The two hemispheres of human brain are functionally asymmetrical, is well known. These take opposite approaches to problem-solving - the left hemisphere structures information analytically and the right hemisphere perceives holistically. Right hemisphere is particularly important in handling novel situations in problem-solving by generating multiple ways of representing the available information. Fixation on a single mode of approach is, perhaps, the most frequent cause of failure in human problem-solving (Posner, 1973). Traditional educational procedures emphasize unidirectional communication of instructions punctuated by fixed alternative responses. This results in sterility of creative problem-solving skills. According to Kubie (1967), this is due to neglecting the preconscious instrument of learning i.e. right brain and laying undue emphasis on conscious part of mentation i.e. left brain. The pedantic teaching of 3 R's imprisons the child's capacity to create something new. Bogen and Bogen (1969) suggested that integrating the two hemispheres' specialized skills, is central to human creativity. Effective education results from a fully acknowledged commitment to functions of both cerebral hemispheres, the fullness of human mind. Development of right hemisphere requires different methods, material and procedures (Samples, 1975) and improvement in right hemisphere often results in improved left hemisphere functioning (Bogen et al., 1972).
According to Reynolds and Torrance (1978), modification of a person's preferred style of thinking and learning is possible through some kind of brief training of six to ten weeks and such training has implications for the field of creative problem-solving skills.

To conduct the present study, a strategy for training right hemisphere was designed and its effect on creative problem-solving skills and cerebral dominance was investigated.

**Statement of the Problem**

**THE EFFECT OF TRAINING STRATEGIES ON CREATIVE PROBLEM SOLVING SKILLS AND CEREBRAL DOMINANCE IN RELATION TO INTELLIGENCE, PERSONALITY AND COGNITIVE STYLE.**

**7.1 Objectives of the Study**

The study was undertaken with the following objectives:

I. To determine whether the training strategies effect creative problem solving skills and cerebral dominance or not.

II. To study if the intelligence, personality and cognitive style effect the creative problem-solving skills.

III. Whether intelligence, personality and cognitive style effect the cerebral dominance.

**7.2 Hypotheses**

The study was designed to test the following hypotheses:

**Hypotheses Concerning Creative Problem-Solving Skills**

**Main Hypotheses**

1. Groups given training through strategy $A_1$ and strategy $A_2$ will not differ significantly on mean gain scores for (a) fluency,
(b) flexibility, (c) originality and (d) creative problem-solving skill totals.

2. There will be no significant difference in mean gain scores of (a) fluency, (b) flexibility, (c) originality and (d) creative problem-solving skill totals of high intelligent and low intelligent subjects.

3. Extraverts and introverts will not differ significantly in terms of mean gain scores for (a) fluency, (b) flexibility, (c) originality and (d) creative problem-solving skill totals.

4. Cognitive style will not account for significant variance in mean gain scores for (a) fluency, (b) flexibility, (c) originality and (d) creative problem-solving skill totals.

**Interactional Hypotheses**

1st Order

5(i) There will be no significant interaction between training strategies and levels of intelligence in respect of mean gain scores on (a) fluency, (b) flexibility, (c) originality and (d) creative problem-solving skill totals.

(ii) Interaction between training strategies and personality types will not significantly effect mean gain scores on (a) fluency, (b) flexibility, (c) originality and (d) creative problem-solving skill totals.

(iii) The training strategies A₁ and A₂ will be equally effective for field independents and field dependents in respect of mean gain scores on (a) fluency, (b) flexibility, (c) originality and (d) creative problem-solving skill totals.
(iv) There will be no significant interaction between levels of intelligence and personality types in terms of mean gain scores on (a) fluency, (b) flexibility, (c) originality and (d) creative problem-solving skill totals.

(v) Levels of intelligence and cognitive style will have non-significant interaction in respect of mean gain scores on (a) fluency, (b) flexibility, (c) originality and (d) creative problem-solving skill totals.

(vi) Interaction between personality types and cognitive style will not be significant in case of mean gain scores on (a) fluency, (b) flexibility, (c) originality and (d) creative problem-solving skill totals.

