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Effectiveness of Heuristic Method in promoting Creativity and Achievement in Science among Senior Secondary School Students of Ranchi District

Shashi Toppo

Ph. D. Scholar, Central University of Jharkhand, Ranchi

Abstract: In order to compete in today's global world the creativity and innovations have become inevitable aspects of everyone's life. This paper investigated how science teachers need to move beyond the rhetoric to effective practices for teaching and fostering creativity. This study aimed to find out the effect of Heuristic Method in promoting creativity and achievement in science among senior secondary school students. It was an experimental study. Sample of the study consisted of 80 students (40 in experimental group and 40 in controlled group) of standard XI from one senior secondary school of Ranchi District, Jharkhand. Experimental group was taught through Heuristic Method whereas the controlled group through traditional method. Rating Scale on Creativity and Achievement test in Science (developed and standardized by the researcher) were used as tools for data collection. Mean, S.D, Bar graphs and 't' test were applied to analyse the data and to draw inferences. The study revealed that Heuristic Method was more effective in promoting creativity and enhancing the Achievement in Science (Chemistry) among senior secondary school students compared to that of traditional Method of teaching Science (Chemistry). Based on the findings of the study the paper also gave some suggestions.

Keywords: Heuristic Method, Traditional Method, Creativity, Achievement in Science (Chemistry)

INTRODUCTION

Creativity and imagination are important in science education, a good science teacher needs to foster students' imaginative skills and creativity as students are future scientists and potential resource of any nation. National Curriculum Framework (NCF) 2005 reiterates that the aim of Science education should be to nurture the natural curiosity, aesthetic sense, and creativity of the child in the field of Science and technology and that the curriculum should engage the learners in acquiring the methods and processes that lead to the generation and validation of scientific knowledge. Creativity has been viewed as something that goes beyond domain – dependent knowledge and skill, however, in both conventional wisdom and most creativity theories. Creativity enables students to look at problems more openly and with innovation. Creativity inspires collective thinking, nurtures ideas and supports resilience. It is fun, joyful, surprising, keeps the mind active and opens the mind of the students. It enables alternative ways of thinking and enhances divergent thinking.

HEURISTIC METHOD

If we really want to make our students scientific and rational, Heuristic method is the best approach of teaching science. Heuristic method is derived from the Greek word 'Heuristo' meaning 'I find out'. Prof. Henry E. Armstrong (1848 – 1937), professor of chemistry at the Imperial College, London was a strong advocate of the heuristic method.

Heuristic method puts the students in the attitude of a discoverer or a researcher. Students should be helped to make their own discoveries based on curiosity and interest, the method makes the acquisition of hearing a great adventure. The desire to overcome difficulties should come from within. Herbert Spencer has thrown light on this method and stated that – "Students must be told minimum and as much as possible they should be encouraged to discover".

The teacher poses a problem before the students and they are provoked to solve it independently by providing all essential facilities and instructions for its solutions. The students may be encouraged to discuss all the aspects of the problem and then given freedom of thought and action for finding out its solution.

In this method the teacher must act only as a guide. He / she should be tolerant of noise, movements of students and their asking uncomfortable questions. He / she should help the students to search for a suitable problem, keeping in mind the age and interest along with the available facilities. Detailed instruction sheet should be given to the students. He / she

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must create an atmosphere of freedom to encourage self-development, spontaneity, self-expression, risk taking and decision making.

