Effectiveness of Concept Mapping Strategy on Physical Science Learning

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ABSTRACT *In educational psychology, helping students in the teaching-learning process to make a meaningful learning experience is an important issue. In case of teaching a new concept it should always start with the presentation of an advance organizer which helps learner in conceptualizing how the new knowledge appropriates with the broader framework. Thus, concept mapping is the best option to construct knowledge in a structural process. The present study was carried out to investigate how far concept mapping strategy has significant effect on student achievement in physical science learning in comparison to the demonstration strategy at secondary level. True experimental design of randomized Solomon four equivalent groups design was applied in this study. Sample of the study consisted of 41 (20 experimental group and 21 controlled group) class IX students from one co-ed school of Howrah district. Experimental group was taught through concept mapping strategy and the controlled group was taught through demonstration strategy. Mixed type group test of intelligence (MGTI) by Dr. P.N. Mehrotra (2008) was used to match the groups. Achievement test in physical science (developed and standardized by the researcher) was used as tool for data collection. Descriptive statistics were applied for data analysis. Inferential statistics like "t" test and ANOVA were also applied to find out the results and inferences. Data was tabulated and analyzed by Excel and SPSS software technique in both. The result of the study showed that there was no significant deference present in gain score achievement (p>0.05) in physical science of class IX students of the experimental and control group.*

Keywords: *Concept Map, Physical Science Learning.*

I. INTRODUCTION

Introduction: In this science and technological era of 21st century, creative innovations of various technology, strategies, new experiments etc. makes a drastically change in all the level of educational field at a faster rate. Nature of teaching-learning process is also improved and modified many times significantly by the help of these innovations. Effective science teaching-learning process very much depends on the nature of representing information in this process. The NCF – 2005 emphasizes learner-centered approach to achieve the objective of the curriculum. Concept Mapping is the unique way for representation of information easily by the learners themselves. This teaching strategy can facilitate the construction of knowledge significantly.

What is Concept Map?: Concept maps reproduce how information is organized and represented in memory. It shows what individuals have knowledge and how their knowledge is structured. Theoretically, knowledge is structured as a semantic network (Collins & Quillian, 1969). On the basis of Ausubel's (1968) meaningful learning theory, Prof. J. D. Novak and his team of researchers at Cornell University developed an instructional aid or technique called 'Concept Map' in the 1970s as a representation of learner's knowledge in science (Novak and Gowin, 1984). Carnine, Silbert, Kame'euni, & Traver (2004) said that "Concept maps, sometimes called graphic organizers or visual-spatial displays, are another way to present material visually (cited in Conderman, Bresnahan & Pedersen, 2009, p. 69).

Concept Map - As an Assessment tool: Ruiz-Primo (2000) describes "concept maps as an assessment tool to measure the organization of propositional (declarative) knowledge in a domain. It consists of a task that elicits structured knowledge, a response format, and a scoring system". According to Lehman, Carter, & Kahle (1985); Mintzes, Wandersee, & Novak (1998) and Novak, Gowin, & Johansen (1983) it is said that - "Concept mapping is potentially a productive tool to identify particular students' misconceptions" (cited in Lawson, 2010, p. 279).

Concept Map and Physical Science Learning: Science is a way or approach adopted for the acquisition of knowledge in search of truth (Mangal & Mangal, 2015, p. 11). From the very beginning of the civilization science performs a crucial role to help the human being in their pursuit of knowledge. It is a dynamic, expanding body of knowledge covering every aspects of the domain of experience. Physical science is one of the parts of science subject. Thus it regards as a compulsory subject in school curriculum. A learner centric instructional approach i.e. concept mapping strategy in the teaching-learning process facilitates cooperative learning in science education. It enhances students' physical science learning experience and achievement

also. This strategy facilitates to identify link between concepts, to consolidate concept in basic forms, to develop problem solving skill, to bring depth & breadth to the learning experience, to relate with the previous knowledge etc. Through this strategy science teaching-learning process becomes easier and student's achievement becomes significantly better than any other strategy (Emmanuel, 2013; Chiou, 2008; Oviawe & Lukmon, 2017 etc). Teaching-learning through this strategy is one type of indirect instruction (Mukherjee, 2014-2015, p. 65). Johnson et al. (1981) were said in their research that "students work in small groups and cooperative in striving to learn subject matter, positive cognitive and affective outcomes result" (cited in Novak, 2008,http://cmap.ihmc.us/Publications/ResearchPapers/TheoryCmaps/TheoryUnderlyingConcetMaps.htm).

