EFFECTIVENESS OF CONCEPT MAPPING STRATEGY ON ACHIEVEMENT IN SCIENCE OF SECONDARY SCHOOL STUDENTS

Smt. B. Sukanya
Research Scholar
Post Graduate Department of Education
Ravindranath Tagore University
Bhopal (MP)

Dr. Ritu Shekhar
Associate Professor & Research Guide
Post Graduate Department of Education
Ravindranath Tagore University
Bhopal (MP)

Meaning of Concept Mapping

In the recent two decays, concept maps have been widely used both to promote and to measure meaningful learning in various disciplines, especially in science teaching (Kinchin 2000a; Novak & Gowin 1984). It has also been applied in a range of contexts such as teacher education (Trent et al. 1998) and evaluation of students' misconceptions (Bartels 1995) or conceptual change (Kinchin 2000b; Trent et al. 1998; Wallace & Mintzes 1990; Trowbridge & Wandersee 1994). The use of concept maps as an assessment tool of academic achievement is an important recent application (Aidman & Egan 1998; Parkes et al. 2000; Wilson 1994), and will form the focus of the present study in the context of an introductory statistics course for the education degree students in a Finnish university. More specifically, this study aims at examining how the students' concept map working supports their learning process and how it is related in their learning outcomes. In addition, results of the study will bring valuable knowledge, the viewpoint which has been emphasized in previous studies (Slotte & Lonka 1999); in what circumstances and what way concept mapping is truly effective to use as a tool for support students representation of statistical knowledge and what methodological limitations and improvements we have to take account in the future concept map research settings.

This study is a relatively new conquest because only a few studies (Roberts 1999; Schau & Mattern 1997) have been reported using this technique in statistics instruction until now. Roberts (1999) used concept maps to measure university science students' understanding of fundamental concepts in statistical inference and problem definition. Concept map scores were also compared with marks awarded for the practical assignment students made after their practical statistical investigation. Schau and Mattern (1997) suggest that concept maps constructed by the students may stimulate their connected understanding and enhance the formation of networks of interrelated propositions in statistics.

Much of the recent reform movement in education, especially in mathematics and science, has been based on the constructivist theory of learning. This theory explains the process of learning as actively constructing knowledge, which interacts with previous knowledge, beliefs, and intuitions. Therefore, we should encourage our students also in statistics classes (e.g. Moore & Cobb 1995; Rautopuro 1999) to be actively involved in their own learning and offer a learning environment that stimulates active learning. Thus, also tools for assess students learning and achievement should be in congruence with constructivist theory of learning.

This emphasis on the cognitive theory in research on learning (Brown et al. 1992) has contributed to the changes in the methods of assessment.

In this study, by analysing and comparing concept map- and non-concept-map groups students' knowledge of statistics before and after introductory statistics course we can also conclude how concept mapping facilitates students' conceptual change in understanding statistical concepts.

In a concept map, each word or phrase is connected to another and linked back to the original idea, word or phrase. Concept maps are a way to develop logical thinking and study skills, by revealing connections and helping students see how individual ideas form a larger whole.

Concept maps were developed to enhance meaningful "earning in the sciences. A well-made concept map grows within a context frame defined by an explicit "focus question", while a mind map often has only branches radiating out from a central picture.

Because concept maps are constructed to reflect organization of the declarative memory system, they facilitate sense-making and meaningful learning on the part of individuals who make concept maps and those who use them.

A concept map is a special form of a web diagram for exploring knowledge and gathering and sharing information. Concept mapping is the strategy employed to develop a concept map. A concept map consists of nodes or cells that contain a concept, item or question and links. The links are labeled and denote direction with an arrow symbol.

Concept mapping is a technique for externalizing concepts and propositions.

Dececco (1968) denied a concept as a class of stimuli, which have common characteristics.

Novak (1984) defines concept as "Perceived regularities or relationships within a group of objects or events and are designated by some sign or symbol.

Concept, according to Wanderse (1990), is regularities in objects or events designated by some label, usually a term.

Novak (1993) defines, Concept Map as 'A diagrammatic representation, which shows meaningful relationship between concepts in the form of propositions that are linked together by words, circles and cross links'.

Theoretical Background of Concept Mapping

The technique of concept mapping was developed by Joseph D. Novak and his research team at Cornell University in the 1970s as a means of representing the emerging science knowledge of students. It has subsequently been used as a tool to increase meaningful learning in the sciences and other subjects as well as to represent the expert knowledge of individuals and teams in education, government and business. Concept maps have their origin in the learning movement called constructivism. In particular, constructivists hold that learners actively construct knowledge.