Merits of Heuristic Method

1. Development of Creativity
2. Enhancement of Scientific Attitude
3. Enhancement of Divergent thinking
4. Development of Imaginative skills
5. Active participation and involvement of students
6. Psychologically sound
7. Clarity and permanency of the knowledge
8. Cultivation of good habits
9. Providing individualised instructions
10. Good relationship between teacher and taught
11. Reduction in the load of home – work
12. Solves problem of indiscipline

Demerits and limitations

1. Not suitable for the elementary classes
2. Expects too much from the students
3. Too much expectations from the teachers
4. Difficulty in covering the syllabus
5. Possibility of faulty conclusions

CREATIVITY

It has been agreed that creativity is a process of an individual producing something unique for himself and others. According to Prof. Paul Torrance; a process of sensing gaps or finding out missing elements, creating ideas or formulating hypotheses and communicating their results and retesting the hypotheses are termed as creativity. Creative thinking is the product which has novelty and value for the thinker or the culture; the thinking is unconventional, highly motivated and persistent or of great intensity; the task requires a clear understanding of the problem. It may be useful to generalize that creative thinking involves the highest mental function and the focus is on the creation or invention.

Development of creativity in the classroom is a significant aspect of classroom interaction where many factors influence the process. A science teacher should know about the process of creativity, means of estimating and measuring creativity and his own role.

Creative process includes the following four stages:

1. Preparation: It is the stage in which a problem is identified and investigated.
2. Incubation: It is the stage where ideas are stored below the level of the psyche.
3. Illumination: A stage where the solution is suddenly experienced.
4. Verification: At this stage new ideas are evaluated.

In this present study the researcher has taken five creative abilities namely; originality, flexibility, imagination, sensitivity and elaboration. These abilities can be measured with the help of tests developed by the researcher and validated by the experts.

LITERATURE REVIEW

Cognitive, Flexibility, working memory and inhibitory control are three core executive functions involved in creative problem solving. Badrova and Leong (2001) had developed the tools to improve them. Teaching older students to be innovative demands instruction that explicitly promotes creativity but is rigorous content rich as well. Within the knowledge domain creative thinking requires a minimum level of expertise and fluency. Through the large body of research this difference was found between a novice and expert cognition (Bransford et al; 2000; Crawford and Brophy, 2006).The difference between the experts (who have the deeper knowledge of the subject) and novices, is their recognition of patterns in information, their ability to see conceptual frameworks or schemata (Bransford et al., 2000; Sawyer, 2005). The students who know enough to grasp meaningful patterns of information, who can readily get applicable knowledge from memory, and who can apply such knowledge effectively to novel problems. This condition of applying is referred to as adaptive expertise (Hatano and Ouro, 2003; Schwartz et al., 2005). Adaptive experts are capable of inventing and adapting strategies for solving unique or novel problems within a knowledge domain. Flexibility

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and innovative application of knowledge results in inventive and creative solutions to problems (Crawford and Brophy, 2006; Crawford, 2007). Hadzigeorgiou, Y., Fokialis, P., and Kabouropoulou, M., (2012) discussed about the notion of creativity in the contexts of science and science education. Trnova,E., and Trna, J. (2014) studied on implementation of creativity in Science training and concluded that creativity is important for students for their life long journey and for future success. Aguilar, D., and Turmo, M.,(2019) discussed on promoting social creativity in Science Education with digital technology to overcome inequalities: a scoping review.

Most of the studies have revealed that creative persons , in a variety of fields , exhibited the same pattern of values and interpersonal relations, including high theoretical and aesthetic values, high self-sufficiency, introversion, greater concern with ideas than with people and uninterested in social activities.

OBJECTIVES OF THE STUDY

1. To study the effectiveness of Heuristic Method in promoting Creativity in Science among senior secondary school students.
2.To study the effectiveness of Heuristic Method in promoting Creativity in Science in terms of originality, flexibility, imagination, sensitivity and elaboration among senior secondary school students.
3. To study the effectiveness of Heuristic Method on Achievement in science among senior secondary school students.

HYPOTHESES OF THE STUDY

$H_0$1: There is no significant difference in promoting Creativity in Science among senior secondary school students taught through Heuristic Method and Traditional Method.

$H_0$2: There is no significant difference in promoting Creativity in Science in terms of originality, flexibility, imagination, sensitivity and elaboration among senior secondary school students taught through Heuristic Method and traditional method

$H_0$3: There is no significant difference on Achievement in Science among senior secondary school students taught through Heuristic Method and traditional method.

