RESEARCH ARTICLE

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Graphic Organisers: The Use of Mind Maps and Concept Maps for Indexing of Concepts in Science Education

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Abstract

Teaching is not limited to making the learners literate; it aims at helping them to become a creator by employing the creative mental faculties such as perception, reason, will, memory, imagination and intuition. The teaching process involves input and output of lot of information which depends on several variables. One of the variables is the learning style of the student. Research acknowledges that every student has a specific or a combination of styles of learning. Like, some learns better while writing, some through listening, some through visuals, some through activity and some learns better if they are taught by using combination of two or more of these styles. The objective of every teacher is 'to impart the knowledge in the best possible manner' and for this, any unusual strategy used by the teacher to meet the diversified needs of the students, can be termed as an Innovative strategy. Such innovative strategies in teaching not only level up the standard of education but also empowers the future generation by strengthening their cognition. The present study aimed to explore the usefulness of concept maps in an understanding of ideas in isolation and the use of Mind Maps in summarising all the ideas as a whole. This was an experimental research with one sample, pre-post-test design. The researcher delivered three chapters of the Biology of IX grade through Concepts Maps and Mind Maps. The sample was selected through purposive sampling technique and the intervention was given for 4 weeks in one of the government schools of Delhi. The analysis revealed that the null hypothesis was rejected and the difference between the scores of pre and post-test was found to be significant. Through the analysis of the Researcher's Diary, used as tool to triangulate the quantitative findings, it was concluded that concept maps and mind maps were found to be effective pedagogical tools to develop the concepts, comparing and contrasting, improve factual recall and to have a deeper level of understanding through interlinking. It was revealed that the mapping was also found to be useful in identifying the learning gaps, build a conceptual hierarchy, and facilitate new learning onto the previous one. The findings of this study were in consonance with the viewpoint of other studies conducted on Graphic organizers. The study suggests the use of Graphic Organisers in the classrooms across the curriculum and subjects as it is based on the technique in which the new information is matched, compared to, contrasted to, joined with or modified to fit in with the previously attended information, thus, assists students to reach to the high levels of cognitive performance.

Keywords: Graphic Organisers, Concept and Mind Map, Indexing of concepts, Innovative Strategy and Pedagogical Tool.

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Introduction

Graphic Organisers

"Leading innovation is not a linear process, educators need to embrace the complexity of improving student outcomes."

-Dr. Aasma Alfadala

Graphic organizers are a visual display of interconnecting different ideas, facts, and thoughts. It is powerful learning, teaching, and assessment tool which guides the learners' thinking and assists them to index new concepts, link new with the prior one and thus ultimately contribute in developing a habit of structured thinking. These tools can be used in any learning situations across the curriculum to arrange ideas. It can be defined as "visual tools that employ lines, circles and boxes to depict four common ways to organize information: hierarchic, cause/effect, compare/contrast, cyclic or linear sequences" (Ellis, E., 2004). It gives visual cues that facilitate in identifying the main areas in wide topic, understand cause and effect, compare and contrast, sequencing and organisation of the whole concept.

Guiding Principles of Graphic Organisers (Figure 1.1):

- Constructivist
- Interactive
- Innovative
- Experimental

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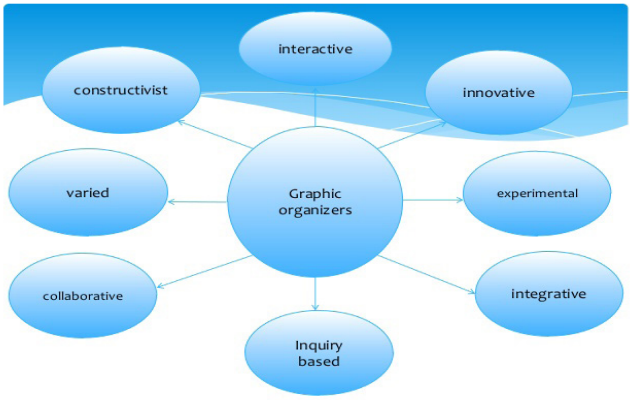


Figure 1.1: Principles of Graphic Organisers
(Source: http://www.inspiration.com/visual-learning/graphic-organizers)

- Varied
- Collaborative
- Inquiry-Based and Integrative.

