses. A sample item, corresponding to the example discussed in the introduction was:

1. Most chemical elements are composed of not just one but several naturally occurring stable isotopes.

    (i) The similar chemical property of isotopes of an element is due to the fact that they all have same electron configuration.(P)

    (ii) Isotopes of an element have same number of protons and electrons but different number of neutrons in the nucleus. (R)

    (iii) C-14 is a radioactive isotope of carbon, used in carbon dating to determine the age of organic (carbonaceous) materials. (A)

    (iv) It makes me think why some isotopes of the elements like Carbon-14, Phosphorus-32 etc are unstable and undergo radioactive decay. (Q)

 Option-(I) considers a scientific principle; it corresponds to the second of the cognitive preference area, to be referred as the 'Principles' area. Option-(II) is essentially a re-statement of the information in the item stem, and thus relates to the first of the cognitive preference area outlined above i.e. 'Recall'. The forth cognitive preference area 'Application' is exemplified by option-(III), whilst option-(IV) corresponds to the third i.e. 'Questioning' area.

The graded rating procedure as suggested by Kempa and Dube (1973) was employed. The students were asked to arrange the options within an item in an order of preference by allotting four marks to the most preferred option, three marks to the next preferred, two marks to the next and one marks to the least preferred response. The advantage of this procedure is that all responses appearing in an item contribute to a student's overall cognitive preference profile, unlike the normal procedure of response selection where rejected options are treated as equally unattractive.

Achievement test in Science

An achievement test in Science for Secondary students was developed and standardized by the researcher for measuring the academic achievement of students as per Science syllabus of grade-X. The marks obtained by the subjects in 'Science Achievement Test' were taken as a measure of their achievement in science.

Analysis and Results

Student's Overall Cognitive Preference

The first objective was concerned with the study of cognitive preferences of secondary school science students. In order to achieve this objective, overall cognitive preference profiles of students were calculated on the basis of mean of R, P, A and Q-scores. The mean and standard deviations of scores obtained for the four cognitive preference areas have been presented in Table-1.

Table 1: Means, Standard Deviations and F- Value for Cognitive Preference modes of the total sample

Cognitive Preference Area	Mean	Std. Deviation	F- Value
Recall	51.66	10.85	56.02*
Principle	53.87	6.78	
Application	47.79	7.34	
Questioning	46.68	13.55	

*Significant at 0.01 level of confidence

A look into the means of different modes (Table-1) makes it evident that Secondary school science students have a strong bias for P (Mn-53.87) followed by R (Mn-51.66), A (Mn -47.79) and Q (Mn-46.68). It leads to the conclusion that students' general order of preference is P—R—A –Q.

At the next step these scores were subjected to Fisher's F-test analysis with a view to the verify hypothesis -1. These results are also entered in table-1. The results (Table-1) reveal that the F-value 56.02 with degree of freedom 3,1996, is significant at 0.01 level of significance. Hence null hypothesis-1 is refuted. This implies that the students differ significantly in terms of modes of cognitive preference in science.

To further investigate the significance of obtained means, t-test was applied to compare the possible combinations of cognitive preference modes. The results of these comparisons are presented in table-2

Table 2: Table showing the Mean and S.D. for different Cognitive Preference modes along with their combinatorial t- ratios

Modes Compared	N	Mean	SD	t-value
Recall	500	51.66	10.85	3.89*
Principle	500	53.87	6.78	
Recall	500	51.66	10.85	6.66*
Application	500	47.79	7.34	
Recall	500	51.66	10.85	6.01*
Questioning	500	46.68	13.55	
Principle	500	53.87	6.78	13.94*
Application	500	47.79	7.34	
Principle	500	53.87	6.78	10.63*
Questioning	500	46.68	13.55	
Application	500	47.79	7.34	1.62
Questioning	500	46.68	13.55	

* Significant at 0.01 level

It is evident from table- 2 that there exists a significant difference in the mean scores of all combinations of cognitive preferences modes except for 'Application-Questioning' combination. On the basis of these results it can safely be concluded that the secondary school science students in general assign highest preference for accepting scientific information at 'Principle' level (Mn-53.87), followed by indicating second and third preference for 'Recall' (Mn-51.66) and 'Application' (Mn-47.79) respectively, whereas 'Questioning mode'(46.68) is the least preferred mode of cognitive preference.