Need and Importance of the study: Science is one of the important and compulsory subjects in school. But practically majority of school students ignores to learn science due to lack of interest and motivation. That's why their achievement towards science becomes low. Majority of teachers generally follow the conventional methods of instruction in schools. Most of the cases students play a passive role. At secondary level, it is very much necessary to teach scientific concepts significantly and meaningfully. Through hands on experiences students can get meaningful learning. Indian Education Commission (1964-66) criticized that if science is poorly taught and badly learnt then it will be burden for learner's mind. Sharma, Harsana & Sharma (2013); Aziz & Rahman (2014); Chawla (2015); Chiou (2008) and Karakuyu (2010) – all have reported that the effectiveness of learning through concept mapping strategy over other strategy is more significant and that concepts maps play positive role in enhancement of learning basic concepts of science. Concept mapping teaching strategy can facilitate this construction of knowledge significantly. Ultimately their achievement will be enhanced. That's why researcher wants to investigate how far concept mapping strategy has significant effect on student achievement in comparison to the demonstration strategy. Hence it has a great need and importance to study the effectiveness of concept mapping strategy on achievement in physical science at secondary level.

Objective:
To compare the effect of concept mapping strategy and demonstration strategy on students' achievement in physical science at secondary level.

Hypothesis:
H_o: There is no significant difference between gain score achievement in physical science teaching through concept mapping strategy and demonstration strategy at secondary level.

Delimitations of the study: The study had following delimitations:
1) This study was conducted on a Co-Ed school named as Gangadharpur Vidyamandir of Howrah district in West Bengal only.
2) The present study was delimited to West Bengal Board of Secondary Education (W.B.B.S.E.) School only.
3) This study was delimited to the secondary level of the school only.
4) The present study was delimited to class – IX standard of secondary level only.

II. METHODOLOGY

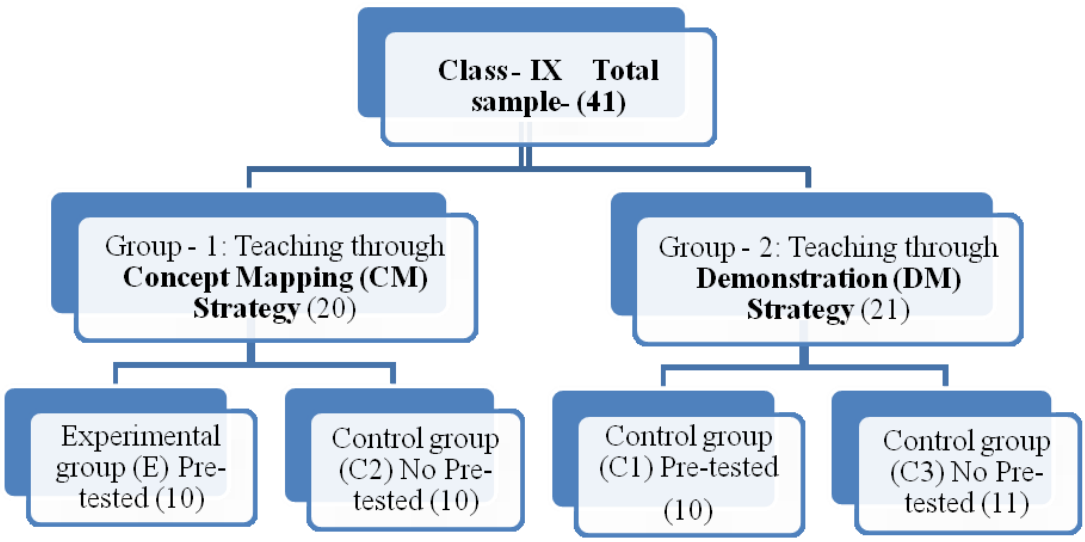
Method of the Study: In this study experimental method was used for controlling and establishing systematic and logical association between manipulated factors and observed effect.
Research Design: True experimental design of randomized Solomon four equivalent groups design was applied in this present study.
Research Paradigm: According to Koul (2014, p. 156), the research paradigm of the study is shown in the following table:

Randomly Assigned	Pre-test (T1)	Independent Variable	Post-test (T2)
Experimental group (E)	T1E	Teaching through Concept Mapping Strategy	T2E
Control group (C1)	T1C1	Teaching through Demonstration Strategy	T1C1
Control group (C2)	No Pre-test	Teaching through Concept Mapping Strategy	T2C2
Control group (C3)	No Pre-test	Teaching through Demonstration Strategy	T2C3

Population and sample of the study: Researchers had considered Bengali Medium Secondary Schools in Gangadharpur, Howrah, under West Bengal Board of Secondary Education as target population. One Bengali

Medium Secondary School (Co-Ed) named as Gangadharpur Vidyamandir had been selected as sample for applying the experimental design. Purposive random sampling technique had been used by the researchers.

Structuring of the Sample: After the experimentation, sample structure was as follows:



Sample of the study consisted of 41 (20 experimental group and 21 controlled group) class IX students. Experimental group was taught through concept mapping strategy and the controlled group was taught through demonstration strategy.

Variables of the study: Investigators had taken teaching strategy (teaching through concept mapping strategy and demonstration strategy) as an independent variable and achievement of students in physical science as a dependent variable in this study. Intervening variables such as boredom, fatigue, excitement, anxiety of the students etc. may not be observed by the experimenter. These intervening variables were beyond the control of the researchers and hence it remains uncontrolled throughout the experimentation. Extraneous variables were controlled by employing following techniques such as technique of elimination, constancy of conditions, organizing matched group, and applying randomization process for chance selection and assignment of subjects to experimental and control groups.

Tools used for the study: Researchers had used Mixed Type Group Test of Intelligence (MGTI) of Dr. P. N. Mehrotra (2008) for measuring intelligence of student and a self made achievement test as measuring tools for this study. A unit plan was prepared on "Matter: Structure of Atom, Physical & Chemical Properties of Matter" from physical science textbook of class IX syllabus of WBBSE was based on concept mapping teaching strategy, selected as an instructional tool for instructing the experimental group. The structure of this unit plan was based on David. P. Ausubel's Advance Organizer Model (AOM) where instruction was given through the concept mapping strategy by using five concept maps, prepared by taking the idea from "Learning, Creating, and Using Knowledge" of Joseph D. Novak, 2012, p. 32. A conventional unit plan was prepared and used for instructing the control group through demonstration strategy.

Procedure of data collection: In this study researchers had selected class – IX standard students of 'Gangadharpur Vidyamandir' as a target population for data collection. According to their intelligence (Mixed Type Group Test of Intelligence) score (T- score) a matched group was prepared. Matched group 1 was selected randomly as 'Experimental Group' and matched group 2 was 'Control Group'. From one half of each group was decided to take a pre-test (T1) before the treatment applied. An achievement test was constructed on class IX physical science chapter 4 of - "Matter: Structure of Atom, Physical & Chemical Properties of Matter". At first it was standardized then applied in Pretest (T1) and Posttest (T2) both. After administering pretest (T1), 'Matched group 1' was taught through concept mapping strategy and 'Matched group 2' was taught through demonstration strategy. This treatment was going on for seven days. After completing the treatment, all the four groups were Post-tested (T2) by using same standardized test which was applied in pretest (T1). Hence, considering the experimental mortality, 56 samples were taken in consideration. After normalization of these samples 41 samples were finalized for analysis the data and interpret the result.

Software & techniques used for the Study: Researchers had used the following statistical techniques like Mean, Variance, Standard Deviation, Standard Error of Mean, 't'-test, ANOVA etc. In this study data was tabulated and analyzed by Excel and SPSS software technique in both.

