USE OF CONCEPT MAP IN SCIENCE EDUCATION: AN APPROACH TO LEARNER-CENTERED INSTRUCTION

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Abstract: Science education in school curriculum is both very significant and demanding issue. Creating an activity based learning environment with a rich science curriculum which engages all the learners is challenging enough. Through concept map drawing, a learner can be able to participate in a brainstorming session where one puts ideas down on paper without criticism. These ideas become clearer when it is linked with each other and arranged in hierarchical or non-hierarchical structure. Hence, the mind becomes free and active to receive new ideas. In this present study researcher wants to address the question that why the use of concept map in science education is an effective approach for Learner-Centered Instruction and how far it plays an effective role on students' understanding level. Finding of the study shows that concept mapping based instruction i.e. Learner-Centered Instruction is more effective in science education and students get better achievement through it.

Key Words: Concept Map, Science Education, Learner-Centered Instruction.

Introduction: In educational psychology, helping students in science education to make meaning of their previous experiences has been an important issue. In this 21st century, new discovery in technologies, new knowledge territories and teaching strategies transforms the student in an active person which is guided by the teachers with agreement with student's learning manners. In this context David P. Ausubel propounded the theory of meaningful verbal learning. On the basis of Ausubel's meaningful learning, J. D. Novak propounded concept mapping as a Learner-Centered Instructional strategy. Through this activity based learning new knowledge is integrated into the existing structures of knowledge. According to Carey & Shavelson (1989), it is proved that "concept maps tap in to some important aspect of students' knowledge structures and enhance meaningful learning".

Significance of the Study: Science education is facilitated by many instructional approaches. With respect to teacher-centered instruction, learner-centered instruction gives learner more space for acquiring systematic and organized knowledge. Use of concept map in science education is one of the examples of learner centric instructional approach. It is one type of indirect instruction (Mukherjee, 2014-2015, p. 65).

Learner-Centered Instruction can be able to develop permanent learning competences of learners and creative skills of both teachers and learners. It is possible for learners to actively participate in the instructional process by interacting with their teacher in the developing of concept maps. Bascones & Novak (1985); Cullen (1990); Heinze-Fry & Novak (1990) and Kalaiyarasi (1998) - all have reported that concept map enhances meaningful learning for science students.

Objective of the Study: In this present study researcher wants to address the question that why the use of concept maps in science education is an effective approach for Learner-Centered Instruction. Researcher also wants to investigate that how far this concept map plays a significant role on reinforcing students' understanding level for constructing knowledge easily in case of activity based curriculum transaction.

Research Questions:

Q 1: Why the use of concept maps in science education is an effective approach for Learner-Centered Instruction?

Q 2: How far concept map plays a significant role on reinforcing students' understanding level?

