Does constructivist approach applicable through concept maps to achieve meaningful learning in Science?

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Contents

Abstract

This study deals with the application of constructivist approach through individual and cooperative modes of spider and hierarchical concept maps to achieve meaningful learning on science concepts (e.g. acids, bases & salts, physical and chemical changes)). The main research questions were: Q (1): is there any difference in individual and cooperative modes of spider concept maps' to achieve meaningful learning in science? Q (2): is there any difference in individual and cooperative modes of hierarchical concept maps' to achieve meaningful learning in science? Q (3): out of spider and hierarchical maps, which one is more effective to achieve meaningful learning in science? Q (4): is this concept map is being applicable for constructivist approach? Sixty-four 7th grade students from an Indian elementary school participated in the study. Thirty-four and thirty participants treated through spider and hierarchical concept map approach with both cooperative and individual modes. It was an immediate and delayed test experimental design. Two teaching approaches used for two experimental groups: one based upon spider concept map approach and other was hierarchical map approach. After all, students' immediate and delayed, cooperative and individual map of both groups were scored and analyzed by using, Jena & Panda, 2009 scoring procedure. The parametric tests, such as one-way ANOVA and Tukey-Kramer Multiple Comparisons Test used to identify any differences between spider and hierarchical map approach, concerning cooperative and individual modes of learning. Both cooperative spider and hierarchical concept map were significantly better than individual learning in science concept. Therefore, concept map is a constructivist learning

Keywords: Constructivist learning, cooperative learning; elementary school; hierarchical concept map; individual learning; spider concept map

Introduction

The current method of teaching science in primary schools is often didactic and does not engage pupil's prior knowledge actively (Toh, Ho, Chew & Riley, 2003). Instead of understanding science concepts, pupils tend to view science is a piece of information. They do not see the big picture of a unit. As a result, new concepts are not assimilated into their long-term memory (Novak & Gowin, 1984). Making conceptualization, clearing misconception, generating idea, validation of scientific knowledge and cultivation of recent ideas are the emerging attempts in science teaching and learning process. It also enhances student's scientific temper, objectivity, critical thinking, prejudice and freedom from science phobia (Novak, 1993). Therefore, several new methods of teaching have been developed and tried out at India and abroad. But it is seen, teachers and teacher educators always in stress to complete the content of science in school. Moreover, content should not be ignored, and to understand, various facts, principles, theories, these should be represent hierarchically (Novak, 1990) and sequential manner (Adult, 1995). Science content and concepts are linked with so many previous and new concepts, sub concepts, examples and processes. In the same time, teacher does not teach these processes like; how to link, interlink the existing concepts with previous concepts and teacher should not ignore the student's past experience. Similarly, freedom should be given to them, to use their experience, for making, doing, experimenting, reading, discussing, asking questions, listening, and thinking, and expressing ideas individually or in groups. Relating to this idea, constructivist philosophers have believed that, learning is a process; it helps for the construction of knowledge (Fraser, & Adward, 1987).

As Novak and Gowin say, (1999, p. 36): "*Learning is the meaning of a piece of knowledge, requires dialog, to exchange sharing sometimes*."*In this context, meanings can be shared, discussed, negotiated*." The constructivist assumes teaching as a "*common, shared process, where the student, thanks to his teacher's help, can show himself progressively good and autonomous in problem solving, concept using, having certain attitudes and in many other questions*" (Solé and Coll, 2001, p. 22). Students may change their knowledge schemes and own thinking schemes at more complex situations by interacting and collaborating ideas (Vygotsky, 1991). In a study, (Okebukola, 1990) thanks to each student for their successful work or performance for a task, which he would not be able to do if he worked individually