III. DATA ANALYSIS & INTERPRETATION

Part 1 - Test for Matched Group: The Experimental and Control groups were matched on the basis of intelligence score (I.Q. Score). 'T'- test was worked out on this I.Q. score and the values are given in the following tables:

Table 1: Group Statistics of I.Q. Score * Type of group:

Subject	Teaching Strategy	Type of Group	N	Mean	Std. Deviation	Std. Error Mean
I.Q. Score	Concept Mapping	Experimental Group	20	32.200	9.4902	2.1221
	Demonstration	Control group	21	35.810	12.1722	2.6562

Table 2: Independent Sample Test of I.Q. Score:

Subject	Variance Nature	Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
I.Q. Score	Equal variances assumed	1.216	**0.277**	-1.055	39	**0.298**	-3.6095	3.4206

- **Interpretation:** Table 1 shows the group statistics of experimental and control groups of I.Q. score. The table 1 reveals that the mean I.Q. score of experimental group (Group 1, taught through Concept Mapping Strategy) and control groups (Group 2, taught through Demonstration Strategy) are 32.200 & 35.810 and their corresponding standard deviation 9.4902 & 12.1722 respectively. Their standard errors of means are 2.1221 & 2.6562 respectively. In the table 2 of Levene's Test for Equality of Variances, it is shown that the Sig. value of I.Q. score is 0.277, which is greater than 0.05 ($p>0.05$). That is equal variances assumed for t-test for Equality of Means. Sig. (2-tailed) value of the 't'-test is 0.298, which is greater than 0.05 ($p > 0.05$). Hence, 't' is not significant. Thus, there is no significant difference present in both the groups with respect to intelligence score, i.e. experimental and control groups are matched on the basis of intelligence.

Part 2 - Test for H_0: To investigate the significant difference in achievement in physical science of the experimental and control group of pre-tested and post-tested group taught through concept mapping and demonstration teaching strategy, descriptive statistics and t-test was applied between mean gain scores of students of experimental & control group.

Table 3: Group Statistics of Pre-tested Test Group:

Deference between the Test	Type of Group	Teaching Strategy	N	Mean	Std. Deviation	Std. Error Mean
Gain (Post Test-Pre Test)	Experimental Group (E)	Concept Mapping (CM)	10	**3.600**	**2.5033**	0.7916
	Control Group (C1)	Demonstration (DM)	10	**3.000**	**4.3205**	1.3663

Table 4: Independent Samples Test of Pre-tested Test Group:

Deference between the Test	Variance nature	Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Gain (Post Test-Pre Test)	Equal variances assumed	3.016	**0.100**	0.380	18	**0.708**	0.6000	1.5790

- **Interpretation:** Table 3 reveals that group statistics of gain score in achievement in physical science of post-tested (T2) and pre-tested (T1) experimental and control group taught through concept mapping and demonstration strategy. It shows that mean gain (Post Test - Pre Test) score of achievement in concept mapping and demonstration teaching strategies are 3.600 & 3.000 respectively. Standard deviations are 2.5033 & 4.3205 respectively. Standard error of means is 0.7916 & 1.3663 respectively. It shows that the groups are heterogeneous in nature. On application of 'F'–test through SPSS software, table 4 of independent samples test is obtained. It shows the results of two tests, that is: Levene's Test for equality of variances and 't'-test for equality of means. Sig. value of Levene's Test for equality of variances shows 0.100, which is greater than 0.05 ($p>0.05$). Hence, 'F' is not significant at 0.05 level of significance. It indicates that the two groups have equal variances. Hence, the statistics associated with equal variances assumed was used here for the 't'-test for equality of means. The 't'-test result shows that the Sig. (2-tailed) value is 0.708, which is greater than 0.05 ($p>0.05$). Hence, 't' is not significant. Therefore the null hypothesis is not rejected at 0.05 level of significance. Thus, it is concluded that no significant deference present in gain score in achievement in physical science of experimental (E) and control group (C1). But a mean gain score deference is present in between them i.e. students (taught through concept mapping strategy) of experimental group (Gain Mean score = 3.600) are significantly better in achievement in physical science than the students (taught through demonstration strategy) of control group (Gain Mean score = 3.000).

