Effectiveness of Pictorial Concept Mapping in the Teaching of Science

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The purpose of this research project was to determine the effects of pictorial concept mapping on the achievement of VIII standard students in the topic of "sources of energy". The study was conducted with 114 students at a secondary school in Mumbai. The students were tested with teacher constructed pre- and post-tests containing multiple, one word and descriptive questions. The descriptive questions were mainly based on understanding and application level. After the pre-test, the control group was given a traditional method of teaching and the experimental group was exposed to concept mapping technique. After these reviews, the students in both groups were given the post-test. Test scores were analysed for any statistically significant difference in the scores with respect to gender and their learning style. The results from the present study indicate that concept mapping has a noticeable impact in student achievement in science education. Students showed a positive attitude towards using pictorial concept mapping in teaching.

Keywords: Pictorial concept mapping, Learning style, Science education, Attitude towards concept mapping

Introduction

Science should emerge as something alive, and therefore exciting. However, condition in schools is not promising. Students find science subject as abstract and conceptual in nature. Many new concepts are introduced to students at school age. Students consider the different concepts as isolated element of knowledge. Due to lack of integration, students find it difficult to form concepts (Brandt et al., 2001) and, it is essential that they understand all required concepts to make science learning meaningful. Ausubel (1968) describes meaningful learning as the establishment of non-arbitrary relations among concepts in the learner's mind. Novak and Symington (1982) devised concept mapping as a cognitive tool to promote meaningful learning.

Concept mapping is a process which involves the identification of key concepts in a domain of knowledge and the organization of these concepts into a hierarchical arrangement. It is a system of teaching and learning that is both consistent with the structure of scientific knowledge. Concept maps are special representations of concepts and their inter-relationships that are intended to represent the knowledge structures that humans store in their minds (Jonassen, Beissner, & Yacci, 1993). Concept mapping is a method to visualize the structure of knowledge. Instead of describing all concepts and their relations in text, one may choose to draw a map indicating concepts and relations in a graph or network. Visual representation has several advantages, visual symbols are quick and easy to recognize, most of us can recall with little effort. Visual representation also allows the development of a holistic understanding that words alone cannot convey, because the graphical form allows representations of parts and whole in a way that is not available in sequential structure of text. Concept maps provide immediate visual data to science instructors on student misconceptions and their level of understanding.

A concept map or visual representation may save thousands of hours of semantic wrangling. Using pictures in concept maps allow participants with varying backgrounds to share their visions. In the present study, pictorial concept map is used to make it more effective. In this study, pictorial concept maps are used as an instructional tool to teach a topic of *"Sources of Energy"* a chapter of general science textbook of standard VIII (Maharashtra Board, 2009).

Review of Literature

Concept maps are based on the constructivist theory of learning. In education, the use of concept maps has been promoted to investigate the students' understanding of a topic (Novak & Gowin, 1984). Concept maps are considered as auxiliary tools for obtaining information related to existing knowledge structure of students (Ruiz-Primo & Shavelson, 1996), assessment of knowledge (Rice, Ryan, & Samson, 1998), adding new knowledge to the concepts which already exist in the minds of the students (Kinchin, Hay, & Adams, 2000), investigation of achievement gain and conceptual reorganization (Carter, Jone, & Rua, 2003), assessing conceptual understanding (Kaya, 2008; Tekkaya, 2003), investigating student's mental model (Chang, 2007), teaching/ learning of concepts (Sket & Glazer, 2005), knowledge integration (Huang & Diao, 2008).

Objectives of the Study

1. To compare the pre-test scores of control group and experimental group with respect to learning of the topic.
2. To compare the post-test scores of control group and experimental group with respect to learning of the topic.
3. To compare the post-test scores of experimental group with respect to gender.
4. To compare the post-test scores of experimental group with respect to learning style.
5. To study the attitude of the students towards the method of Pictorial Concept Mapping.
6. To compare the attitude of students with respect to gender and learning style.

Methodology

Sample

One hundred and fourteen students of VIII standard selected from Mahatma School of Academics and Sports at New Panvel were the sample for the present study.

Research Tool

Lesson plans: Lesson plan was prepared based on Herbatian method by Herbert Spensor on the topic *"Sources of Energy"* of VIII standard.

Pictorial concept maps: Based on the topic *"Sources of Energy"* from VIII standard science textbook, the researcher developed a standard pictorial concept map.

Pre-test: Pre-test was prepared to measure students' pre-requisite knowledge on the topic *"Sources of Energy"*.