Role of the Concept Maps

A concept map is a graphic organizer, which uses schematic representation, hierarchically to organise a set of concepts, connected by means of words in order to build meaningful statements. It shows meaningful relationship between concepts in the shape of propositions, and it reveals each student's comprehension and knowledge structure (Novak and Gowin, 1999). Novak and Gowin (1999, p. 1) tells us "*concept mapping is a way to help students and educators to see the meanings of learning materials*." It reveals the way in which we could assimilate the concept structure with the source of knowledge, on which the map prepares. When it is made by a working group and being shared by all students, it gives colourful pleasure oftheir reflexive thought (Novak and Gowin, 1999) and it can become an excellent process of building knowledge in a social environment that is cooperative and constructivist. To put it briefly, concept maps are excellent tools for a cooperative activity that will lead to a very meaningful learning (Novak, 2002). Out of different types of concept maps, spider concept map may be organized by placing the central concept in the centre of the map and outwardly radiating sub concepts linked to it and students may easily understand the cause/effect relationships of science by linking, interlinking, sub concepts and examples with the super concept. Their cognitive structure increases radially by the collaboration of new and old knowledge (Beissner, Jonassen & Grabowski, 1994). Spider concept map is a multi flow map, in which multiple outcomes found by the multiple inputs of concepts, sub concepts (Merrill &Tennyson, 1997). In this map, the complex cause and effect relationships can be expressed by the central event with sub concepts depicted or both sides' radials help students to branch their knowledge structure in a meaningful way (Kolloffel & Tessa, 2011). Similarly, the hierarchy concepts may represent the information in the descending order of importance. The most important information is placed on the top and illustrates the downwards classification of the concepts. The super concepts should be placed in the top and the sub concepts are downwardly depicted to express the total concept in a true manner (Hinze- Fry & Novak, 1990).

Collaborative and Individual Modes of Concept Mapping

Okebukola & Ogunniyi (1984) studied the learning mode (*e.g.* cooperative or individualistic) under concept mapping strategy. The objective of the study was to know the student's achievement after concept mapping strategy. The cooperative learning involved the students working in small heterogeneous ability groups while the individualistic mode involves students working alone on an assigned task. They found cooperative mode of concept mapping has improved student's misconception and doubt significantly more than individual map practices. Cooperative group student's achievement and retention are much better than individual learner. Crandell, & Soderston, 1996) compared the effect of collaborative concept mapping on elementary pre service teachers' anxiety, efficacy, and achievement in physical science. The study conducted with pre service teachers (n=118, HE Science), indicated that collaborative concept map could lower the anxiety about learning physical science, lower all the trait anxiety, and increase science achievement. However, it did not have a significant effect on anxiety toward teaching physical science, self-efficacy, and outcome expectancy. Chiu, Huang, & Chang, (2000) studied the collaborative concept mapping process, mediated by computer. The subjects learned and constructed concept map during instruction and the researchers identified that the four patterns of computer-mediated collaborative concept map should process information: (1) concept introduction; (2) limited concept introduction; (3) less link establishment; and (4) proposition construction orientation. Collaborative concept map practice is a useful practice among students. Van Boxtel *et al* 1997 compared the study of collaborative construction of conceptual understanding, interaction processes, and learning outcomes in emerging from a concept mapping and a poster and collaborative concept mp approach is a suitable technique for classroom management. Similarly, Gilbert & Greene (2002) investigated the college students' collaborative use of concept map as inspiration generation to learn educational technology. 15 higher education psychology students were the sample of the study. After concept map learning among students cooperatively to educational technology the researchers found that the concept maps are most stimulating activity among the samples. The cooperative concept map has positive effect on students learning. Inspiration by the teacher is not directly influence the achievement of the students but collaborative concept map has directly promotes meaningful learning. In fact, Kealy, 2001; Van Boxtel *et al* 2002 studied the knowledge maps and their use in computer-based collaborative learning environments. 13 higher education biology students are the purposive samples of the study. The purpose of the study was to study the effect of concept map on achievement of the students through computer based collaborative learning. The findings of the study stated that there exists significant difference in achievement scores between collaborative learners and collaborative concept map learners.