POPULATION AND SAMPLE OF THE STUDY

In the present study the population consisted of senior secondary school students of Ranchi studying under state syllabus of Jharkhand State. Randomly 80 Science students of standard eleven were taken as sample for the study. Students were divided into Experimental and Control groups. The experimental and control groups consisted of 40 students each.

METHODOLOGY AND PROCEDURE OF DATA COLLECTION

The present study was an experimental study. In order to conduct the experiment, the investigator selected the school through simple random sampling technique. After selecting the school the investigator met the Science teacher (Chemistry) after obtaining the permission of principal. The dates to administer the test and implement the Heuristic Method were decided. The procedure in which the present study was conducted comprised of four phases. Phase I: Administration of the pre-tests a) Rating scale on Creativity in Science. b) Achievement test in Science (Chemistry). Phase II: Treatment. Phase III: Administration of the post-test. a) Rating Scale on Creativity in Science. b) Achievement test in Science (Chemistry). Phase IV: Analysis and interpretation of the data. Rating scale on Creativity in Science and Achievement test were constructed by the Investigator and validated by the experts. To measure the effect of Heuristic method on creativity and Achievement in Science, descriptive and inferential statistics were used.

DELIMITATIONS OF THE STUDY

1) The study was limited to only one randomly selected Senior Secondary School of Ranchi District.
2) The content chosen by the Investigator for the instructional material was limited only to the discipline of Science (Chemistry) from Standard eleven of state syllabus.
3) The Creativity in Science that have been studied in present study were limited to the abilities: originality, flexibility, imagination, sensitivity and elaboration only.

ANALYSIS AND INTERPRETATION

Objective One: To study the effectiveness of Heuristic method in promoting Creativity in Science among senior secondary school students.

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The descriptive and inferential statistics were used for analysis and interpretation of the objective one.

Table 1: Representing the Numbers, Mean, SD, 't' value and Results of Experimental and Control Groups on creativity in science among senior secondary school students

Group	N	Mean	SD	df	't' value	Significance Level
Experimental Group	40	7.18	2.26	78	3.68	Significant at 0.05 Level
Control Group	40	4.28	4.42			

From the table 1 it is observed that the obtained't' value is 3.68 and it is more than the theoretical value of 1.99.So, the alternate hypothesis gets accepted and the null hypothesis gets rejected. That is there is a significant difference in promoting creativity in science among the senior secondary school students taught through Heuristic method and Traditional Method. Further, as the experimental group mean (7.18) is more than control group mean (4.28), it can be concluded that the experimental group students have developed better Creativity in science than the control group students.

Second Objective: To study the effectiveness of Heuristic Method in promoting Creativity in Science in terms of originality, flexibility, imagination, sensitivity and elaboration among senior secondary school students.

The analysis and interpretation of the objective have been done using both descriptive and inferential statistics. The descriptive statistics used for analysis includes mean, Standard deviation and graphical representation with the help of bar graph, which has been presented in the form of table and figure.

Table 2: Mean and Standard Deviation of gain scores on creativity in science of the experimental and control groups in terms of originality, flexibility, imagination, sensitivity and elaboration.

Creativity	Group	Number of students	Mean	SD
Originality	Experimental	40	1.8	1.00
	Control	40	0.25	0.50
Flexibility	Experimental	40	0.88	1.27
	Control	40	0.63	1.73
Imagination	Experimental	40	1.35	1.50
	Control	40	0.40	1.24
Sensitivity	Experimental	40	1.28	0.47
	Control	40	1.80	1.22
Elaboration	Experimental	40	1.80	1.58
	Control	40	1.33	0.47