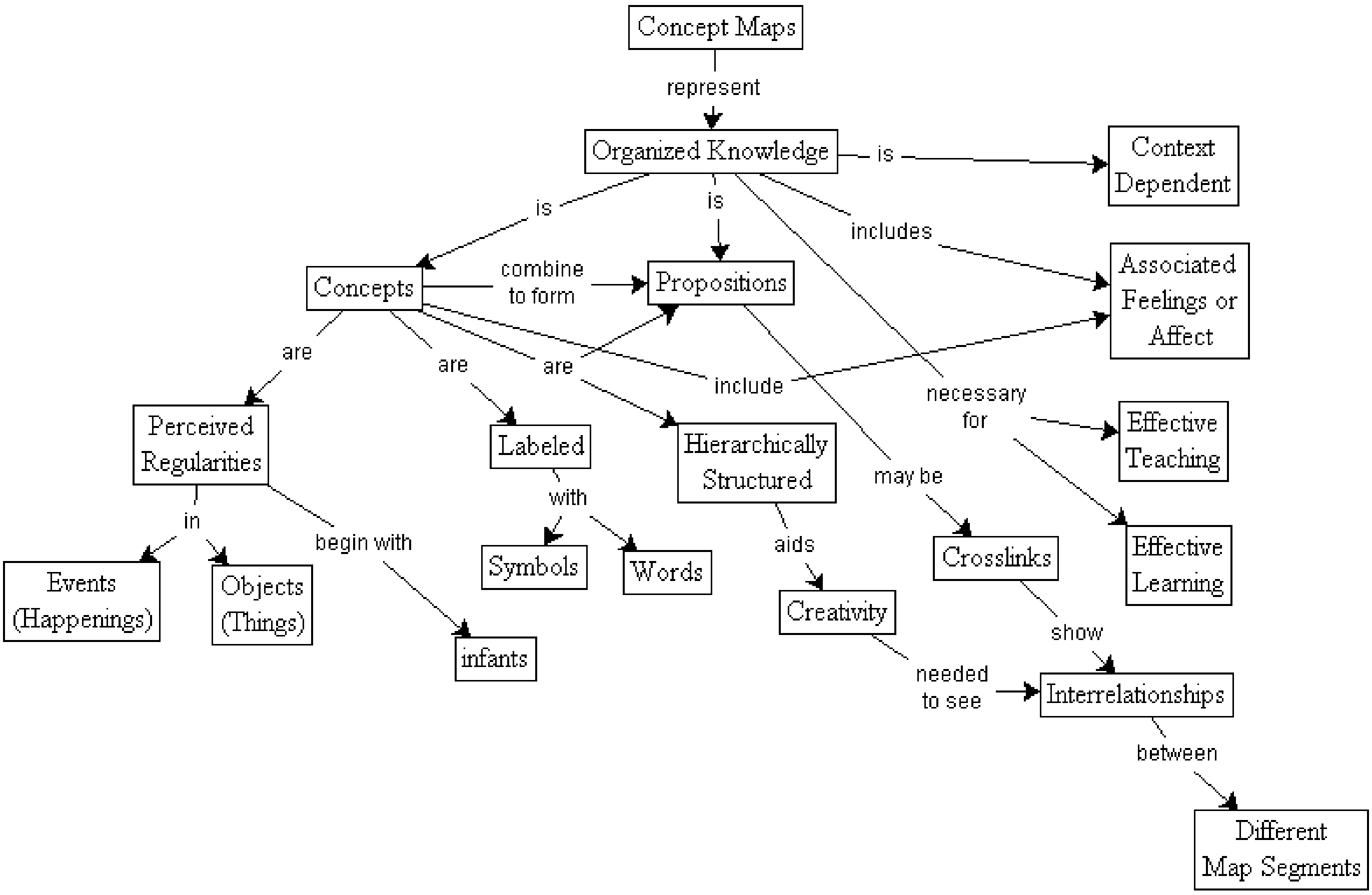
Concept Map: "Concept Map is a diagram consisting of bubbles (called "nodes") that contain descriptions of relevant concepts and arrows (called links or "propositions") that connect nodes with labels describing the nature of the linkage between the concepts" (cited in Buxton & Provenzo, 2011, p. 364). According to Ronis (2008, p. 26) it is said that – "for the individual student, knowledge is organized as "internal concept maps" or schemata (psychological webs of interconnected pieces of information)". "Concept mapping is a generic term that describes any process for representing ideas in pictures or maps" (Kane & Trochim, 2007, p. 01).

History of the Development of Concept Map: In the early 1980's, J. D. Novak of Cornell University first developed the use of concept maps as a teaching strategy. It was derived from Ausubel's meaningful learning theory. Concept map places a great emphasis on the influence of students' previous knowledge on subsequent meaningful learning. According to David P. Ausubel, the theory of meaningful learning is concerned with the following three aspects of instructional process. These are - "1) how knowledge (curriculum content) is organized, 2) how the mind works to process the new ideas (learning), and 3) how these ideas about curriculum and learning can be applied by teachers when they present new instructional material to students" (cited in Pedagogy of Science, Textbook For B.Ed. Part - I, N.C.E.R.T., 2013, p. 232). A parallel exists between the process of how an individual organizes the science concepts or ideas and the process of how they organize that knowledge in their minds as a form of cognitive structure. That's why a connection is build up with the new concepts and the more inclusive concepts. These more inclusive ideas or concepts are called as advance organizers. These advance organizers helps learner in conceptualizing new knowledge in science which appropriates with the broader framework of the concept. Hence, the presentation of an advance organizer is always comes first in case of instruction of a new concept in science. Thus, a shifting in acquisition of more abstract concepts to concrete concepts is shown. Learning is not only the acquisition of new concepts but the construction of meaningful link among concepts (Ausubel, 1968). In the 1970's, Prof. J. D. Novak and his team of researchers at Cornell University developed 'Concept Map', an instructional aid or technique which represents learner's knowledge in science (Novak and Gowin, 1984). The idea of the development of 'Concept Map' is solely based on Ausubel's meaningful learning theory.