Novak states that "meaningful learning involves the Assimilation of new concepts and propositions into existing cognitive structures."

Concept maps are used to stimulate the generation of ideas, and are believed to aid creativity.

Concept Map as a Tool for Learning Knowledge

Concept mapping is a highly flexible tool that can be adapted for use almost any group of learners in education, students and teachers from primary schools to universities, for example concept mapping has been referred as a cognitive tool that facilitates transferring of performance and comprehensive learning (e.g. Parkes et al. 2000).

Concept mapping is based on Ausubel's theory of meaningful learning. In concept mapping process the learner is required to make a conscious effort to identify the key concepts in new information and relate them to concepts in her existing knowledge structure. Therefore, concept maps represent the structure of students' ideas, with emphasis on the relations between ideas. A critical component of students' cognitive understanding is the negotiation among the many concepts and ideas they are continually processing (Ayersman, 1995).

One of these is the observed poor attitude of science teachers towards concept mapping. The other is how to assist teachers in teaching concept mapping such that they can gain greater confidence, especially with teaching concept mapping in science classrooms.

Previous Studies

Edmundson and Smith (2000) reported that concepts maps greatly facilitated understanding of the relevant pathophyologic mechanism among the students studying eternity. Study also reported that the responses from the faculty were also very positive. It is also argued that concept can help make conceptual relationships explicitly, identify errors and omissions and reveal misconcepts in student understand.

Pongodi (2000) studied the use of concept mapping in concept attainment in chemistry of class IX students and concluded that the students attained the concepts more easily and effectively through concept mapping.

Kharatinal M. and Nagarjuna G. (2006) studies the effect of concept mapping has knowledge organizers of Cell Biology. They found that concept mapping is an effective instructional tool.

Ahuja Amit (2007) studied the effectiveness of concept mapping as an instructional tool in learning and retention of concepts among students as compared to conventional method of instruction and found positive results.

Mary, R. Sahay and Raj, I. Paul (2007) studied the effectiveness of concept mapping as a strategy to enhance the performance of B.Ed. trainees in Environmental Studies. Positive results were reported.

Chandra Dinesh Mayuri (2008) studied the effect of concept mapping on science achievement, scientific aptitude and problem solving ability of secondary students and concluded that concept mapping was effective.

Moon, B.M., Hoffman, R.R. & Canas, A.J. (2011) studied the expanding application of Concept Mapping included its role in knowledge education, institutional memory preservation and ideation. With the advent of the concept mapping tools knowledge modeling software kit, concept mapping is being applied with increased frequency and success to address a variety of problems in the workplace.

Starr (2015) studied Concept maps as a heuristic for science curriculum development: Toward improvement in process and product. This study outlined the use of concept maps as a tool for science curriculum development and discusses the changes that occur in the teacher's view of the curriculum with successive revisions of the maps. The use of concept maps can help science teachers to develop science curriculum that is hierarchically arranged, integrated, and conceptually driven.

The above study reveals that there are very few studies conducted on Concept Mapping in Science among different population. Therefore, there is a need to conduct the experimental study on the effectiveness of concept mapping strategy on achievement in science at the secondary school level. Hence, the present study is an attempt in this direction and stated the problem.

Design of the Study

The study is of Quasi experimental in nature, wherein both control and experimental groups are considered. The experimental group is taken intact in its natural setting without controlling many variables. Regular teaching teacher taught the control group and the investigator has taught both the experimental group by using concept mapping as Instructional strategy and the control group by using traditional method. The intact classes of IX standard as a whole were considered as experimental and control group for the study. The pre-test and the post-test two group design is adopted for the study.

Sample of the Study

The sample of the study consists of 40 students of IX standard studying in English Medium School of Tumkur city. The sample was drawn based on purposive and cluster sampling technique. Two sections 'A' and 'B' were selected wherein one (B) section was considered as experimental group and the other (A) as control group.

Variables of the Study

a. **Independent Variables:** Concept Mapping Strategy, Conventional Strategy

b. **Dependent Variables:** Achievement in Science

c. **Moderate Variables:** Gender – Boys & Girls

Objectives of the Study

1. To study whether there is a significant difference between pre and post-test scores of achievement in science of students of experimental group.
2. To study whether there is a significant difference between pre and post-test scores of achievement in science of boys of experimental group.
3. To study whether there is a significant difference between pre and post-test scores of achievement in science of girls of experimental group.