Constructivist Approach use through Concept Maps

Kostoovich *et al* 2007 observed from their study concept map as a constructivist tool for student's learning and knowledge evaluation. They found, concept map might serve as potentially useful tool in physics studied among medical students. Simon, & Schifter, 1991 investigated the using of constructivist approach with online concept map: relationship between theory and nursing education. This study described an online course that used concept maps and self-reflective journals to assess student's thinking processes. The use of concept map with reflective journal provided a learning experience that allowed students to integrate content consistent with a constructivist paradigm. This integration is a developmental process influenced by the personal preferences of students, concept map design, and content complexity. This developmental process provides early evidence that the application of concept mapping in the online environment, along with reflective journal, allows students to make new connections, integrate previous knowledge, and validate existing knowledge. Similarly, Aitken & Deaker,2008 examined concept map as constructivist tool for student's learning and knowledge evaluation. This study indicated that, concept mapping might serve as a potentially useful tool in physics studies with medical students by helping them better to understand the underlying physics concept. Quantitative analysis revealed that almost all students in the intervention groups emphasized, concept map stimulates the understanding of the concept; enables systematic repetition of concepts. However, qualitative analysis of students' answers to the open-type question highlighted that, concept mapping helped students: systematize their physic knowledge, develop their conceptual understanding of the nature and structure of physics concepts, and develop their understanding through collaborative learning (Haney & Czerniak, 2003).

Concept Map provides Meaningful Learning

Okebukola & Jegede (1988) studied on cognitive preference and learning mode as the determinant of meaningful learning through concept mapping. All students on the programme had taken Biology, Chemistry, Physics, Mathematics and English course as their requirements. The primary t-test revealed no significant difference between the mean pre test scores on achievement of experimental and control group. Novak (1990) observed from the study, concept maps as diagram of two meta-cognitive tools facilitates meaningful learning. The finding of the study indicated that concept mapping is a meaningful strategy in learning. Similarly, Okebukola (1990) studied the effect of concept mapping techniques on attaining meaningful learning of concept genetics and ecology. Overall result indicated that concept mapping is significantly better than no treatment, but the two together are significantly better than either alone. Concept map serves as a tool to help learners to organize their cognitive frame works into more powerful integrated pattern (Fraser & Adward, 1987; Schemid, & Telaro, 1990).

Purpose of the Study

In this study, existing concept and its theoretical description are expressed by hierarchical and spider concept maps by the help of elementary school students. The building of concept maps (e.g. hierarchical and spider concept map) from the theoretical conceptualization; needs creativity, collaboration and sharing of information among the peer. The 1st purpose was to know the effectiveness of spider/hierarchical cooperative concept-map approach over spider/hierarchical individual concept map science learning among the elementary school students. The 2nd was whether concept map applicable for constructivist approach. The 3rd was to evaluate the learners' concept map and learning behaviours by using (Jena & Panda, 2009) scoring procedure.

Significance of the Study

Concept mapping is a constructivist approach, which enhances meaningful learning in science (Heinze-Fry and Novak, 1990). Literature suggested, concept map found an interdisciplinary approach and it assists quality instruction among students both individually and cooperatively (Novak, 1990). Especially, in science learning, review of the literature has much supported evidence, indicating the positive direction of concept map (Okebukola, & Jegede, 1988). This promoted the need for more studies to be carried out on the use of concept mapping in teaching and learning at local primary science education. So many, evidence showed, cooperative modes of concept map learning was significant and meaning making over individual modes of learning (Fraser, 1993; Novak & Gowin, 1984). However, hierarchical concept maps were studied more than spider concept map learning (Wallace & Mintzes, 1990). This is being experimented and investigated in this study through evaluation of the pupils' immediate and delayed test scores on their linkages of the concept maps. The comparison of pupils' first map scores and second map scores of both spiders and hierarchical cooperative and individual modes concept map encourages knowing concept retention among pupils and it has a wide range of educational implication at all levels of science learning (Cañas et al. 2001).

From all the studies, there was no clear equal evidence on concept map and on student's achievement. Hence, further investigation is requisite in this area.

Research Questions

Q(1): Is there any difference in individual and cooperative modes of spider concept maps' to achieve meaningful learning in science?

Q(2): Is there any difference in individual and cooperative modes of hierarchical concept maps' to achieve meaningful learning in science?