Achievement test: The post-test was prepared to measure students' achievement. The six levels of Bloom's taxonomy (Bloom, 1969) were used to make sure that the items were at the different levels of objectives. The post-test contains multiple, one word and descriptive questions. The descriptive questions were mainly based on understanding and application level questions like *"how did overuse of fossil fuels create energy crisis or why is it now necessary to use fuel with thrift?"*

Attitude scale: An attitude scale was prepared by the researcher to analyze the attitude towards concept mapping.

Learning style inventory: Barsch's (1991) learning style inventory was used.

Treatment

The researcher used equivalent pre-test post-test group design. Two groups were formed out of which one be control group and another be experimental group. The unit selected for the study was *"Sources of Energy"*. Control group was taught by using Herbatian method including five steps viz., *presentation, comparison, association, generalization* and *application*. Experimental group was taught by using pictorial concept map. This group was introduced to the topic by asking developmental questions. The questions based on previous knowledge of the students were asked to students and teachers gradually developed the topic. Along with that teacher, pictorial concept map was developed on the board by taking active participation of the students. Students based on the discussions added the propositions. Before teaching, both experimental and control group were given pre-test to assess their previous knowledge. Post-test on the topic after teaching was given to both experimental and control group to measure their achievements. Students in the experimental group were asked to fill an attitude scale and a learning style inventory. The students were asked open-ended reflection questions on their experience of learning with concept mapping like how they found this teaching method different than that of regular method, in what way this method helped them to understand the concept.

Analysis and Interpretation

Pre-test and post-test scores of control group and experimental group with respect to learning of the topic

Pre-test scores of control group and experimental group						Post-test scores of control group and experimental group				
Group	**N**	**Mean**	**SD**	**t value**	**LS**	**Group**	**N**	**Mean**	**SD**	**t value**
Control group	57	4.2	2.0	0.8	N.S.	**Control group**	57	6.1	3.1	7.0
Experimental group	57	4.5	1.4			**Experimental group**	57	10.4	3.4	

Table 1: Mean, SD and t-value of the pre-test and post-test scores of control group and experimental group with respect to learning of the topic

Mean, standard deviations and t-value for pre-test scores in science were calculated. The mean score for the experimental group was 4.5, while that of the control group was 4.2. A t-test for independent samples was carried out to test whether the experimental and the control groups differed significantly on pre-test achievement in the topic. Non-significant differences

were found with t=0.8 at 0.05 level. As there were no significant differences on the pre-test, it can be assumed that the two groups started out with equivalent means. Mean, SD and t-value for post-test scores were calculated. Mean of post-test scores of experimental group was higher (10.4) than that of control group (6.1). The t-value calculated for post-test scores revealed that control and experimental group differed significantly with t=7.0 at 0.01 levels.

Post-test scores of control group and experimental group with respect to gender

Control						Experimental					
Gender	**N**	**Mean**	**SD**	**t-value**	**LS**	**Gender**	**N**	**Mean**	**SD**	**t- value**	**LS**
Boys	29	6.6	2.8	1.0	N.S	**Boys**	32	10.4	3.2	0.09	N.S
Girls	28	5.7	3.4			**Girls**	25	10.4	3.7		

Table 2: Mean, SD and t-values of the post-test scores of control group and experimental group with respect to gender

The mean, SD and t-values of post-test scores of boys and girls for the control and experimental groups with respect to gender were calculated. Result shows that mean scores of girls (5.7) in the control group are lower than those of boys (6.6). In the experimental group, mean of post-test scores of both boys and girls are 10.4 and 10.4 respectively. The t-value was calculated for post-test scores of control group (1.0) and experimental group (0.09) with respect to gender. It did not differ significantly even at 0.05 levels.

Analysis of variance for the attitude scale scores with respect to learning style

Group	N	Mean	SD	F ratio	LS
Visual learner	35	94.5	4.7	45.4	0.01
Auditory learner	16	80.9	5.5		
Kinesthetic learner	6	78.7	9.0		

Table 5: Mean, SD and F-ratio of attitude scores of experimental group with respect to their learning style

Post-test scores of boys and girls of control group and experimental group

Boys	N	Mean	SD	t value	LS	Girls	N	Mean	SD	t value	LS
Control	29	6.6	2.8	5.0	0.01	**Control group**	28	5.7	3.4	4.8	0.01
Experimental	32	10.4	3.2			**Experimental**	25	10.4	3.7		

Table 3: Mean, SD and t-value of post-test scores of boys and girls of control group and experimental group

However, there is significant difference between the post-test scores of boys as well as girls of control group and experimental group. The t value calculated for the control and experimental group when differentiated by gender (boys, t=5.0, p>0.01; girls t=4.8 (p>0.01) was significant.