Key features of Concept Map: According to Novak and Canas (2008) (cited in Mohapatra, Mahapatra & Parida, 2015, p. 164) the key features of a concept map are highlighted in the following:

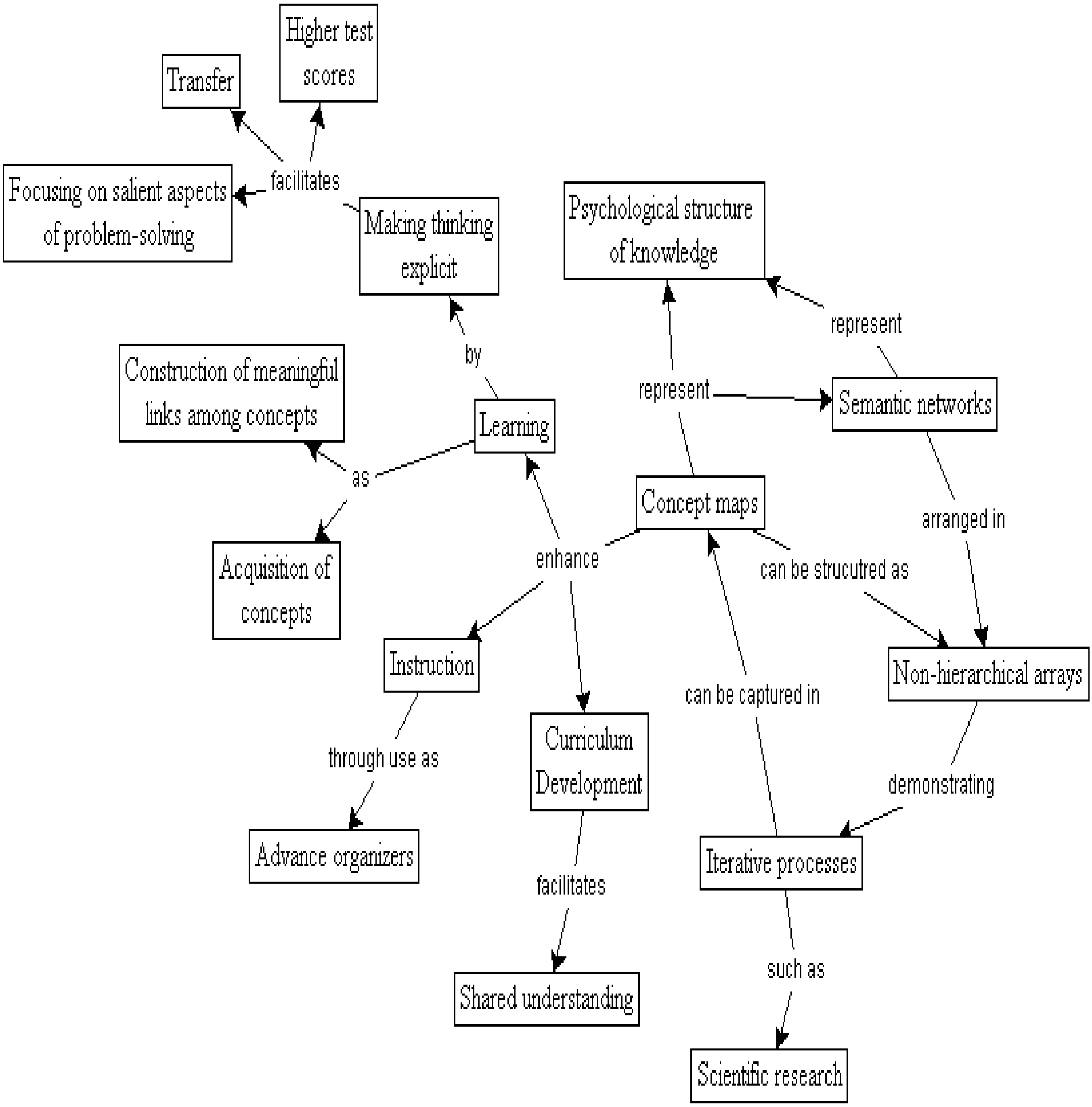
- Concepts, represented by 'nodes' are usually enclosed in circles or boxes. Concept may be thought of as a mental framework of any context. It is arranged in a hierarchical or nonhierarchical order depending on the cognitive structure of the knowledge domain and the context.