IV. DISCUSSION & CONCLUSION

Discussion of the Result: Finding of the present study indicated that concept mapping teaching strategy had no significant effect on the achievement in physical science on class IX students than teaching through demonstration strategy. Hence null hypothesis (H_0) is accepted in this present study. The same findings have been seen in other research studies: Moreira (1978); Lehman, Carter & Kahle (1985); Pankratius (1990); Peter G. Markow & Robert A. Lonning (1998); Snead Donald & Snead, Wanda L (2004); BouJaoude & Attieh (2008); Karakuyu (2010); Nwoke, Iwu & Uzoma (2015); Martins-Omole, Yusuf & Guga (2016). Thus it can be concluded from the finding that the application of concept mapping teaching strategy has no significant effect on the achievement in physical science. These studies are similar to the present finding. Present study shows that mean gain ((Post Test-Pre Test) score of achievement in concept mapping and demonstration teaching strategies are 3.600 and 3.000 respectively. This deference arises due to the deferent treatment i.e., by concept mapping strategy and demonstration strategy. The mean gain score result shows that concept mapping teaching strategy improves students' achievement in physical science of class IX. But, in spite of the mean gain deference present between the two groups it was not sufficient for rejecting the null hypothesis (H_0). Significant changes between the experimental (E) and control group (C1) (teaching through concept mapping strategy and demonstration strategy) comes after a long period of giving instruction to the learner. The reasons behind this finding are – 1) Teaching through concept mapping strategy enhances long term memory of the learners. To familiar with this strategy it should take a long time for meaningful learning (Novak J. D. & Musonda D., 1952). 2) Sometimes students were said that it was no words for linking the concepts. Cardemone (1975) & Bogden (1977) said in their research that they did not have words on the linking lines between concepts. 3) Stuart (1985) - reviewed the use of concept maps in research, instruction and assessment. He presented a variant of Novak, Gowin and Johansen's system of scoring concept maps and acknowledged the deficiencies of current scoring schemes. It was concluded that a more holistic and qualitative scoring technique needs to be developed. 4) Briscoe (1991) indicated that students are usually of the opinion that to memorize contents in the text book is enough and it does not make much sense creating concept mapping. Other students comment that to use concept

mapping in learning is difficult. Many students even think that they do not have sufficient knowledge framework to create concept mapping and tend to give up when the slightest frustration is encountered. 5) Otis (2001) reported that concept maps are not appropriate for assessment purposes, because the complexity of a map does not appear to be correlated with concept understanding.

Educational Implications: Educational implications of concept mapping strategy in learning physical science are potentially signified in now a day. It needs to be explored in our schools as they are of tremendous use for learners, teacher, curriculum developers and evaluators (cited in Pedagogy of Science, Textbook For B.Ed. Part - I, N.C.E.R.T., 2013, p. 233). According to this textbook, some educational implications of concept mapping strategy are – 1) It will be helpful for learners to construct their knowledge positively. 2) Concept maps can be used by the learners for meaningful acquisition of concepts. 3) Learner can make better sense of the complex materials. 4) Learner's knowledge gaps can be identified through the concept mapping strategy. 5) Students can summarize materials at the time of the examination preparation. 6) This strategy helps a teacher to plan a lesson by identifying key concepts. 7) It remarkably helps a teacher to identify the learner's misconceptions in their learning process.

Limitations of the Study: Investigators have faced some problems or constraints during this study. Future researcher should take these limitations under consideration on their research work. Some of those limitations were: 1) Due to shortage of time period, the instruction (treatment) was given only for 8 working days. 2) Only two subunits were taken from the selected unit for giving instruction to the learners in those 8 working days. 3) During this short period a good rapport between students and teacher was not established properly. It will be better if the study will conduct in a residential school. 4) Absenteeism of the subjects is another vital limitation of this study. It is very unlikely that all the subjects will attend for the instructional period for all the day. Experimental mortality is the major limitation in this study.

Conclusion: From the whole analysis, interpretations, and discussion of the result, it can be concluded that concept mapping teaching strategy is not an effective teaching strategy in this context. As a whole it has no significant effect on the achievement in physical science among all the students of class IX in Gangadharpur Vidyamandir of Howrah district in West Bengal. But after getting feedback from the students, it is concluded that this strategy helps the learner to achieve better than the demonstration strategy in their acquisition of meaningful learning in physical science complex concept.

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