2nd Order

6(i) There will be no significant interaction among training strategies, levels of intelligence and personality types in terms of mean gain scores on (a) fluency, (b) flexibility, (c) originality and (d) creative problem-solving skill totals.

(ii) Training strategies, levels of intelligence and cognitive style will not interact significantly with respect to mean gain scores on (a) fluency, (b) flexibility, (c) originality and (d) creative problem-solving skill totals.

(iii) Interaction among training strategies, personality types and cognitive style will not be significant for mean gain scores on (a) fluency, (b) flexibility, (c) originality and (d) creative problem-solving skill totals.
(iv) Levels of intelligence, personality types and cognitive style will have non significant interaction in terms of mean gain scores on (a) fluency, (b) flexibility, (c) originality and (d) creative problem-solving skill totals.

3rd Order

7. There will be no significant interaction among training strategies, levels of intelligence, personality types and cognitive style with respect to mean gain scores for (a) fluency, (b) flexibility, (c) originality and (d) creative problem-solving skill totals.

Hypotheses Concerning Cerebral Dominance

Main Hypotheses

8. Groups taught through strategy $A_1$ and strategy $A_2$ will not differ significantly with respect to mean gain scores on (a) whole brain, (b) left brain and (c) right brain.

9. High intelligent and low intelligent subjects will not differ significantly in terms of mean gain scores on (a) whole brain, (b) left brain and (c) right brain.

10. There will be no significant difference in respect of mean gain scores for (a) whole brain, (b) left brain and (c) right brain of extraverts and introverts.

11. Cognitive style will not affect significantly mean gain scores of (a) whole brain, (b) left brain and (c) right brain.

Interactional Hypothesis

1st Order

12(i) Interaction between training strategies and levels of intelligence will not be significant in respect of mean gain scores for (a) whole brain, (b) left brain and (c) right brain.
(ii) There will be no significant interaction between training strategies and personality types with respect to mean gain scores on (a) whole brain, (b) left brain and (c) right brain.

(iii) Field - independents and field-dependents will not have significant interaction with training strategies for mean gain scores of (a) whole brain, (b) left brain and (c) right brain.

(iv) Levels of intelligence will not interact significantly with personality types in respect of mean gain scores on (a) whole brain, (b) left brain and (c) right brain.

(v) There will be no significant interaction between levels of intelligence and cognitive style for mean gain scores of (a) whole brain, (b) left brain and (c) right brain.

(vi) Personality types and cognitive style will have no significant interaction with respect to mean gain scores on (a) whole brain, (b) left brain and (c) right brain.

2nd Order

13(i) Interaction among training strategies, levels of intelligence and personality types will not be significant for promoting gains on (a) whole brain, (b) left brain and (c) right brain.

(ii) Training strategies, levels of intelligence and cognitive style will have no significant interaction with respect to mean gain scores on (a) whole brain, (b) left brain and (c) right brain.

(iii) There will be no significant interaction among training strategies, personality types and cognitive style for mean gain scores on (a) whole brain, (b) left brain and (c) right brain.
Levels of intelligence, personality types and cognitive style will not interact significantly for mean gain scores on (a) whole brain, (b) left brain and (c) right brain.

3rd Order

Interaction among training strategies, levels of intelligence, personality types and cognitive style will not be significant with respect to mean gain scores on (a) whole brain, (b) left brain and (c) right brain.

7.3 Sample

The multi-stage random sampling technique was employed to raise the sample. 260 students of IX class were taken to conduct the study.

Four schools were randomly selected out of recognised and aided high schools of Ludhiana city. 65 students were selected randomly from IX class of each school. Out of four schools, two schools were randomly assigned to group G₁ and two schools to group G₂. Those students who did not attend regularly were dropped later on. So 240 students were taken for analysis of data. Each group included 120 students.

7.4 Experimental Design and Procedure

The design of the present study was pretest-post test-experimental design. Group G₁ was given training through strategy A₁ and group G₂ through strategy A₂. The training lasted for 6 weeks. Achievement test in creative problem solving skills in mathematics and Torrance’s test of style of Learning and Thinking were administered before and after
training. Hundal's General Mental Ability Test, Eysenck's M.P.I. and Witkin's group Embedded Figures Test were also administered to the subjects of both groups.