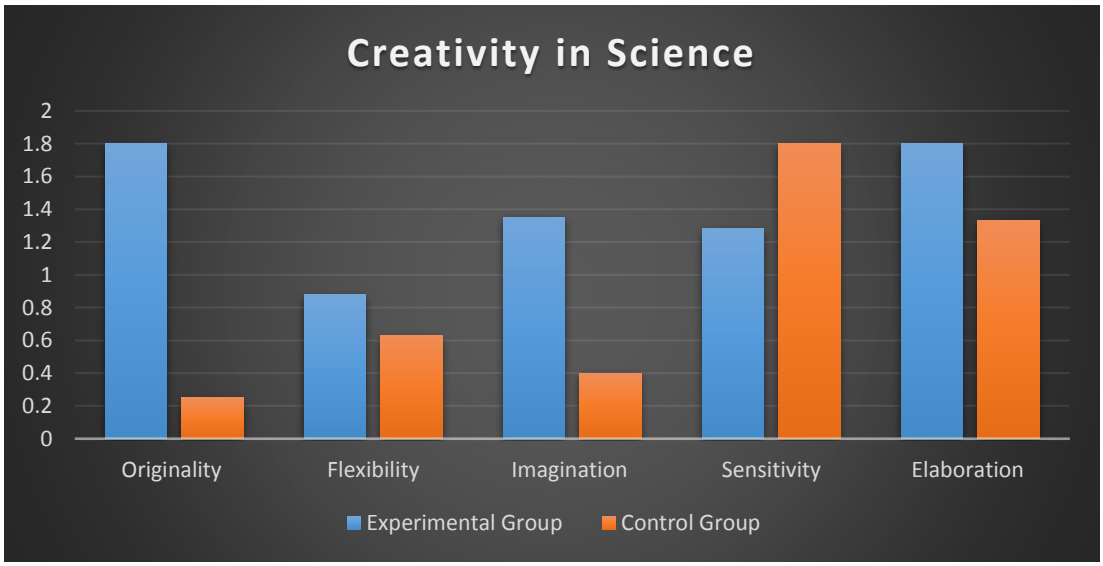

Figure 1: Representing the mean scores of the experimental and control groups in promoting creativity in science in terms of originality, flexibility, imagination, sensitivity and elaboration.

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From the table 2 and figure 1 it is observed that on the same test the mean scores in terms of originality, flexibility, imagination, sensitivity and elaboration of experimental group is higher than that of control group. Further the mean score in terms of sensitivity is higher in the case of control group in comparison with the experimental group. This shows that experimental group has performed better than control group in terms of originality, flexibility, imagination, and elaboration. The height difference between two bars show the difference between the scores of the two groups. The significance of the difference was tested using the inferential statistics.

To test the significance of difference in terms of creativity namely originality, flexibility, imagination, sensitivity and elaboration. Five null hypotheses were formulated in relation to objective two. Inferential statistics was used to analyze and interpret the null hypothesis. The't' test was used to find out the significant differences in the creativity in terms of originality, flexibility, imagination, sensitivity and elaboration of the students of Standard Eleven taught through Heuristic method and traditional Method. The null hypotheses are formulated below;

$H_0(1)$: There is no significant difference in promoting creativity in science namely originality among senior secondary school students taught through Heuristic method and traditional Method.

$H_0(2)$: There is no significant difference in promoting creativity in science namely flexibility among senior secondary school students taught through Heuristic method and traditional Method.

$H_0(3)$: There is no significant difference in promoting creativity in science namely imagination among senior secondary school students taught through Heuristic method and traditional Method.

$H_0(4)$: There is no significant difference in promoting creativity in science namely sensitivity among senior secondary school students taught through Heuristic method and traditional Method.

$H_0(5)$: There is no significant difference in promoting creativity in science namely elaboration among senior secondary school students taught through Heuristic method and traditional Method.

Table 3: Number (N), Mean (M), Standard deviation't' value and results of gain scores on Creativity in science among senior secondary school students of Experimental and Control groups.