Types of Graphic Organisers:

The graphic organizers are numerous, and still, the number is growing as more and more creativity is being put into it. The graphic organizers are prepared for different objectives; some are prepared for information gathering, some help in a sense making of the information gathered, and some helps in analysis, and some contribute into reaching a conclusion. Some of the examples of graphic organizers are given in Figure 1.2.

Concept Mapping and Mind Mapping as learning tools

Introduction to Concept Maps: Novak (2006) defines "Concept maps are hierarchical graphical tools used to organize and represent concepts and ideas in the best possible understandable manner. It is an attempt to show how the key idea can be split down further into specific sub-ideas. They include concepts, usually enclosed in circles or boxes, to represent relationships between concepts indicated by a connecting line linking two concepts. Words on the line referred to as linking words or linking phrases, specify the relationship between the two concepts." Concept maps are "visual road maps" to show pathways in a specific knowledge domain. Novak explains some of the terms connected with concept maps, they are as follows: • Concepts: Concepts are perceived regularity in events or objects, or records or events or objects designated by a label. The label for the most concept is a word or more than one word, sometimes symbols such as + or % are used. • Propositions: propositions are the statements about some object or event in the universe, either naturally occurring or constructed. Propositions contain two or more concepts connected using linking words or phrases to form a meaningful statement. Sometimes these are called semantic units, or units of meaning. It is acknowledged in the researches that the concept maps are one of the powerful tools in assisting students to reach to the high levels of cognitive performance. Concept maps define the relationship between the concepts. It represents "meaningful relationships between concepts in the form of propositions" and explains "propositions as two or more concept labels linked by words in a semantic unit" (Novak, 2006). In concept maps the concepts are seen in boxes or bubbles, and there is a link line with a connecting verb. The concept maps show hierarchy with the most inclusive concept at the top and the subtopic come down the line, which can have cross-links.

Introduction to Mind Maps

Wikipedia has defined mind map as "a diagram used to represent words, ideas, tasks, or other items linked to and arranged radially around a central keyword or idea. It is generally used to generate, visualize, structure, and classify different ideas. As an aid in dealing with complex information, the mind map assists in organizing, problem-solving, decision making, and defining. Mind maps have only one central idea at the center and the keywords all around the central concept. There are no linking words, and concepts are not in bubbles or boxes.

How Information get Processed and Indexed in Mind

The whole functioning and processing of brain involves gathering of information (encoding), storage of gathered information, and retrieving the stored information as and when required. As per the Information Processing Theory, Memory can be divided into three storage systems, i.e., sensory, short term, and long term memory. Sensory memory (SM) is said to be responsible for the transduction of external sensory information to electrical stimulation, which generally works for less than ½ second for vision and about 3 seconds for hearing. The SM holds a replica of what is received through auditory and visual modalities. After, SM, limited information is transferred to short term memory (STM), and during this phase, some information loss occurs, as decay appears to be the primary mechanism of memory loss. Within STM, there are three basic operations which runs i.e., iconic memory (the ability to hold visual images), acoustic memory (the ability to hold sounds) and working memory (how the individual is responding to given information at any given point of time). The encoding and consolidation of information lead to the transfer of information from STM to the long term memory (LTM). Only limited information, which is attended, rehearsed, properly organized and indexed, transfers from STM to LTM. The process of transfer of information depends on several factors like the meaningfulness or emotional content of an item. Therefore, the Information Processing Theory for better retention suggests to make the learning more relevant, meaningful and linked to previous ones.

Review of Related Literature

Eppler J. Martin (2006) conducted a study on the comparison between concept maps, mind maps, conceptual diagrams, and visual metaphors as complementary tools for knowledge construction and sharing. The study revealed that different visualization techniques could be used in complementary ways to augment motivation, attention, understanding and recall. The researcher discussed the advantages and disadvantages of concept maps, mind maps, conceptual diagrams and visual metaphors.

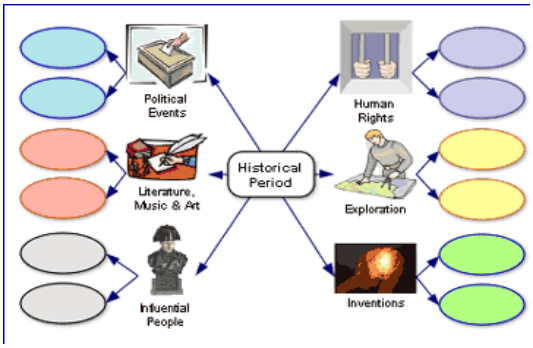
Trifone, J. D. (2006) found in the study titled "The Efficacy of Concept Mapping in Motivating Students to take a more meaningful approach to learn" that concept mapping was helpful in encouraging a meaningful approach to learning. Adaptive variations were in direct relation to the standard of mapping proficiency. The results support the principles of the expectancy-value theory. The study has revealed that the use of concept mapping is an effective learning approach.