Q(3): Out of spider and hierarchical maps, which one is more effective to achieve meaningful learning in science?

Q(4): Is this concept map applicable for constructivist approach?

Methodology

Design

A short literature review points out that it is an attempt to find a clear effect of spider and hierarchical concept map with individual and cooperative modes on elementary science concept. Based on this an immediate and delayed map test study was conducted, focusing on the effectiveness of map learning. The present study was an experimental design because this design provides control of when and to whom the instruction is applied and has randomly assigned to the experiment to the two schools. Pupils in the two experimental groups were continuously exposed to concept map learning for two months on concepts (e.g. chemical science(acids, bases & salts, physical and chemical changes). Secondly, pupils constructed a concept map in groups as well as individually on these concepts. There was no control group, but only two experimental groups, one was hierarchical group and second was spider concept map group. Finally, the pupils of both groups were assigned to construct concept map on concept chemical reaction. The subjects were requested to construct first map test (i.e. immediate test) and after two months, again the same map (i.e. delayed map test) on same concept chemical reaction. The data were analyzed in the quantitative analysis technique like ANOVA and Tukey-Kramer Multiple Comparisons Test.

Sample

The study was linked with the 7th grade elementary school of India, and the researcher has taken 64 subjects as the sample of the study. In this connection, 7th grade, sec B, students (n=34), were randomly undertaken as spider concept map group and 7th grade sec C students (n=30) were treated as hierarchical concept map group for the experiment. The researcher for his experiment has been purposely selected those participants.

Instrumentation

In this study, the researcher has used two types of instructional tools. Because of related literature, Spider Concept Map Approach and Hierarchical Concept Map instructional strategies were used in the present study. After instruction, learners' first map (*i.e.* immediate map test), and second maps test (*i.e.* delayed map test) were evaluated by a standard scoring procedure (Jena & Panda, 2009) was the measuring tool for the study.

Procedure of Data Collection

Out of thirty-four students (i.e. spider concept map), twenty and fourteen students were assigned to cooperative and individual instruction respectively. Similarly, hierarchical concept map students (n=30) was assigned into fifteen and fifteen for cooperative and individual instruction respectively, then instruction started by the researcher with why and how types of questions, to the students, related to the chemical science. To achieve the skeletal question's answer, the researcher has advised the students to read the textbook page carefully twice and he has advised the students to select the big word or super concept first, which is necessary to answer the skeletal questions, then sub concepts, very sub concepts and examples, to construct spider and hierarchical concept map. The researcher facilitated the learner to arrange concepts, like spider net, all sub concepts, super concepts the students were arranged radially for the super concept. After, Spidery arrangement of concepts and sub concepts, students are advice to connect the concepts by to arrows and linking words to make the propositions. The researcher has advised to the entire group to exchange their maps for necessary modification, addition, and deleting of the concept by the peers. The best map, the researcher has generalized in front of all students for the clarification of their doubt and misunderstanding. The researcher has also prepared the spider concept map for all concepts in his own activity plans. In the end, he has drawn the map on the blackboard for student's very sensible clarification. Similarly, hierarchical individual and collaborative groups constructed their maps in hierarchical manner. The spider and hierarchical individual group students learned and practised the map individually, but collaborative students learned and practised the map cooperatively.

Figure 1. Spider concept map activity on *acid* (During instruction)