4. To study whether there is a significant difference between pre and post-test scores of achievement in science of students of control group.
5. To study whether there is a significant difference between experimental and control groups with respect to pre-test, post-test and gain scores of achievement in science.
6. To study whether there is a significant difference between boy and girls with respect to pre-test, post-test and gain scores of achievement in science of total samples.
7. To study whether there is a significant difference between boy and girls of experimental group with respect to pre-test, post-test and gain scores of achievement in science.
8. To study whether there is a significant difference between boys and girls with respect to pre-test, post-test and gain scores of achievement in science of control group.

Hypotheses of the Study

In pursuance of above stated objectives the following hypotheses were formulated.

1. There is no significant difference between pre and post-test scores of achievement in science of students of experimental group.
2. There is no significant difference between pre and post-test scores of achievement in science of boys of experimental group.
3. There is no significant difference between pre and post-test scores of achievement in science of girls of experimental group.
4. There is no significant difference between pre and post-test scores of achievement in science of students of control group.
5. There is no significant difference between experimental and control groups with respect to pre-test, post-test and gain scores of achievement in science.
6. There is no significant difference between boy and girls with respect to pre-test, post-test and gain scores of achievement in science of total samples.

7. There is no significant difference between boy and girls of experimental group with respect to pre-test, post-test and gain scores of achievement in science.
8. There is no significant difference between boys and girls with respect to pre-test, post-test and gain scores of achievement in science of control group.

Tools Used in the Study

The tool used in the study was Concept Attainment test which was prepared by the investigator with the help of the research guide and by following the steps for standardization of the test.

a. Concept Attainment test constructed by the investigator.
b. Concept Mapping constructed by the investigator.

Concept Attainment Test

Construction: The concept attainment test was developed to assess the attainment of certain concepts in Science, among IX standard students. Twenty-five multiple-choice items were prepared. The concept attainment test consists of multiple choices of Twenty-five items, with a total of Twenty-five marks.

The test items were given to experts based on the area of science for valuable comments and suggestions.

Administration: Concept attainment test was administered to both the experimental and control group as a pretest. The science was taught by the investigator using concept mapping to the experimental group, and also the control group was taught by the investigator by using traditional method. The same test was given as a posttest for assessing the science achievement after two weeks of teaching the unit by concept mapping strategy.

Scoring: The scoring of concept map was based on Novak's scoring criteria for concept maps.

Implementation of the Study

Concept attainment test was administered as pre-test for both control and experimental groups. The concept maps were developed in science at the end showing the relationship of concepts or network of concepts in the map. The investigator prepared the concept maps as a part of instructional process along with the explanation by placing the most inclusive concepts at the top (super ordinate) followed by subordinate concepts and examples. At the end of the lesson concept maps were developed on the blackboard by reviewing the whole lesson with the help of students. The students were made to select a section or small portion of the material given and construct concept maps individually in groups.

At the same time the investigator has taught the control group on science topic by using conventional method. To make the comparison, control group was not taught by concept mapping.

After the implementation of the concept mapping strategy for about two weeks for the experimental group, and traditional approach of teaching for the control group, concept attainment test was conducted to both the groups as post-test. As the experimental group was taught by concept mapping strategy concept mapping test was administered to this specific group.

Statistical Techniques Used

The hypotheses of the study were tested by making an analysis of the collected data with the help of Mean, SD and t-test.

Valid, reliable and adequate, the data were carefully processed, systematically classified and tabulated, scientifically analyzed, intelligently interpreted and rationally concluded.

Analysis and Interpretation of Data

Table-1 : Results of t-test between experimental and control groups with respect to pre-test, post-test and gain scores of achievement in science

Variable	Attitude	n	Mean	SD	t-value	P-value	Signi.
Pre-test	Experiment	40	11.5250	1.4498	0.6805	>0.05	NS
	Control	40	11.3250	1.1633			
Post-test	Experiment	40	17.2750	3.1378	7.5664	<0.05	S
	Control	40	13.2250	1.2707			
Gain	Experiment	40	5.7500	3.2640	6.9472	<0.05	S
	Control	40	1.9000	1.2770			

From the above table it can be seen that,

- A non-significant difference is observed between experimental and control groups with respect to pre-test scores of total students in science (t=0.6805, p>0.05) at 0.05 level of significance. Hence, the null hypothesis is accepted and alternative hypothesis is rejected. It means that the students of experimental and control groups have similar pre-test scores in science.
- A significant difference is observed between experimental and control groups with respect to post-test scores of total students in science (t-7.5664, p<0.05) at 0.05 level of significance. Hence, the null hypothesis is rejected and alternative hypothesis is accepted. It means that the students of experimental have higher post-test scores in science as compared to control group students.
- A significant difference is observed between experimental and control groups with respect to gain of pre and post-test scores of total students in science (t=6.9472, p<0.05) at 0.05 level of significance. Hence, the null hypothesis is rejected and alternative hypothesis is accepted. It means that the students of experimental have higher gain of pre and post-test scores in science as compared to control group students.