Vakilifard, A., and Armand, F. (2006) in the study "Effects of 'Concept Mapping' on Second language learners' Comprehension of Informative Text" revealed that the experimental group obtained better performance than the group that had used the traditional approach.

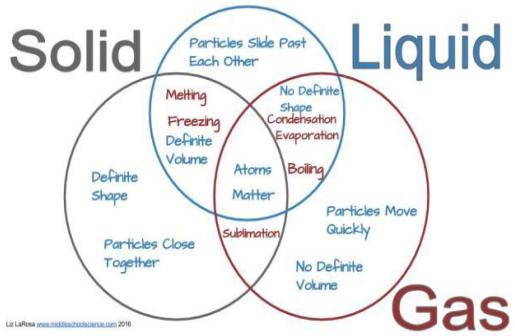
Rao, P.M. (2004) in the study "Effect of Concept mapping in Science on Science Achievement Cognitive skills and Attitude of Students" revealed that the experimental group students had performed better when compared to the control group on an achievement test, process skills and concept attainment test on the post-test. The analysis of the attitude shows that 90% of the students had a positive attitude towards concept mapping strategy. The strategy had a differential effect on the different levels of intelligence groups. The F-value shows for concept attainment test was found significant, implying that there is a difference within and between the students of different intelligence in their concept attainment ability. But there was no difference found either between or within the different grades of students in their performance of process skills. There was no difference observed between girls and boys in their achievement, process skills, concept attainment and in their attitude towards concept mapping.

Farrand, Hussain and Hennessey (2002) conducted a study to examine the effectiveness of using the 'mind map' study technique to improve the factual recall from the given text. It was found that

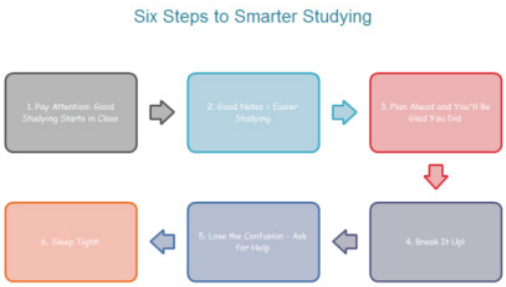
Web Organiser:



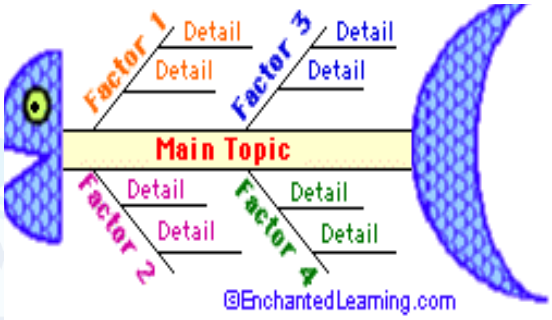
Venn Diagram:



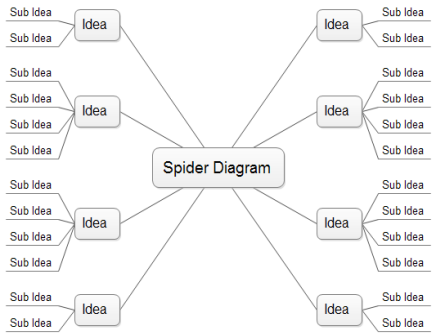
Sequence Chart:



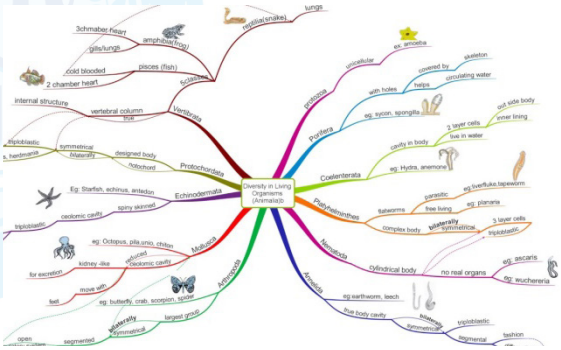
Fish Bone Map:



Spider Map:



Mind Map:



Cluster/ Cloud Maps

Concept Map:

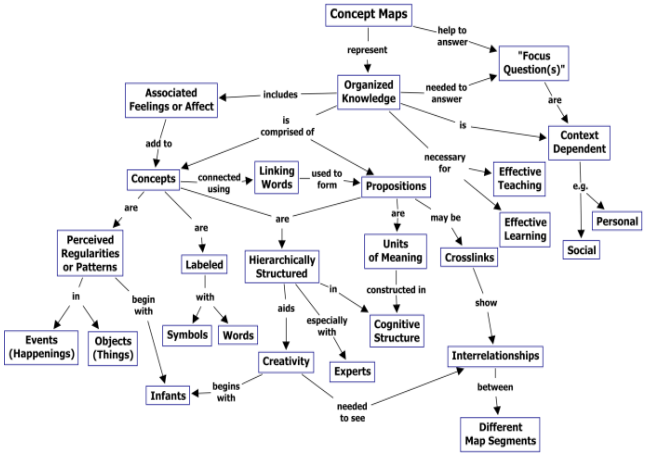


Figure 1.2:. Representing some of the types of Graphic Organisers
(source: https://mindmappingsoftwareblog.com/concept-maps-vs-mind-maps/, https://www.enchantedlearning.com/graphicorganizers/)

Mind maps proved to be an effective study technique when used for written material. However, in the study, it was suggested that before applying mind maps as a study technique, one needs to consider ways of improving motivation amongst users. The sample in the experimental group was trained in the mind map technique and was asked to apply it to the text. Recall was measured after a week. The findings states that the factual knowledge in the experimental group was found to be greater by 10% (adjusting for baseline) (95% CI -1% to 22%).

Andal, R. (1991) in the study "Concept mapping in learning Physical Science and its relation to Scholastic Performance, Cognitive Ability, Attitude towards Concept Mapping and Science Interest among standard IX students" found that cognitive ability, attitude towards concept mapping and science Interest had both a significant direct influence on scholastic performance and an indirect influence through concept mapping. On comparing the coefficientt of determination, the highest extent of determination had been found between cognitive ability and concept mapping for all the three groups. For coeducation students, 51% cognitive ability accounted for concept mapping performance; for boys, it had been 49% and for girls 44%. The contribution of cognitive ability to scholastic performance had been lower in all three groups. 19 % in the case of boys, 37% in the case of girls, and 38% in the case of coeducation students. The experimental and control group of boys, girls, and coeducation students were found to have no difference in the post-test scholastic performance scores in physical science. Girls were found to have performed better than boys in post-test scholastic performance scores in physical science. Coeducation students were found to have performed better than girls and boys in post-test scholastic performance in physical science. Co-education students were found to have performed better than girls and boys in concept mapping.

Rationale

The performance in the academic area is directly proportional to the creativity of the learners in indexing the newly learnt information and relating it to the previously saved one. And, the Investment theory (Sternberg, 2006) states that such creativity requires a confluence of six distinct but interrelated resources i.e., intellectual abilities, knowledge, styles of thinking, personality, motivation, and environment. In the present scenario, the main focus of educational scientists is towards making the learning experiences more meaningful and relevant so that our future citizen becomes creative thinkers rather than followers. Recently in India, the teacher education curriculum is also revamped as per the new requirement of the era. The innovative methods of teaching are preferred over traditional methods of teaching, and the teachers are also aimed to prepare in the teacher education institutions in the same way. Presently, there is a demand for system of more researches in researching the effectiveness and implications of innovative pedagogical tools. It is acknowledged in various recent researches that the graphic organizers are based on the constructivist cognitive model and are also considered to be the new and creative strategy of teaching and learning. The review on 'the usage of graphic organizers' has stimulated the curiosity in the researcher to explore how children index newly learnt concepts through the use of graphic organizers. The researcher have attempted in this study to find the effectiveness of concept maps and mind maps in teaching and learning of science concepts.

Research Questions

- How can the complex and technical based information in Science be made more interesting and easy for the learners?
- What innovative strategy can be adopted in the classrooms to make Science understandable rather than a subject of rote memorization?
- How the use of mapping the concepts in Science influence the cognitive abilities of the learners?

