# Concept Mapping in Science: A Literature Review

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### Abstract:

Several types of researches have been conducted worldwide  in order to explore, examine and verify the utility and effectiveness of various instructional strategies on students' learning outcomes. Concept mapping is one among these evolving teaching strategies which has been subject to exploration since its discovery by Joseph D.Novak in 1972. It is an instructional strategy in which concept maps are used to organise and represent knowledge in graphical form. Through this review paper, the authors have intended to examine seven research studies which were based on the use of concept mapping method in teaching science related disciplines. It was found that all of these studies were experimental in nature. Either quasi experimental designs or fctorial design were adopted for exploring effectiveness of concept mapping instructional strategy on various learning outcomes of the students.  Achievement along with other learning outcomes like motivation for learning science, opinion of students regarding utilisation of concept map etc. have been the prime focus of these researches.  Findings of most of these studies revealed that concept mapping method in comparision to traditional teaching method is able to enhnce achievement and other learning outcomes of the students. However,  contrary results were also being reported by the research studies conducted by Pandey (2019) & Jena (2011) in which traditional teaching methods in comparision to concept mapping method were either could produce better results or was equally effective in enhancing achievement and other learning outcomes in some categories of students. Some other instructional strategy when compared with concept mapping had produced mixed results. Overall, it can be said that concept mapping has been evolved as a promising instructional strategy which is required to be further explored in order to harness its full potential.

*Keywords*: Science Education, Concept mapping, Instructional strategy &  Achievement

## 1. INTRODUCTION:

Several types of researches have been conducted worldwide  in order to explore, examine and verify the utility and effectiveness of various instructional strategies on students' learning outcomes. Concept mapping is one among these evolving teaching strategies which has been subject to exploration since its discovery by Joseph D.Novak in 1972.  In this paper, seven research studies based on concept mapping which were carried out in India have been reviewed and a brief report has been presented. These research studies have been downloaded from the webportal of shodhganga, India.  In the upcoming sections a brief idea of concept mapping has been dealt which is followed by the brief review report of each study and finally discussion & conclusion have been presented.

## 2. CONCEPT MAPPING:

Concept mapping is a technique for externalizing concepts and propositions (Novak & Gowin, 1984). It can be considered as an instructional strategy in which concept maps are used to organise and represent knowledge in graphical form. In concept maps, concepts are presented within a box which may be of circular or of any other shapes. The two boxes are connected through a line which shows the relationships between the concepts. Further, words on linking line called linking phrases or linking word specify the relationship between the concepts. It is characterized by its hierarchical form. Concept maps represent knowledge in a hierarchical form in which  the most general concept is written at the top and the most specific concept is written below the most general concept. Then, the presence of cross-links between concepts helps to determine the relation of concepts from one domain of knowledge to others. Hence, "there  are two features of concept maps that are important in the

facilitation of creative thinking: the hierarchical structure that is represented in a good map and the ability to search for and characterize new cross-links (Novak & Cañas, 2006).

## 3. BRIEF REPORT OF RESEARCH STUDIES :

In this section a brief report of seven research studies based on concept mapping have been presented.

A study was conducted by Pandey (2019) to investigate the effectiveness of concept attainment and concept mapping teaching strategies on achievement in Biology. Cluster sampling method was employed for the selection of 310 students of class IX from two schools located in Prayagraj city in Uttar Pradesh. Investigator employed non-equivalent single group pre-test post-test quasi-experimental design. various tools were used for collection of data which included i) Biology achievement test constructed by the researcher herself, ii) Neo- Personality Questionnaire constructed by K.S.Mishra and iii) Culture Fair Intelligence Test Scale 3, form A, constructed by R.B.Cattle and A.K.S.Cattle. Biology achievement test, Neo- Personality Questionnaire and Culture Fair Intelligence Test Scale 3-form A, were used to measure achievement, different personality traits and intelligence level of the learners respectively. Various statistical techniques apart from ANOVA were used for analysing the data. Findings of the study revealed that concept mapping strategy was equally effective in comparision to traditional teaching in enhancing achievement in biology among boys and girls. However for girls the result showed that concept mapping strategy was more effective for enhancing achievement. The findings of the present study have also revealed that exposure to concept mapping and concept attainment teaching strategies to more alienated girls, more divergent girls and more intelligent girls is less effective than traditional teaching method in terms of their ahievement in biology. Exposure to concept mapping teaching strategy is more effective than concept attainment teaching strategy in case of more divergent girls and more intelligent girls. Exposure to concept mapping teaching strategy was more effective than concept attainment and traditional teaching strategies for teaching biology to less divergent girls, less alienated girls, and less intelligent girls. In case of boys no significant effect of interaction was found between teachning strategy and personality traits.