Analysis of variance for post-test scores of different learning style

Learning style	N	Mean	SD	F ratio	LS
Visual learner	35	12.4	2.2	38.7	0.01
Auditory learner	16	7.4	2.4		
Kinesthetic learner	6	6.5	2.1		

Table 4: Mean, SD and F-ratio of the post-test scores of experimental group with respect to their learning style

Mean, SD and F-ratio were calculated for the attitude scale scores of experimental group students towards concept mapping with respect to learning style. The result shows that the mean score of overall attitude was high for visual learner (94.5) and the same was low for kinesthetic learners (78.7). F-ratio (45.4) calculated for the overall attitude showed that students differed significantly among themselves at 0.01 levels.

Analysis of variance for attitude scale scores of boys and girls

Gender	N	Mean	Std. Deviation	t- value	LS
Boys	32	88.3	8.0	0.7	N.S
Girls	25	89.9	9.9		

Table 6: Mean, SD and t-value of the attitude scores of experimental group with respect to gender

Mean, SD and t-value were calculated for the attitude of students towards concept mapping with respect to gender. From Table 6, it is seen that the mean score of overall attitude of students was high for girls (89.9) and the same was low for boys (88.3). The t-value (0.7) revealed that boys and girls did not differ significantly even at 0.05 levels.

Percentage wise distribution of students according to their attitude towards concept mapping

Level of attitude	No. of students	% of students
Very good	26	46
Good	28	49
Average	03	5
Poor	00	00
Very poor	00	00

Table 7: Percentage-wise distribution of students according to their attitude towards concept mapping

The attitude scale was administered on the students of experimental group. According to the scores of scale, around 46% of the students have very good attitude towards the pictorial concept mapping method of teaching, 49% of the students found it good and 5% responded as average. The students in the experimental group answered reflection questions on their experience in learning with the help of pictorial concept map at the end of the treatment period.

Students replied that concepts were clear through this method of teaching. Concept mapping helped them organize information leading to better understanding and the ability to answer questions easily, assisted them in summarizing the learned material, helped them to analyze the concept and helped them to retain the learned concept for a longer time. This method of teaching encouraged them to participate in the class and group interaction and it help to promote the attitude towards science education. Most students (74%) said that pictorial developmental concept mapping should be used to teach most of the topics in science and 54% said that it should be applied in other subjects also.

Discussion

According to the achievement points obtained at the end of the study, concept mapping was found to be more influential in student success than the traditional method. The analyses in the present study have shown that there was a significant difference in the post-test score of control and experimental group at 0.01 levels. More specifically, experimental group has higher mean score (10.4) than that of control group. This is in line with the findings of other experimental studies conducted by Kabaca (2002), Mclay and Brown (2003) which compared concept mapping to the traditional method and concluded that the former was more successful. Further analysis investigated the significant difference of post-test score with respect to gender. There was no significant difference of post-test score of control and experimental group with respect to gender. These reflections also support the claim highlighted in previous research that the post test score of concept mapping techniques is not influenced by gender of the student (BouJaoude & Attieh, 2003).

Another finding arising from the present study is that there was a significant difference in the post-test score of experimental group students with respect to their learning style preference. Very few research studies were carried out based on concept mapping with respect to learning style of students viz., *visual learner, auditory and kinesthetic*. The result of this study contradicts the conclusions derived from learning style preference and student aptitude for concept maps (Kostovich, Poradzisz, Wood, & O'Brien, 2007). The present study revealed that there was a significant difference in their attitude towards concept mapping with respect to their learning style.

Other questions in the attitude scale elicited student's attitude towards concept mapping. Students, in general, showed a very positive attitude towards using concept mapping in teaching. They agreed that concept mapping was a very good technique for learning and found it very beneficiary. These students suggested that concept maps helped them summarize and organize new information, retain information longer and simplify their learning tasks. Furthermore, concept mapping helped to discover and correct their mistakes. Thus, it could be concluded that concept mapping helped students develop and use metacognitive skills, which resulted in better achievement.

Another finding that emerged from this present study is that gender variable does not influence the attitude of students towards concept mapping. The present study shows that there is no significant difference in their attitude towards concept mapping with respect to their gender.

Some other research studies have indicated that concept map construction may have a positive effect on students' attitude and feelings towards discipline and the coursework and task within that discipline (Broggy & McClelland, 2008; Novak, 1990; Okebukola, 1992; Roth, 1994).

Conclusion

Concept mapping is a tool that can be used for facilitating learning and assessing meaningful learning. It helps in gaining better comprehensive understanding of learning information. This study provided some insights into the use of concept mapping in teaching of science. It provided significant results concerning its effect on different learners. Moreover, the results showed that concept mapping helped low achievers to achieve high scores in the topic of *"Sources of Energy"*. Finally, students exhibited positive attitude towards using concept mapping in the topic. Concept maps served to clarify links between new and old knowledge, giving an opportunity for the learners to internalize the concepts.

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