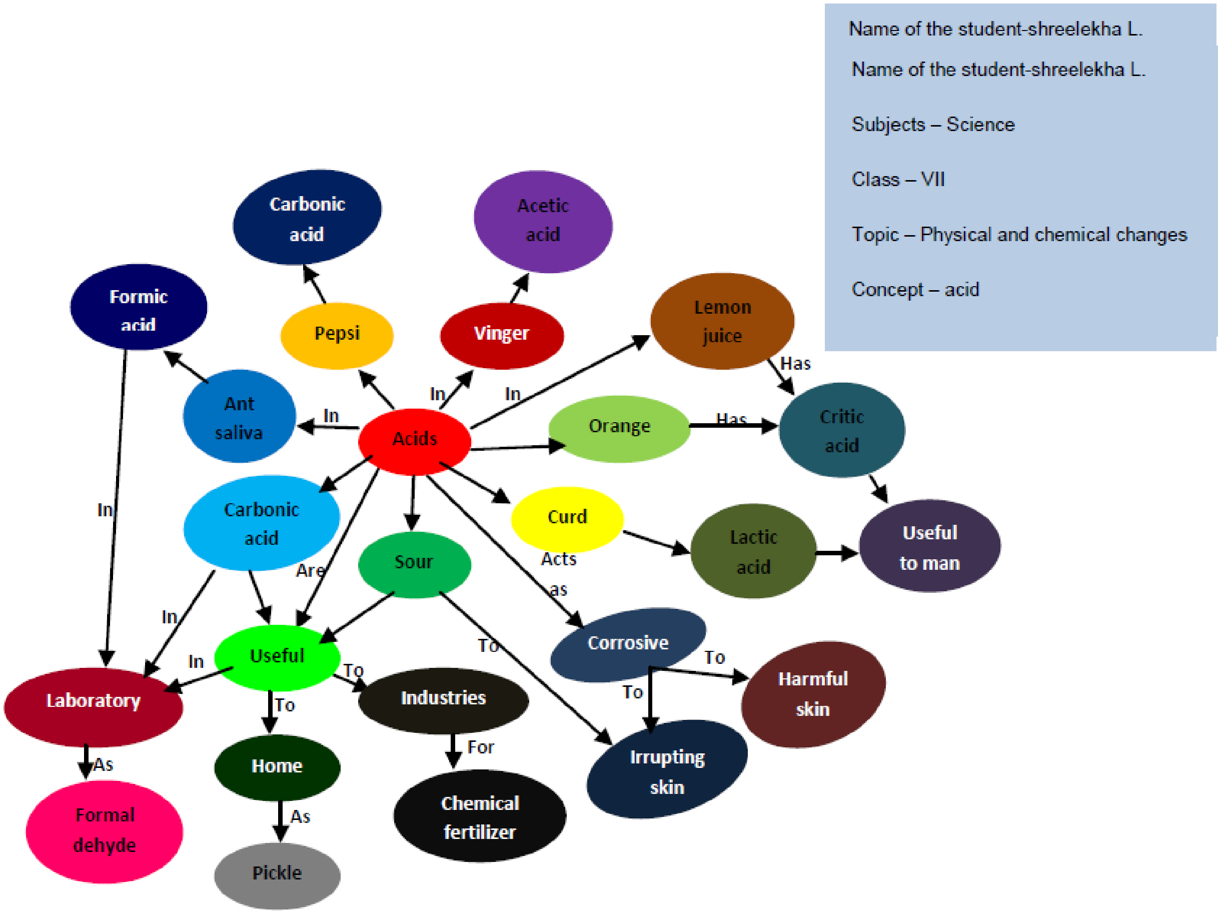
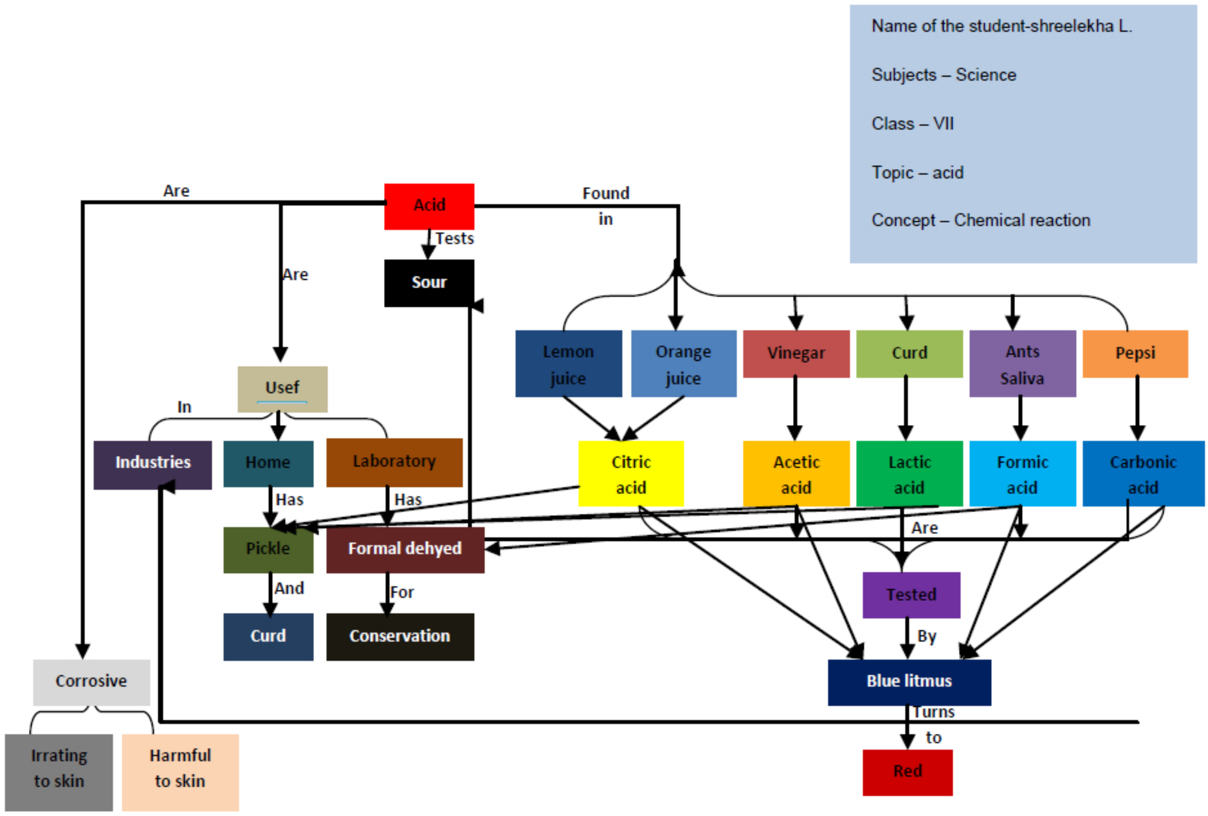