Another similar study was conducted by Joseph (2018) to study the effect of concept mapping approach in comparison to traditional method of teaching on certain selected cognitive and affective correlates in Chemistry at the higher secondary level. Investigator has taken achievement in Chemistry and self-regulated learning as cognitive correlates whereas student course satisfaction and science learning motivation as affective correlates. Further, pre-test post-test nonequivalent group quasi-experiment design was employed to conduct the study. Stratified random sampling was used as the investigator was given due consideration to gender and management of the school for the formulation of strata. For the collection of data, investigator used four tools namely (i) Test of achievement in Chemistry, (ii) Self-regulated learning scale, (iii) Student course satisfaction scale and (iv) Science and learning motivation scale. The findings of the study revealed that concept mapping approach is significantly more effective than activity-oriented method in enhancing achievement in Chemistry and motivation to learn science. Concept mapping approach was also found to be significantly more effective in enhancing self-regulated learning and course satisfaction among students.

Sharma (2015) studied effectiveness of concept mapping as a follow- up learning strategy on undergraduate students in chemistry with respect to achievement and retention. Quasi-experimental, pre-test, post-test control group design with further follow-up test was employed. Purposive sampling method was used for the selection of sample and sixty undergraduate engineering students were selected for the study. Investigator developed two parallel forms of criterion-referenced test in chemistry and a layout was developed in order to categorise statements which deal with thinking session for cognitive processes. Mean, standard deviation, t-test, product moment correlation, cluster analysis, MANCOVA, and Turkey HSD test (for post hoc) were employed. Findings of the study revealed that concept mapping as follow-up learning strategy was effective to enhance achievement in chemistry at knowledge, understanding, and application levels of learning. However, concept mapping could not generate any significant effect on the retention of learning among the learners.

Jena (2011) conducted a study to explore the effects of Concept Mapping on meaning-making in learning Science and attitude of elementary children. The researcher aimed to compare the effect of hierarchial concept mapping, spider concept mapping and traditional method of teaching on meaning-making in science learning i.e. meaningful learning. Here, meaning-making in science learning refers to learner-generated activity which results in the selection and organisation of relevant information. Further, it also includes making of links between concepts which helped in the storage of information for a longer time period. The purposive sampling method was used for the selection of grade VII students as sample and quasi-experimental design with pre-test post-test non-equivalent group design was adopted to conduct an experiment. Three measuring tools namely (i) achievement test, (ii) concept map science attitude scale and (iii) expert concept map was used for the collection of data. Both the achievement test and concept map Science attitude scale were developed by the researcher himself. Mean, standard deviation (SD), t-ratio ,ANOVA, correlation, analysis of covariance (ANCOVA) and Turkey-Kramer multiple comparison test techniques were used for the analysis of data. The findings of the study revealed that both hierarchical concept map and spider concept map approach was found to generate significantly greater effect on the meaningful learning in science and its retention in comparison to the traditional method of teaching. However, hierarchical concept map and spider concept map approach were equally effective in enhancing meaningful learning in science and its retention.

Chacko (2009) studied the effect of concept mapping on various cognitive processes and scholastic performance in general Science. The sample consisted of 60 students who belonged to seventh-grade students of Spicer higher secondary school, Pune. The sample was selected on the basis of the matched group sample. The group was matched on the basis of an intelligence test score. Quasi-experimental pre-test post-test control group design was employed to conduct the experiment. Various tools used in the study include (i) pramila group test of intelligence (PGTI) scores, (ii) test for measuring higher mental ability in science (THAMGS), (iii) two self developed achievement tests for biology and chemistry. and (iv) an opinionnaire formulated by Trifone (2006). THAMGS was used for measuring various cognitive processes. Further, statistical techniques include mean, standard deviation, variance and t-test. The findings of the study showed significant difference between the achievement scores of experimental group (taught by concept mapping) and control group (taught by traditional method). Moreover, a significant difference was also reported between experimental group and control group in the scores obtained on test of higher mental ability in general science (THAMGS). In addition, the finding of the study indicated a positive attitude of students towards the use of concept mapping as a pedagogical tool.