Objectives of the Study

- To study the effectiveness of graphic organizers on the comprehension of Science content by the Learners of Secondary Stage.

Hypothesis

The hypothesis of the study is:-

- There is no statistically significant difference in the pre-tests and post-test scores of the test (achievement test on comprehension) in science after the intervention (teaching through concept and mind maps).

Delimitations of the Study

- Out of all the Graphic Organisers, concept, and mind maps are used in the study.
- In Science, three chapters of Biology i.e. 1: Cell: The structural unit of life, 2: Why do we fall ill? and 3: Diversity in living organisms, selected in the study.
- The study is conducted on IX grade students of Government Sarvodaya Co-Educational Senior Secondary School Sector-7, Rohini, New Delhi.

Research Methodology

The present study has a mixed design with a qualitative and quantitative approach for data collection and analysis. The data collected before and after the intervention was analyzed qualitatively (through content analysis) and quantitatively through (inferential statistics).

Population and Sample of the Study

The population of the study was the IX grade students of the government school of Delhi. The sample was selected through a purposive sampling technique, and 30 students have been selected for the study. This was an experimental study, with one sample, pre-post test design. It has one independent variable and one dependent variable. Teaching biology chapters through graphic organizers (concept and mind maps) was the independent variable, and achievement test in Science was the dependent variable.

Tools used in the Study

The following tools were used in the study

- Three achievement tests (with the same degree of difficulty) of Biology, IX grade, prepared by the researcher.
- Researcher's Diary (maintained throughout the study).

Procedure

The study started after seeking permission from the Principal. The objective and rationale of the research was explained to the Principal and Science teacher of IX grade of Government school taken under study. On discussion with the science teacher, one section of IX grade was found to be academically weak and with some behavioral issues. It was decided to experiment the strategy on this class for improvement and better academic results. The

chapters were identified and selected by the science teacher. Due to time constraints, only three chapters were selected. Although these chapters were already taught by the Science teacher, most of the students were failing in remembering the concepts. They were performing not up to the mark academically (as assessed in pre-test and school regular assessments).

The researcher prepared concept maps and mind maps on three chapters of Science from the Biology Section and got it approved by the experts. The concept and mind maps were made on four parameters: the visual appeal, information covered, degree of complexity, and linking of new to previous related concepts.

The students were taught for about 15 days and 80 minutes (2 periods) each day (1200 hours in 15 days). The students were informed in advance about the pre-test (10 Multiple Choice based questions from each chapter: total 30 questions) to be taken on these three chapters. After taking the pre-test, from the next day, the intervention started. To maintain the internal validity of the research, all three chapters were taught by the researcher only. The concept building of each chapter was done by using the concept maps, and in the end, summarising of the chapter was done by using mind maps. The researcher prepared chart papers and pasted them on the walls of the classrooms, conducted discussions, brainstorming sessions to maintain interest and motivation. After teaching each chapter, a quiz on the concepts and a group activity on preparing concept and mind maps were conducted in order to provide hands-on experience on map making in Science. After teaching all three chapters, a final post-test (with the same difficulty index, 30 MCQs, 10 from each chapter) was prepared and administered. (Images 1.1, 1.2, 1.3, 1.4 and 1.5 showing the execution of experiment in school). After the span of 4 weeks, the second post-test was administered to assess the retention and concept and mind mapping skills.

The pre-test score and post-test scores were collected after careful administration of the test. Scoring of the data was done using the procedure and marking scheme. It was then carefully tabulated and fed into the computer. The data collected was analyzed by applying inferential statistics.

Image 1.1: The researcher explaining concept and mind mapping

Image 1.2: The researcher explaining the Indexing of different concepts

Image 1.3: Students practicing concept map on board

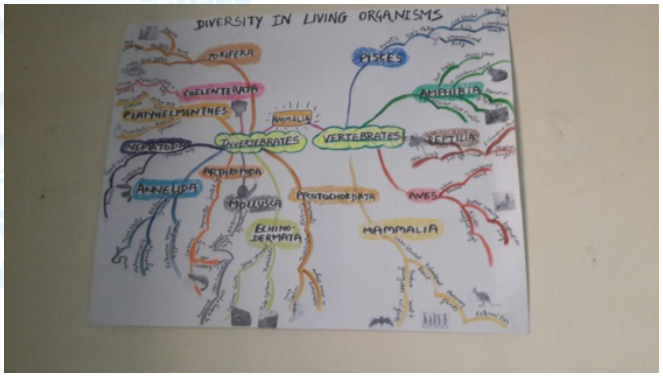


Image 1.4: The final Mind Map prepared by the students in Group work on 'Diversity in living organisms'