Table-2 : Results of t-test between Boys and Girls with respect to pre-test, post-test and gain scores of in science of total samples

Variable	Attitude	n	Mean	SD	t-value	P-value	Signi.
Pre-test	Boys	40	11.6500	1.4420	1.5499	>0.05	NS
	Girls	40	11.2000	1.1368			
Post-test	Boys	40	16.4250	3.5365	3.6005	<0.05	S
	Girls	40	14.0750	2.1290			
Gain	Boys	40	4.7750	3.7175	2.8296	<0.05	S
	Girls	40	2.8750	2.0530			

From the above table it can be seen that,

- A non-significant difference is observed between Boys and Girls with respect to pre-test scores in science (t=1.5499, p>0.05) at 0.05 level of significance. Hence, the null hypothesis is accepted and alternative hypothesis is rejected. It means that the Boys and Girls have similar pre-test scores in science.
- A significant difference is observed between Boys and Girls with respect to post-test scores in science (t=3.6005, p<0.05) at 0.05 level of significance. Hence, the null hypothesis is rejected and alternative hypothesis is accepted. It means that the Boys have higher post-test scores in science as compared to Girls.
- A significant difference is observed between Boys and Girls with respect to gain of pre and post-test scores in science (t=2.8296, p<0.05) at 0.05 level of significance. Hence, the null hypothesis is rejected and alternative hypothesis is accepted. It means that the Boys have higher gain of pre and post-test scores in science as compared to Girls.

Table-3 : Results of t-test between Boys and Girls of experimental group with respect to pre-test, post-test and gain scores in science

Variable	Attitude	n	Mean	SD	t-value	P-value	Signi.
Pre-test	Boys	20	11.7500	1.6819	0.9811	>0.05	NS
	Girls	20	11.3000	1.1743			
Post-test	Boys	20	19.3500	2.4339	5.5594	<0.05	S
	Girls	20	15.2000	2.2850			
Gain	Boys	20	7.6000	3.1187	4.3212	<0.05	S
	Girls	20	3.9000	2.2219			

From the above table it can be seen that

- A non-significant difference is observed between Boys and Girls students of experimental group with respect to pre-test scores in science (t=0.9811, p>0.05) at 0.05 level of significance. Hence, the null hypothesis is accepted and alternative hypothesis is rejected. It means that the Boys and Girls of experimental group have similar pre-test scores in science.

- A significant difference is observed between Boys and Girls of experimental group with respect to post-test scores in science ($t=5.5594$, $p<0.05$) at 0.05 level of significance. Hence, the null hypothesis is rejected and alternative hypothesis is accepted. It means that the Boys have higher post-test scores in science as compared to Girls of experimental group.
- A significant difference is observed between Boys and Girls of experimental group with respect to gain of pre and post-test scores in science ($t=4.3212$, $p<0.05$) at 0.05 level of significance. Hence, the null hypothesis is rejected and alternative hypothesis is accepted. It means that the Boys of experimental group have higher gain of pre and post-test scores in science as compared to Girls of experimental group.

Results of the Study

On the basis of the above analysis reported from the above tables, the findings of the study are as follows:

- The students of experimental and control groups have similar pre-test scores in science.
- The students of experimental have higher post-test scores in science as compared to control group students.
- The students of experimental have higher gain of pre and post-test scores in science as compared to control group students.
- The Boys and Girls have similar pre-test scores in science.
- The Boys have higher post-test scores in science as compared to Girls.
- The Boys have higher gain of pre and post-test scores in science as compared to Girls.
- The Boys and Girls of experimental group have similar pre-test scores in science.
- The Boys have higher post-test scores in science as compared to Girls of experimental group.

- The Boys of experimental group have higher gain of pre and post-test scores in science as compared to Girls of experimental group.

Discussion and Educational Implications

This study provides an additional insight into prior research conducted in concept mapping and its effect on learning. The findings reveal that concept mapping has a noticeable impact on student achievement and student attitudes. Further, although results of the learning outcomes are encouraging.

Investigator has found that concept maps were found to be useful tool for organizing a lecture or teaching science. Moreover, they were not only aided in planning instruction, but also has their own understanding of the subject matter been increased in students. It has to be considered that the methods of mind mapping and concept mapping can be used only if one has got familiar with them.