Kumar (2009) studied relative effects of concept mapping and concept attainment model of instruction and explored their relation to study habits (Good study habits and bad study habits) and style of learning and thinking (left brain, right brain and whole brain). The researcher employed purposive - cum – randomised sampling technique for the selection of the sample. The study was conducted on 450 students selected from five different schools of Chandigarh. Pre-test post-test ($3 \times 3 \times 2$) factorial design was employed to conduct the study. Further, the various tools used for the collection of data include an achievement test which was developed by the investigator himself, style of learning and thinking (SOLAT) developed by Torrance, study habits inventory which was developed by M.Mukhopadhyay and D.N.Sansanwal. Statistical analysis included mean, median, standard deviation, skewness, kurtosis and F-test. The findings of the study reveals significant gain in acquisition of concepts in science of experimental groups ( taught through concept mapping and concept attainment model respectively) over control group ( taught through traditional teaching). Further, a significant interaction was reported between instructional strategies and style of learning and thinking for acquisition of science concepts. Meanwhile, students possess good study habits , can learn more with concept mapping method.

Kochhar (2007) studied the effects of concept mapping and computer-assisted instruction to acquire concepts of Biology in relation to the style of learning and thinking. The researcher compared the effectiveness of three instructional strategies namely computer-assisted instruction (CAI), concept mapping (CM) and self-learning module (SLM) on students' achievement in Biology. Further, the researcher has also investigated the interaction between the instructional strategies (CAI, CM and

SLM) with the style of learning and thinking in the acquisition of biological concepts. Pre-test post-test (3×3) factorial design was employed and sample constituted 120 students of class twelve standard who opted for biology as a subject. For the experimentation, schools were selected by using purposive sampling technique. Data were collected by using achievement test and opinionaire developed by the researcher himself and the test of the style of learning and thinking (SOLAT-1988)  developed by Torrance. SOLAT-1988  was used with the intention to identify hemispheric/cerebral dominance, opinionnaire was used to know the  opinion of students towards the instructional strategies (CAI, CM & SLM). The statistical technique involved to analyse the data were mean, median, mode, standard deviation, skewness, kurtosis, and t-test. Findings of the study revealed that concept mapping and computer-assisted instructional strategies were significantly superior over the self-learning module. However, concept mapping and computer-assisted instruction did not differ significantly in enhancing the  acquisition of biological concepts. Further, the style of learning and thinking were found redundant factor for the acquisition of Biological concepts. The significant effect of interaction could be seen between the instructional strategies and style of learning and thinking. Consequently, concept mapping was found to significantly enhance the acquisition of biological concepts in the whole-brain students than  the left-brain students. Sutdents found the use of concept maps helpful in generating ideas, assimilation of new concepts, and in integrating new and old knowledge

## 4. DISCUSSION AND CONCLUSION:

The review of the above mentioned studies shows that in order to examine the effectiveness of concept mapping method of teaching, it is compared with other methods of teaching in which traditional teaching method was the most common. Some other methods to which concept mapping was compared are concept attainment method (Pandey,2019; Kumar,2009), computer assisted instruction (Kochhar,2007 ), activity oriented method (Joseph,2018) and self learning module (Kochhar,2007) . Apart from this, two types of concept mapping approach were also compared to invesigate their effectiveness by Jena (2011). In some studies interaction effects of instructional strategy with personality (Pandey,2019) and with learning and thinking style (Kochhar,2007;Kumar,2009) were also investigated.

Effectiveness of instructional strategies were explored in terms of various cognitive and affective learning outcomes of the learners such as achievement, acquisition of concept, motivation for learning science, opinion of students regarding utilisation of concept map. Among all these, achievement is the most common dependent variable selected for investigation in these studies. In order to measure all these variables, various tools intending to produce quantitative data were used.

It was found that all of these studies were experimental in nature. Either quasi experimental designs or fctorial design were adopted for exploring effectiveness of concept mapping instructional strategy on various learning outcomes of the students.  The quasi-experimental pre-test post-test control group design was used in most of these research studies. For instance, it was utilised by Joseph (2018); Sharma (2015), Jena (2011); and Chacko (2009) in their studies.  Hence, it seems that pre-test post-test control group design was found to be the most common and popular quasi-experimental research design.

The findings of the studies presented mixed results about effectiveness of concept mapping strategies. For instance, Sharma (2015) found that concept mapping as a follow-up learning strategy has significant effect on achievement but has no significant effect on retention of learning in chemistry at the undergraduate level.