Cognitive Preference and Academic Achievement

The second objective of this study is concerned with the relationship between cognitive preference and academic achievement in science. The means and standard deviations of scores obtained for the three sub-groups (low, average and high) on academic achievement, for different cognitive preference areas are given in table-3. The verification of hypothesis-2 was analysed by Fisher's F-test, to examine whether students differ significantly on the four modes of cognitive preferences. The results of this analysis are presented in table-3.

Table 3: Analysis of variance of Cognitive Preference scores of the students of different achievement group

Cognitive Preference Mode	Achievement Categories						F- Value
	Low Achiever (1) (N=83)		Average Achiever (2) (N=323)		High Achiever (3) (N=94)		
	Mean	SD	Mean	SD	Mean	SD	
Recall	57.00	7.94	52.71	10.30	43.35	10.43	46.18*
Principle	54.34	6.57	54.52	6.76	51.19	6.39	9.36*
Application	48.32	5.25	47.57	7.70	48.03	7.51	0.411
Questioning	40.32	10.11	45.18	12.66	57.42	13.33	48.37*
Preference Style	R—P—A—Q		P—R—A—Q		Q—P—A—R		

* Significant at 0.01 level

A reference of table 3 reveals that student categorized as low, average and high achiever group shows a difference in their pattern of cognitive preference style. As low achievement group student's order of preference is R—P—A—Q , average achievement group students has preference style P—R—A—Q while high achievement group students have order of preference as Q—P—A—R. The reflected trend makes it clear that in general low achievers have the highest preference for 'Recall', whereas high achievers have the highest preference for 'Questioning' and the average achievers show a strong preference for 'Principle'.

The results presented in table-3 reveal significant F-values at 0.01 level of significance for 'Recall', 'Principle' and 'Questioning'. Hence null hypothesis-2 is partially rejected. Further, to find out the specific significant mean differences, where F value was found significant, t-test was applied for comparing the possible pairs of cognitive preference modes with three categories of students. The results of these comparisons are presented in table 4, 5 and 6.

Table 4: Mean, S.D. and t-values for 'Recall' mode of different achievement groups

Achievement Category	N	Mean	SD	t-value
Low(1)	83	57.00	7.94	4.16*
Average(2)	323	52.71	10.30	
Low(1)	83	57.00	7.94	9.89*
High(3)	94	43.35	10.43	
Average(2)	323	52.71	10.30	7.73*
High(3)	94	43.35	10.43	

* Significant at 0.01 level

As it is clear from the table- 4 that low achievers have the highest preference for 'Recall' mode in comparison to average and high achiever groups and that all the groups differ significantly on the means of 'Recall' mode. It is becoming apparent that as the achievement level increases preference for 'Recall' mode decreases.

Table 5: Mean, S.D. and t-values for 'Principle' mode of different achievement groups

Achievement Category	N	Mean	SD	t-value
Low(1)	83	54.34	6.57	0.22
Average(2)	323	54.52	6.76	
Low(1)	83	54.34	6.57	3.24*
High(3)	94	51.19	6.39	
Average(2)	323	54.52	6.76	4.44*
High(3)	94	51.19	6.39	

* Significant at 0.01 level

Table-5 compares the means of different achievement groups for the 'Principle' mode .It is clear from the table that average achiever group have highest preference for principle mode. No significant difference was found between the mean of low and average group on principle mode. Low and high achiever groups differ significantly in their mean P-scores. A similar trend was appeared for average and high achiever group.

Table 6: Mean, S.D. and t-values for 'Questioning' mode of different achievement groups

Achievement Category	N	Mean	SD	t-value
Low(1)	83	40.32	10.11	3.70*
Average(2)	323	45.18	12.66	
Low(1)	83	40.32	10.11	9.71*
High(3)	94	57.42	13.33	
Average(2)	323	45.18	12.66	7.94*
High(3)	94	57.42	13.33	

* Significant at 0.01 level

Results in table-6 clearly indicate significant difference between groups based on achievement categories for mean score on 'Questioning' mode. It also reveals the opposite trend as expressed for questioning mode as compared to 'Recall' mode (table-4) among the students of different achievement categories. It is apparent that high achievers have highest preference for 'Questioning' mode than low and average achievers.