7.5 Tools used

Following tools were used to collect data:

- Training strategies: $A_1$-strategy to train right hemisphere and $A_2$-strategy to train left hemisphere.
- Achievement Test to measure Creative Problem-solving Skills in Mathematics (developed by the investigator for local use).
- Torrance's test for Style of Learning and Thinking, SOLAT (1988).
- Hundal's General Mental Ability Test, Panjabi version (1962).
- Eysenck's Maudsley Personality Inventory (Hindi version) by Jalota and Kapoor (1966).
- Group Embedded Figure Test by Witkin et al. (1971).

7.6 Data Collection

Using above mentioned tools, the following data were collected:

- Achievement scores in creative problem-solving skills in mathematics on the following dimensions:
  (a) Fluency (F)
  (b) Flexibility (X)
  (c) Originality (O)
  (d) Creative problem-solving skill totals
- Cerebral dominance scores in respect of:
  (a) Whole brain (W)
  (b) Left brain (L)
  (c) Right brain (R)
- Intelligence scores
- Personality scores
- Cognitive Style scores

7.7 Statistical Analysis of Data

The data were analysed by computing mean, median and S.D. To test hypotheses analysis of variance (2 x 2 x 2 x 2) and t-ratios were computed. The results are given in Tables 5.6, 5.7, 5.8, 5.9, 5.14, 6.6, 6.7, 6.8, 7.1, 7.2, 7.3 and 7.4.

Table 7.1
Summary of mean gain scores and F-ratios of groups taught through strategy A₁ and strategy A₂ for creative problem solving skills and cerebral dominance

<table>
<thead>
<tr>
<th>Sr. no.</th>
<th>Variable</th>
<th>Strategy A₁</th>
<th>Strategy A₂</th>
<th>F-ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Fluency</td>
<td>13.120</td>
<td>5.037</td>
<td>53.22**</td>
</tr>
<tr>
<td>2.</td>
<td>Flexibility</td>
<td>11.268</td>
<td>4.088</td>
<td>42.64**</td>
</tr>
<tr>
<td>3.</td>
<td>Originality</td>
<td>15.520</td>
<td>5.037</td>
<td>66.10**</td>
</tr>
<tr>
<td>4.</td>
<td>Creative problem-solving skill totals</td>
<td>39.142</td>
<td>14.062</td>
<td>82.68**</td>
</tr>
<tr>
<td>5.</td>
<td>Whole brain</td>
<td>12.908</td>
<td>2.217</td>
<td>46.01**</td>
</tr>
<tr>
<td>6.</td>
<td>Left brain</td>
<td>-18.600</td>
<td>-1.517</td>
<td>65.14**</td>
</tr>
<tr>
<td>7.</td>
<td>Right brain</td>
<td>5.174</td>
<td>0.591</td>
<td>3.37</td>
</tr>
</tbody>
</table>

** 0.01 level
Table 7.2
Summary of mean gain scores and F-ratios of high intelligence to and low intelligence subjects for creative problem-solving skills and cerebral dominance

<table>
<thead>
<tr>
<th>Sr. no.</th>
<th>Variable</th>
<th>Mean gain scores of high intelligence group</th>
<th>Mean gain scores of low intelligence group</th>
<th>F-ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Fluency</td>
<td>10.014</td>
<td>8.128</td>
<td>0.03</td>
</tr>
<tr>
<td>2.</td>
<td>Flexibility</td>
<td>8.348</td>
<td>6.997</td>
<td>0.18</td>
</tr>
<tr>
<td>3.</td>
<td>Originality</td>
<td>13.150</td>
<td>7.359</td>
<td>5.20*</td>
</tr>
<tr>
<td>5.</td>
<td>Whole brain</td>
<td>8.437</td>
<td>6.674</td>
<td>1.17</td>
</tr>
<tr>
<td>6.</td>
<td>Left brain</td>
<td>-12.024</td>
<td>-8.061</td>
<td>0.00</td>
</tr>
<tr>
<td>7.</td>
<td>Right brain</td>
<td>4.363</td>
<td>1.378</td>
<td>2.03</td>
</tr>
</tbody>
</table>