Some of the research studies reported that concept mapping is a better instructional stratgy than others. For instance, Joseph (2018) reported concept mapping as more effective method over the activity-oriented method while Kochhar (2007) reveals that concept mapping is superior over the self-learning module for enhancing achievement in chemistry and acquisition of biology concept respectively. Further,  Jena (2011) & Chacko (2009) reported that concept mapping is more effective than the traditional method of teaching. According to Jena (2011) concept mapping approach can significantly contribute more for enhancing meaningful learning in science and its retention in comparison to the traditional method of teaching.

In contrary to this, Pandey (2009) reported that both concept mapping and traditional methods of teaching are equally effective in enhancing learning outcomes. Further, while investigating interaction effect of teaching strategy, and personality traits. she didnt find any significant difference in achievement score of boys possesing different personality traits. Consequently, concept mapping, concept attainment and traditional teaching method was found to be equally effective in case of boys. However, she found that different categories of girls responded differently to different teaching strategy. Concept mapping strategy was found to be more effective than concept attainment and traditional teaching strategies for teaching biology to less divergent girls, less alienated girls, and less intelligent girls. Kumar (2009) and Kochhar (2007) had reported the existence of significant interaction between instructional strategies and style of learning and thinking. Kochhar (2007) revealed that concept mapping could significantly enhance the acquisition of biological concepts in the whole-brain students than the left-brain students.

The discussion above has strongly indicated towards potentiality of concept mapping method in generating positive impact on variety of learning outcomes of the students. Further, it also indicated that when students were categorised on the basis of intelligence, personality traits and their learning styles, they responded in different ways to concept mapping instrucional strategy, hence individual difference has to be considered while planning for their learning. Moreover, further researches are required to investigate the effect of concept mapping on more categories of students. In order to measure the learning outcomes, some qualitative way of data collection may be used to seek further insight about various dimensions of concept mapping. Overall, it can be said that though concept mapping has been evolved as a promising instructional strategy for science learning, but it is required to be further explored in order to harness its full potential.

## REFERENCES:

1. Chacko,S.(2009). *Effect of concept mapping on the cognitive processes and scholastic performance in general science for standard VII students within Pune city* [Doctoral thesis, University of Pune]. Shodhganga reservoir of Indian thesis. http://hdl.handle.net/10603/3823

2. Jena,A.K.(2011). *Concept mapping as a constructivist approach for meaning making in science learning and attitude among elementary school children* [Doctoral thesis, Utkal University]. Shodhganga: A reservoir of Indian thesis. http://hdl.handle.net/10603/281033

3. Joseph,B.E.(2018). *Effectiveness of concept mapping approach on select cognitive and affective correlates in teaching chemistry at higher secondary level* [Doctoral thesis, Mahatma Gandhi University]. Shodhganga: A reservoir of Indian thesis. http://hdl.handle.net/10603/252096

4. Kochhar, R.S.(2007). *Effectiveness of computer assisted instruction and concept mapping in acquisition of Biological concepts in relation to style of learning and thinking* [ Doctoral thesis, Panjab University]. Shodhganga: A reservoir of Indian thesis. http://hdl.handle.net/10603/80738

5. Kumar,V.(2009). *Relative effectiveness of concept mapping and concept attainment model of instruction in relation to study habits and style of learning and thinking* [Doctoral thesis, Panjab University]. Shodhganga : A reservoir of Indian thesis http://hdl.handle.net/10603/84850

6. Novak, J.D.,& Gowin, D.B.(1984). *Learning how to learn*. Cambridge University Press.

7. Novak,J.D.,& Cañas,A.J.(2014). The theory underlying concept maps and how to construct them.Technical report IHMC CmapTools 2006-01 Rev o1-2008. https://www.researchgate.net/publication/215439441_The_Theory_Underlying_Concept_Maps_and_How_to_Construct_Them

8. Pandey,D.(2019). *Effectiveness of concept attainment and concept mapping teaching strategies for teaching Biology to class IX students* [Doctoral thesis, University of Allahabad]. Shodhganga: A reservoir of Indian thesis. http://hdl.handle.net/10603/270035

9. Sharma,G.(2015). *Effect of concept mapping as a follow-up learning strategy on achievement and retention of undergraduate students in chemistry* [Doctoral thesis,Kurukshetra University]. Shodhganga: A reservoir of Indian thesis http://hdl.handle.net/10603/117767