Fig. 1: Example of a Hierarchical structure of Concept Map:



Source:https://www.google.co.in/search?q=hierarchical+concept+map&source=lnms&tbm=isch&sa=X&ved=0ahUKEwjfm_nV_83bAhVEvY8KHUjqAgoQ_AUICigB&biw=1366&bih=635#imgrc=1H-QmnHg6f7d-M:

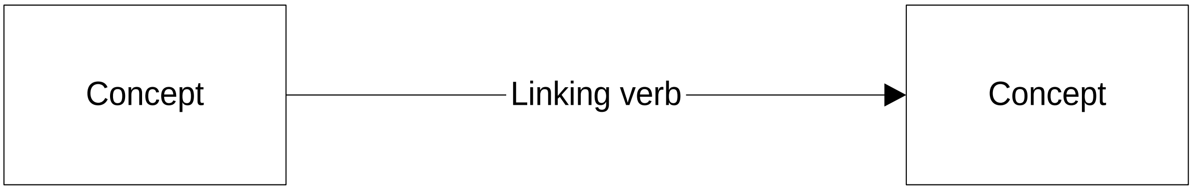
Fig. 2: Example of a Non-Hierarchical structure of Concept Map:



Source:https://www.google.co.in/search?q=hierarchical+concept+map&source=lnms&tbm=isch&sa=X&ved=0ahUKEwjfm_nV_83bAhVEvY8KHUjqAgoQ_AUICigB&biw=1366&bih=635#imgrc=o9vn1rFADQb5SM:

- Relationships between concepts indicated by connecting 'lines' or 'linkages' linking two or more concepts appropriately. Arrowheads indicate the direction of the connection. Directions may be unidirectional or bidirectional in nature.

Fig. 3: Notation of Concept Mapping:

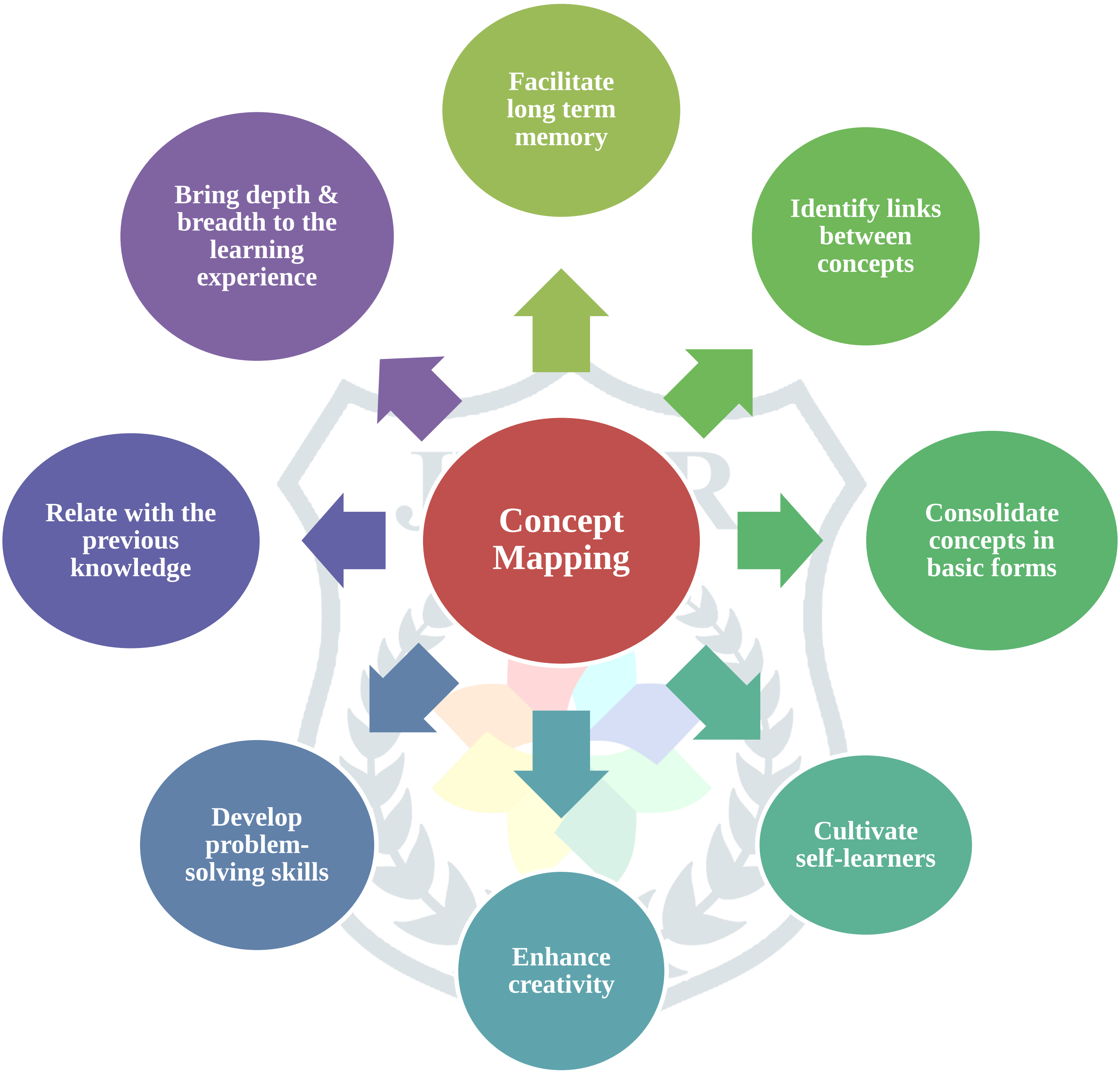


- ‘Labels’ associated with each connecting lines or linkages are represented by the nature of the relationship between two or more concepts. The label being a word (s) or a phrase (generally in ‘verb’ form) – although sometimes it may be symbols (such as +, -, × or ÷).
- A focus questions guiding the construction of the concept map.
- Cross-links indicating relationships between concepts which belongs to the different segments of the concept map.
- Specific examples of concept map significantly clarify the meaning of concepts.

Concept Map and Science Education: “Science is a way or approach adopted for the acquisition of knowledge in search of truth” (Mangal & Mangal, 2015, p. 11). Science performs a crucial role for pursuing knowledge. It has been a wonderful tool in the hands of human beings.

Science is a systematic and organized body of knowledge which covers every aspects of the domain of human experience. Hence, it regards as a compulsory subject in school curriculum. Nature of science combines with the scientific truth, scientific knowledge, scientific attitude, scientific faith, and scientific temper etc. Using concept map in science education is very much essential and relevant for this purpose. Due to lack of interest and motivation, maximum school students ignore to learn science. Sometimes they face some problems to summarize critical information, describe concepts and/or organize ideas in proper and useful ways. In case of new subject matter memorization they leave without relating new information with the existing knowledge. That’s why their achievement towards science decreases day by day. Demonstration strategy is one of the examples of direct instruction or monologue instruction (Mukherjee, 2014-2015, p. 41) which is mostly used for science teaching in schools. Students play a passive role here. In this context instruction by using concept map is one of the best examples of learner control instruction or indirect instruction (Mukherjee, 2014-2015, p. 66). Through this instructional strategy (using concept map as a tool) science teaching-learning process becomes easier and student’s achievement becomes significantly better than any other strategy (Emmanuel, 2013; Chiou, 2008; Oviawe & Lukmon, 2017 etc). In different ways concept mapping strategy enhances student’s achievement in physical science. This is depicted in the following:

Fig. 4: Different aspects of achievement through Concept Mapping:



Learner-Centered Instruction through Concept Mapping: Piaget (1964) reported that traditional methods of teaching are verbal (expository, didactic) and formal, that is teacher centered, with the teacher lecturing and the student being the passive recipient of knowledge. Ausubel (1968) found that meaningful learning can be achieved only when pre-exist in the mind, the necessary relevant concepts and cognitive structures (subsumers) will subsume the new knowledge otherwise rote learning has to be invoked. Cardemone (1975) found that the preparation of a master concept map for the topic of ratio and proportion helped him to plan instruction on this topic. Bogden (1977) also found that concept maps prepared by him in a genetics course were found to be valuable in learning the course by a small minority of students. Cardemone (1975) & Bogden (1977) did not have any words on the linking lines between two concepts.

Novak & Gowin (1984) carried detail experiments for growing the science of concept mapping at an exponential pace. "Researchers have used concept maps to track conceptual change by comparing maps that students construct before and after a learning experience (Pearsall, Skipper, & Mintzes, 1997; Sen, 2002) or comparing maps from groups at different achievement levels (Wilson, 1998)" (cited in Alexander & Winne, 2006, p. 832).

Through this Learner-Centered Instruction, students work together in small groups to learn the instructional objectives of cognitive, affective and psychomotor domains. Donnelly et al. (1999) argued that "cooperative learning methods create an environment in which student – student interactions are encouraged through group discussions, the collective adoption of action strategies, and group efforts toward common learning objectives" (cited in Huang et.al., 2017, p. 209). Johnson et al. (1981) were said in their research that "students work in small groups and cooperative in striving to learn subject matter, positive cognitive and affective outcomes result" (cited in Novak, 2008, http://cmap.ihmc.us/Publications/ResearchPapers/Theory Cmaps/Theory UnderlyingConceptMaps.htm). Use of concept map on cooperative learning process is very much important for structuring learner's knowledge domain effectively. Hence, formation of small groups for working cooperatively to construct concept maps in many contexts is very useful in their concern subject's achievement. To date, concept maps are very much used in cooperation to help teachers and students to clarify and articulate the knowledge.

Educational Implications: Use of concept map in science education has many advantages. It facilitates Learner-Centered Instruction. Hence, use of concept map in Learner-Centered Instruction has following educational implications: 1. Concept map helps teachers to convey a clear idea of the topics and their relationships to their students. 2. Instruction through concept mapping strategy facilitates less likely to miss and misinterpret any important concepts. 3. They can make better sense of the complex materials. 4. It will be helpful to learner for meaningful acquisition of concepts and construct their knowledge positively. 5. Using concept maps in science education can reinforce students' understanding and learning more easily. 6. Through this concept mapping teacher can assess their students' achievement by identifying misconceptions of the concepts. Cullen (1990) and Heinze-Fry & Novak (1990) discussed the use of Concept Mapping as a tool is helpful in overcoming misconceptions in science.

Conclusion: From all the above discussions it is concluded that through open-ended activity based instruction i.e. Learner-Centered Instruction, students preferably create their own phrases and map structure easily. This type of instruction is truly promoted by the modern curriculum. To build proper cognitive structure with meaningful concepts in science education students have to overcome from misconceptions in science. Lambiotte & Dansereau (1992) and Kumudha (2000) – all are said that concept mapping strategy is very much effective for meaningful acquisition of knowledge in science than other traditional strategies. Hence, use of concept map in science education promotes learner-centered instruction significantly. This instructional activity (Using concept map) - "1) more accurately reflect differences across students' knowledge structures, (2) provide greater latitude for demonstrating students' partial understanding and misconceptions, (3) supply students with more opportunities to determine their conceptual understanding, and (4) elicit more high-order cognitive processes, such as explaining and planning" (Vanides, J. et.al. - 2005). Hence, concept map reinforces student understanding level in different perspectives and makes an insight of students' thinking about science.

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