* 0.05 level
** 0.01 level
Table 7.3
Summary of mean gain scores and F-ratios of extraverts and introverts in respect of creative-problem-solving skills and cerebral dominance

<table>
<thead>
<tr>
<th>Sr. no.</th>
<th>Variable</th>
<th>Mean of gain scores of extraverts</th>
<th>Mean of gain scores of introverts</th>
<th>F-ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fluency</td>
<td>10.117</td>
<td>7.788</td>
<td>1.04</td>
</tr>
<tr>
<td>2</td>
<td>Flexibility</td>
<td>8.177</td>
<td>7.058</td>
<td>0.33</td>
</tr>
<tr>
<td>3</td>
<td>Originality</td>
<td>9.598</td>
<td>11.124</td>
<td>4.48*</td>
</tr>
<tr>
<td>4</td>
<td>Creative problem-solving skills</td>
<td>27.681</td>
<td>25.260</td>
<td>0.61</td>
</tr>
<tr>
<td>5</td>
<td>Whole brain</td>
<td>6.624</td>
<td>8.729</td>
<td>4.65*</td>
</tr>
<tr>
<td>6</td>
<td>Left brain</td>
<td>-10.842</td>
<td>-9.086</td>
<td>0.16</td>
</tr>
<tr>
<td>7</td>
<td>Right brain</td>
<td>4.104</td>
<td>1.364</td>
<td>1.36</td>
</tr>
</tbody>
</table>

* 0.05 level
Table 7.4

Summary of mean gain scores and F-ratios of field independents and field dependents for creative problem-solving skills and cerebral dominance

<table>
<thead>
<tr>
<th>Sr. no.</th>
<th>Variable</th>
<th>Mean of gain scores of field dependents</th>
<th>Mean of gain scores of field dependents</th>
<th>F-ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>fluency</td>
<td>9.717</td>
<td>8.495</td>
<td>0.87</td>
</tr>
<tr>
<td>2.</td>
<td>Flexibility</td>
<td>8.653</td>
<td>6.797</td>
<td>2.73</td>
</tr>
<tr>
<td>3.</td>
<td>Originality</td>
<td>12.412</td>
<td>8.347</td>
<td>4.07*</td>
</tr>
<tr>
<td>5.</td>
<td>Whole brain</td>
<td>10.254</td>
<td>5.128</td>
<td>8.15**</td>
</tr>
<tr>
<td>6.</td>
<td>Left brain</td>
<td>-11.500</td>
<td>-8.755</td>
<td>0.32</td>
</tr>
<tr>
<td>7.</td>
<td>Right brain</td>
<td>2.183</td>
<td>3.515</td>
<td>2.45</td>
</tr>
</tbody>
</table>

* 0.05 level
** 0.01 level
7.8 Conclusions

The following conclusions were drawn from the results of present study.

1. Right brain training strategy emerged as a superior strategy to the left brain training strategy so far as creative problem-solving skills in mathematics, measured by the test developed by the investigator, was concerned. Students became more fluent, flexible and original in solving problems (Table 7.1).

2. There was a shift from left hemisphere mode of learning towards the integrated mode, that is whole brain by training the right hemisphere (Table 7.1).

3. High intelligent subjects scored higher on originality than low intelligent subjects irrespective of training strategies whereas fluency, flexibility and creative problem-solving skill totals were not affected by levels of intelligence (Table 7.2).

4. Introverts scored higher on originality in solving mathematical problems than extraverts irrespective of strategies of training, whereas other dimensions of creative problem-solving skills were not affected by personality types (Table 7.3).

5. The group having field independent cognitive style scored higher on originality than field dependent group on creative problem solving skill test (Table 7.4).

6. Introverts and field independents used integrated mode of learning than extraverts and field-dependents respectively, irrespective of training strategies (Table 7.3 and 7.4).
7. Levels of intelligence, personality types, cognitive style and training strategies when paired among themselves did not show any interaction in terms of performance in creative problem-solving skills in mathematics and cerebral dominance (Tables 5.6, 5.7, 5.8, 5.9, 6.6, 6.7 and 6.8).