Discussion and Conclusion

The mean and standard deviations of scores obtained for the four cognitive preference areas have been presented in Table-1. It can be observed that the means are reasonably closer to the theoretical value of 50 (This follows from the fact that the total score for all 20-items of the test is 200, i.e. $\sum S_R + \sum S_P + \sum S_A + \sum S_Q = 200$, where 'S' denotes item scores. Equal preference for all areas covered would give a theoretical mean area score of $200/4 = 50$). This may be assumed as evidence that the test had no undue bias for/against any particular cognitive preference area. The standard deviations also indicate high discriminatory properties of the test especially for 'R' and 'Q'. It may be observed that on an average there is little difference in the mean scores of the four modes. Analysis of variance with repeated measures reveals statistically significant differences in mean scores within the test. It leads to infer that Secondary school science students have a strong bias for 'P', and their general order/sequence of preference is 'P--R--A--Q'.

The findings of the study are in agreement with those of Tamir(1976), Rogel (1974), Kempa and Dube (1973), and Sahana (1995) as they had also inferred strong preference for 'Principle' mode followed by 'Recall'. However, the results are not supported by Rathore and Singh (1987) who reported 'Recall' as the first preferred mode among tenth grade biology students.

Comparison of the mean scores for students in different achievement categories revealed a strong dependence of cognitive preference orientation on academic achievement. The cognitive preferences of students in different achievement group differ significantly. High achiever group of students showing strong preference for 'Questioning' and least preference for 'Recall', appear to exhibit a high degree of 'scientific curiosity' and in their acceptance of scientific information a distinct inclination towards 'pure science' is reflected. On the contrary the 'low achiever group' of students lack scientific curiosity as they show opposite trends in preferences i.e. highest preference for 'Recall' and least preference for 'Questioning'.

This conclusion is strongly supported by studies conducted by Tamir (1976), Barnett(1974), Kempa and Dube (1973) and Rathore and Singh (1987). Admittedly, the trends reported for cognitive preferences have not been alike in all studies, which probably may ascribe to the subject specific nature of cognitive preference test. In conclusion this study infers that cognitive preferences are related to the distinctive achievement categories and as such exhibit to be a relevant variable in relation to academic achievement among secondary school science students.

References

Bagchi, J.P. 2002. An investigation into Factors Affecting Cognitive Preferences Styles in Biology, Journal of Science and Mathematics Education in S.E. Asia Vol. XXV, No.1. Retrieved from http://www.recsam.edu.my/R&D_Journals/ Year2002/41-55.

Bagchi, J.P. and Uddin, H. 1990. Cognitive preferences of secondary science teachers in India: The example of Uttar Pradesh. *International Review of Education* **36**(4): 453-467.

Barnett Howard, C. 1974. An investigation of relationship among Biology achievement, Perception of teacher style, and cognitive preferences. *Journal of Research in Science Teaching* **11**(2): 141-147.

Dolan Ramont, J. and Sharot Tail 2012. Neuroscience of Preferences and Choices: Cognitive and Neural Mechanism. First edition, Academic Press, Elsevier Inc.

Heath, R.W. 1964. Curriculum, Cognition and Educational Measurement. Educational and Psychological Measurement **24**(2): 239-253.

Joe, A.I. 1983. An Exploratory Study of Nigerian Students' Cognitive Preferences in Biology, *Journal of the Science Teachers' Association of Nigeria* **22**(1): 104-112.

Kempa, R.F. and Dube, G.E. 1973. Cognitive Preference-Orientation in Students of Chemistry, *British Journal of Educational Psychology* 43: 279-288.

Malone John A. and Cavanagh Robert F. 1997. The influence of student's cognitive preference on the selection of science and mathematics subjects. *International Journal of Science Education* **19**(4): 481-490.

Myron, W. 1964. An unfolding analysis of Cognitive Preferences. Research Bulletin, *Educatioal Testing Service* **64**: 7

Ogunyemi, E.O. and Bettie, J.C. 1974. An Investigation of Cognitive Preferences in Mathematics among High and Low Mathematics Achievers in two Nigerian Secondary Schools, *African Journal of Educational Research* **1**(1): 97-105.

Okebukola, P. A. and Jegede, O.J. 1988. Cognitive Preferences and Learning Mode as Determinants of Meaningful Learning through Concept Mapping, *Science Education* **74**(1): 489-500.

Rathore, H.C.S. and Singh, A.P. 1987. Cognitive Preferences and Academic Achievement of Tenth Grade Biology Students, *Indian Educational Review* **22**(4): 29-37.

Tamir, P. 1976. The relationship between Achievement in Biology and Cognitive Preferences Styles in High School students, *British journal of Educational Psychology* **46**: 57-67.

Williams C. 1975. A Study of Cognitive Preferences. *The Journal of Experimental Education* **43**(3): 61-77.