Image 1.5.: Students presenting their concept maps

Table 1: Percentage Means

S.No.	*Sample Size (N)*	*Pre Test Score*	*Post Test 1 Score*	*Post Test 2 Score*
1.	30	32%	48%	45%

Table 2: t-value analysis

Scores	*N*	*Mean*	*SD*	*df = (n-1)*	*t (computed value)*	*t (expected value) at 0.05 level*	*Result*
Pre-test Score	30	7.8	2.71	29	3.83	2.048	SIGNIFICANT
Post Test Score	30	18.6	4.83				

Analysis and Findings of the Study

Level of significance: 0.05

As the computed value of t is greater, it is considered significant at 0.05 level of significance (for a two-tailed test), and hence H_o stands rejected.

Null hypothesis framed in the study was found to be rejected. There is a statistically significant difference found in the pre-test scores and post-test scores of the achievement test of the sample under study.

The prime focus of the researcher in the study was to see the effectiveness of concept mapping and mind mapping on academic achievement in Science (Biology). The analysis of the scores obtained in the academic achievement test shows that there is a significant difference between the pre-test and post-test scores of the students. Moreover, the observation schedule used for triangulation has also revealed the impact of the usage of concept and mind maps on the learning and interest of students.

Analysis of the researcher's diary (observation notes): In this study the researcher used concept mapping for introduction and explanation of the concepts, and it was found that it has helped students to identify their misconceptions and to link up their prior knowledge with the new one. It has led to the active participation of students throughout the teaching. The researcher observed students taking part actively in group discussions and in the construction of maps. The construction of concept mapping has given them a better scope of reviewing the topic taught, recapitulate and also to reflect on the content. Preparing smaller concept maps while teaching step by step with an aim to deconstruct the chapter and then merging many concept maps with one major concept has helped students in conceptual bridging. It was found that concept maps and minds maps have helped the teacher to organize the content of the chapter in the systematic hierarchy so that no idea is unaddressed or presented in a slapdash manner. The concept maps helped to focus and bring the attention of the students towards how to establish relationships and connections between ideas and concepts, which ultimately helps in better retention of the concept. It was observed that it not only impacts on the learning of students but also on the creativity and ability of self-expression. It also functions as a mnemonic aid, induces attention, and stimulates curiosity. It allowed the space for divergent questioning.

At the end, the researcher used the construction of Mind maps for summarising the whole chapter. It was found to be an excellent tool for consolidating the whole chapter. It has been observed that the mind maps used in the research by the researcher have made a high impact on the mind of the learners as it gives a full range of visual and sensory tools. They can be used by the students to express their ideas, identify the links and present the relationships between thoughts. It helps the teachers to identify the learning gaps, build conceptual understanding and facilitate new learning onto the previous one. The degree of hierarchy in the construction of mind maps represented the ability of students to reorganize existing and new knowledge in different levels and it reveals the degree of mastery of the conceptual structure of the topic.

Conclusion

The result shows that there was an enhancement in learning and understanding of students taken understudy as a sample. It is concluded in the study that the graphic organizers are proved to be effective in better comprehension of Science content by the Learners of Secondary Stage.

Suggestions

This study has indicated that concept mapping and mind mapping are effective pedagogical tools that can be used by the teachers in classrooms. It not only breaks the monotony of teaching through the lecture method but also supports the construction of knowledge by the student. The researcher presents the following suggestions:

Teachers must use different defensible strategies in teaching-learning. The introduction of new techniques creates and maintains the interest of students towards learning.

A teacher may plan to give an opportunity to students for self-learning and to construct the knowledge on their own through different techniques like using concept and mind maps. However, meaningful feedback to students while construction of concept maps and mind maps must be considered on a serious note.

A teacher may use concept and mind maps for different purposes, for example, for teaching, for making the students learn, for assessment, etc.

Recommendations for Future Research

To study the effectiveness of concept mapping and mind mapping in different academic domains.

- To study the efficacy of graphic organizers as assessment tools.
- To study the impact of usage of graphic organizers on students with special needs.

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