8. Extravert-field independent subjects who got training through right brain strategy became more flexible in solving mathematical problems than their counterparts who were trained through left brain strategy (Tables 5.14, Sr. no.4).

9. Extravert-field independent subjects show more flexibility in solving mathematical problems when taught through right brain strategy than extravert-field dependent subjects who were trained through left brain strategy (Table 5.14, Sr. no. 5).

10. Extravert-field independent subjects had higher flexibility scores in solving mathematical problems when they got training through right hemisphere strategy than introvert-field independents who were given left hemisphere strategy (Table 5.14, Sr. no. 6).

11. Field independents possessing extravert personality when taught through right brain strategy became flexible in solving mathematical problems than field-dependents having introvert personality and taught through left brain strategy (Table 5.14, Sr. no. 7).

12. In case of extraverts getting training in right hemisphere and having field dependent cognitive style were found to be more flexible in solving mathematical problems than extraverts of field independent cognitive style getting training through left hemisphere (Table 5.14, Sr. no. 10).
13. Extravert-field dependents taught through right hemisphere strategy scored higher on flexibility than their counterparts (Extravert-field dependents) who were taught through left brain strategy (Table 5.14, Sr. no. 11).

14. Introvert-field independents getting training in left hemisphere solved mathematical problems more flexibly than extravert-field dependents getting training in right hemisphere (Table 5.14, Sr. no. 12).

15. Field-dependents trained through right hemisphere strategy and possessing extravert nature were found to be more flexible in solving mathematical problems than field dependents of introvert nature and getting training in left hemisphere (Table 5.14, Sr. no. 13).

16. Field independents having introvert personality and taught through right hemisphere strategy scored higher on flexibility than field independents of extravert nature and trained through left brain strategy (Table 5.14, Sr. no. 15).

17. Through right hemisphere strategy, introvert-field independents had higher flexibility scores than extravert-field dependents taught through left hemisphere strategy (Table 5.14, Sr. no. 16).

18. Introvert-field independents getting training through left hemisphere strategy were found to be more flexible in solving mathematical problems than introvert-field independents getting right hemisphere training (Table 5.14, Sr. no. 17).
19. In case of introverts, field independent subjects scored higher on flexibility when given right hemisphere training than field dependents who were given left hemisphere training (Table 5.14, Sr. no. 18).

20. In case of field dependents, introverts getting right hemisphere training showed more flexibility in solving mathematical problems than extraverts getting left hemisphere training (Table 5.14, Sr. no. 20).

21. Introverts with field independent cognitive style and getting left hemisphere training showed more flexibility in solving mathematical problems than introverts with field dependent cognitive style when taught through right hemisphere strategy (Table 5.14, Sr. no. 21).

7.9 Implications

The present study has a wide range of implications for the field of educational psychology. Some of the implications are given below:

The study revealed that increase in creative problem-solving skills is possible through training the right hemisphere and there is a shift towards the integrated mode of learning. So the traditional methods of teaching i.e. training the left hemisphere must be supplemented by methods of training the right hemisphere, so that the whole brain may be utilized instead of half.

Curriculum taught in present educational system is not suitable for training the right hemisphere. It should be modified in such a way that there is a place for developing right hemisphere and both hemispheres cooperate for the full potential of human brain.
High intelligent subjects, introverts and field independent subjects become more original than low intelligent subjects, extraverts and field dependents respectively. Special care should be given to them, so that their talent can be explored.

Introverts and field independents shift towards the integrated mode of learning than extraverts and field dependents respectively, therefore, right brain training should be given to them, so that they develop integrated approach in solving mathematical problems.

7.10 Suggestions for Further Research

i. Replication of this study is encouraged to further substantiate the findings.

ii. Studies with smaller sample size may be carried so that more intensive training may be given.

iii. Research may be carried out by taking training periods of different duration.

iv. A follow-up research is advisable to find out to what extent the increase in creative problem-solving skills and change in cerebral dominance developed through training, persists.

v. Research may be replicated with male and female population, so that effect of training on sex may be noted.

vi. Effect of training on different age groups, different areas may be studied.

vii. Research may be carried out to find the effect of training on creative problem solving skills in subjects other than mathematics.

viii. Study may be replicated by taking other variables.

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