Figure 2. Hierarchical concept map activity on *acid* (During instruction)



Immediate Test

After the end of the instructional session, the researcher has advised the students of both the group to construct chemical reaction map as an immediate test. The spider concept map individual and collaborative students advised to draw map on chemical reaction and similarly hierarchical map group students of both modes advised to draw map in the hierarchical manner.

Delayed Test

After one month, the researcher has advised to construct the same map, to know their retention and learning performance.

Technique of Scoring

The study conducted by Markham et al,1994; Novak,1993; Roth & Roy Choudhary,1994; are intermediate response format has followed 1 point, 5 points, 10 points & 1 points to the number of propositions, hierarchical level, cross links, examples respectively. For open-ended task, Ruiz Primo et al, 1996 has established, scoring based on propositional accuracy.

In the recent study, the researcher has followed open-ended task or response format to score the students' map. 1-point to the meaningful proposition, 3 points for each hierarchy, 2 point for each cross-link &1 point for each example respectively by following recent technique (*i.e.* Jena & Panda, 2009).

Analysis and Results

Both cooperative spider and hierarchical concept map were significantly better than individual learning in science concept; therefore concept map is a constructivist learning.

With response to Q(1) (*i.e. Is there any difference in spider concept map individual and cooperative modes to achieve meaningful learning in science?*) Table 1a, 1b and 1c states cooperative spider concept map is more effective than individual modes of spider concept map and it provides meaningful learning in science.Table-1 is showing the mean, SD & t-ratio of immediate and Delayed Spider concept map scores of chemical science achievement and retention level among of students of cooperative and individual modes of learning. Spider concept map cooperative modes of learner's (n=20) immediate map score mean (22.55) & SD (1.605) were nearly equal with their delayed map score mean (19.9) & SD (2.403). Their t-value (df 19, 0.00 p<.01) was not significant at 0.01 level. It means, there existed no significant difference between immediate and a month delayed map scores. Therefore, retention was high among the cooperative group learners.