Creativity	Group	Number of students	Mean	SD	't' value	Remark
Originality	Experimental	40	1.8	1.00	8.60	Significant at 0.05 level
	Control	40	0.25	0.50		
Flexibility	Experimental	40	0.88	1.27	2.32	Significant at 0.05 level
	Control	40	0.63	1.73		
Imagination	Experimental	40	1.35	1.50	3.10	Significant at 0.05 level
	Control	40	0.40	1.24		
Sensitivity	Experimental	40	1.28	0.47	2.48	Significant at 0.05 level
	Control	40	1.80	1.22		
Elaboration	Experimental	40	1.80	1.58	1.88	Not Significant at 0.05 level
	Control	40	1.33	0.47		

From the table 3 it is observed that the obtained 't' value corresponding to originality, flexibility, imagination and sensitivity are 8.60, 2.32, 3.10 and 2.48, which are greater than the theoretical value of 1.99. Hence, the null hypotheses $H_0$1, $H_0$2, $H_0$3 and $H_0$4 are rejected and the alternate hypotheses are accepted. This means that there are significant difference in the creativity in science namely originality, flexibility, imagination and sensitivity among senior secondary school students taught through Heuristic method and traditional method. It is observed that the obtained't' value corresponding to elaboration is 1.88 and it is less than the theoretical value 1.99. Hence, the null hypothesis is accepted that "there is no significant difference in the creativity in science namely elaboration among senior secondary school students taught through Heuristic method and traditional method". Finally, it can be concluded that Heuristic method is better than traditional method in promoting creativity in Science among senior secondary school students.

Third Objective: To study the effectiveness of Heuristic method on Achievement in Science among senior secondary school students.

The descriptive and inferential statistics were used for analysis and interpretation of the objective three.

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Table 3: Representing the Numbers, Mean, SD, 't' value and Results of Experimental and Control Groups on achievement in science

Group	N	Mean	SD	df	't' value	Significance Level
Experimental Group	40	24.95	5.94	78	4.59	Significant at 0.05 level
Control Group	40	12.41	5.78			

Form the above table it is observed that the obtained 't' value 4.59 is greater than the theoretical value 1.99. Therefore, the null hypothesis "there is no significant difference on Achievement in Science among senior secondary school students taught through Heuristic method and Traditional Method" is rejected and the research hypothesis is accepted. Hence, it is concluded that there exists a significant difference in the mean gain scores of Experimental Group and Control Group on Achievement in Science among senior secondary students.

RESULTS AND DISCUSSION

1. It is found that Heuristic method is more effective than traditional method in promoting creativity in science among the senior secondary school students.
2. It is found that Heuristic method is more effective than traditional method in promoting creativity in terms of originality, flexibility, imagination, sensitivity and elaboration among senior secondary school students.
3. It is found that experimental group of senior secondary school students have better achievement in Science than control group senior secondary school students. Hence, heuristic method is more effective than the traditional method.

Some of the suggestions are as follows:

1. Students should get a variety of learning situations to solve the problems.
2. Heuristic Method (Discovery Approach) or Problem solving method should be encouraged in the science education.
3. Thought provoking questions should be asked in the classroom to stimulate thinking among the students.
4. Students should be encouraged to practice risk taking abilities, independent judgement, and self-assured actions.
5. Science teachers should create a conducive environment to meet the curiosity of the students
6. Science teachers should provide experiences with mind stretching exercises.
7. Students should get an opportunity to increase sensitivity.
8. Students should be helped by science teachers to understand why they engage in various exercises related to creative thinking.

CONCLUSION

In Indian school situation, it is the responsibility of the science teacher to provide conducive environment for students where they can work independently and solve problems with innovation. It will enable the students to develop creativity, take challenges, see in new ways, recognize new patterns, make new connections, construct new networks, take risks, take advantages of chances, think originally, flexibly, divergently and imaginatively, ability to elaborate, ability to improvise, innovate and invent. A science teacher can utilize science club and Science Lab as places which stimulate self-learning and students can pursue projects of their own choice.

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