From the above study it is also noticed that concept maps in science give students an opportunity to:

(1) think about the connections between the science terms being learned,

(2) organize their thoughts and visualize the relationships between key concepts in a systematic way, and

(3) reflect on their understanding.

It can be concluded from the study that students better remember information when it's represented and learned both visually and verbally.

In summary, this study indicates that concept maps in science can effectively promote learning of students and thus, can be added to the teaching strategies of science teachers.

This study has implications especially for science teachers where curriculum is being developed and mainly based on concept acquisition. Using concept mapping tools in science classes will help students to develop better understanding of important concepts. Students in this study demonstrated that concept maps helped them to understand the learning processes of developing interrelationships, creating meaning schemes and constructing knowledge bases.

References

- Ahuja Amit (2007). Effectiveness of Concept Mapping in Learning of Science. Doctoral Thesis, Delhi University, India.
- Brinkmann, A. (2002). Knowledge Maps - Tools For Building Structure in Mathematics. Available at *astrid.brinkmann@math.edu.de*
- Caldwel, W.H. (2006). Developing A Concept Mapping Approach to Mathematics Achievement in Middle School. Proceedings of the Second Conference on Concept Mapping at San Jose, Costa Rica.
- Carvalho, M., Arguedas, M., Eskridge, T., et al. (2001). Concept maps: Integrating knowledge and information visualization. In S.O. Tergan & T. Keller (Eds.), *Knowledge and information visualization: Searching for synergies* (205-219). Heidelberg/NY: Springer Lecture Notes in Computer Science.
- Chandradinesh Mayuri (2008). To Make Science Learning Joyful. Paper presented in III National Science Teachers' Conference in Kolkata, India.
- Chang-long, C. (2011). Concept Mapping in Secondary School Chemistry Experiment in Teaching and Evaluation. *Journal of Research in Science Teaching*, 45, 314-326.
- Diana, C.R. (1998) studied on Using concept maps to assess student learning in the science classroom: Must different methods compete? *Journal of Research in Science Teaching*, 1103-1127.
- Edmondson, K. (2000). Assessing science understanding through concept maps. In J. Mintzes, J. Wandersee and J. Novak (Eds.), *Assessing Science Understanding*, San Diego: Academic Press, 19-40.
- Edwards, J., and K. Fraser (1983). Concept maps as reflectors of conceptual understanding. *Research in Science Education,* 13, 19-26.
- Kharatmal M. and Nagarjuna G. (2006). Knowledge Organizers of Cell Biology. Knowledge Representation, Homi Bhabha Center for Science Education, TIFR, Mumbai, India, 124-125.
- Malone, J. and Dekkers, J. (1984). The Concept Map as an Aid to Instruction in Science and Mathematics. *School Science and Mathematics*, 84(3).
- Mary R. Sahay and Raj I. Paul (2007). Effectiveness of Concept Mapping as a Strategy to Enhance the Performance of B.Ed. Trainees in Environmental Studies. University News, 45(44), 67-72.

- Moon B.M., Hoffman R.R. and Canas A.J. (2011). Applied Concept Mapping: Capturing, Analysing and Organizing Knowledge. CRC Press.
- Nadeem (2011). Using Concept Mapping for Needs Analysis for a Social Support System in Learning Network. *International Journal of Interactive Mobile Technologies* (IJIM), 5(1).
- Novak, J. (1990). Concept Mapping: A Useful Tool for Science Education. *Journal of Research in Science Teaching*, 27(10), John Wiley & Sons, Inc., 937-949.
- Pongodi N. (2000). A Study about the Use of Concept Mapping in Concept Attainment in Chemistry among Students of Standard IX. Doctoral Thesis, Department of Educational Technology, Bharathidasan University, Tiruchinapalli, India.
- Snead Donald S. and Wanda L. (2004). Concept Mapping and Science Achievement of Middle Grade Students. Journal of Research in Childhood Education.
- Starr, M.L. and Krajcik, J.S. (1990). Concept maps as a heuristic for science curriculum development: Toward improvement in process and product. *Journal of Research in Science Teaching*, 27:987-1000.
- Wandersee, J. (2000). Using concept mapping as a knowledge mapping tool. In Fisher, K., Wandersee, J., & Moody, D. (Eds.), Mapping Biological Knowledge, 127-142. Dordrecht: Kluwer.
- Xiufeng Liu (2004) studied on using concept mapping for assessing and promoting relational conceptual change in science. *Science Education*, 373-396.