With contrast to cooperative spider concept map, individual modes of immediate Spider concept map (n=14) mean (18.741) & SD (0.726) were higher than their delayed map scores mean (11) & SD (0.877).Their t-value (df 13, 3.67 p<.01) was significant at 0.01 level. It means, there existed significant difference in individual modes through spider map learning as recorded from their immediate and delayed map scores. The retention level was low among individual learners as comparable to cooperative modes of learning through spider map approach.Table-1c depicts the One-way Analysis of Variance (ANOVA) for map scores among SCM group of cooperative and individual modes of chemical science concepts states that there existed significant difference between two modes of learning. The F value (df 3/64, 30.248 p<.01) was significant at 0.01 level.

The result found from Q(2) (*i.e. Is there any difference in hierarchical individual and collaborative concept maps to achieve meaningful learning in science?*) was cooperative spider concept map was more effective than individual modes of spider concept map and it provided meaningful learning in science (table 2a, 2b and 2c).Table-2a shown the mean, SD & t-ratio of immediate and Delayed Hierarchical concept map scores of chemical science achievement and retention level among of students of cooperative and individual modes of learning. Hierarchical concept map cooperative modes of learner's (n=15) immediate map score mean (22.333) & SD (1.759) were nearly equal with their delayed map score mean (20.866) & SD (1.884). Their t-value (df 14, 0.017 p>.01) was not significant. It means, there existed no significance difference between immediate and a month delayed map scores. Therefore, retention was high among the cooperative group learners. Similarly, individual modes of immediate Hierarchical concept map analysis in chemical science states that student's (n=15) mean (19.867) & SD (1.533) were higher than their delayed map scores mean (12.666) & SD (1.345).Their t-value (df 14, 5.134 p<.01) was significant. It means, there existed significant difference in individual modes through spider concept map learning as recorded from their immediate and delayed map scores and it cleared that retention level was low among individual learners as comparable to cooperative modes of learning through Hierarchical concept map approach(table 2b).Table-2c depicts the One-way Analysis of Variance (ANOVA) for immediate & Delayed Map scores among Hierarchical concept map group of cooperative and individual modes of chemical science concepts states that there existed significant difference between two modes of learning with regards to their level of retention. The F value (df 3/56, 31.204 p<.01) was significant at 0.01 level. Therefore, cooperative modes of Hierarchical map approach were meaningful in chemical science than individual mode of learning.

In fact, to achieve the Q(3) (*i.e. Out of spider and hierarchical maps, which one is more effective to achieve meaningful learning in science?*), it was found, collaborative spider and hierarchical concept maps were better over both of individual maps on achieving meaningful learning in science(table 3a,3b and 3c).Table-3a depicts the *Tukey-Kramer Multiple* comparative analysis (q) of both in SCM and HCM cooperative groups' immediate performance was better than their individual modes of learning. There q-value (df 33, 0.353 p>.01) was not significant at 0.01 level and there existed no significant difference between two teaching strategies with respect to their immediate test scores. The comparative analysis of SCM vs. HCM with their cooperative modes of learning for chemical science found that there existed no significance difference between two teaching strategies with respect to their delayed test scores. There q-value (df 33, 0.013 $p>.01$) was not significant. Therefore, there was no difference between SCM & HCM teaching strategies in chemical science on cooperative modes of learning (table-3b). Table-3c depicts the One-way Analysis of Variance (ANOVA) for immediate & delayed map scores between spider concept map & hierarchical concept map group of cooperative and individual modes of chemical science concepts states that there existed significant difference between two modes of learning concerning their level of retention. The F value (df 7/120, 25.048 $p<.01$) was significant at 0.01 level. Therefore, cooperative modes of Spider concept map and Hierarchical concept maps provide meaningful learning in chemical science than individual mode of learning.

With reference to table 1, 2 & 3 it was cleared that collaborative learning is useful than individual learning. Q(4)(*i.e. Is this concept map applicable as a constructivist approach?*) is in a right direction, and collaborative learning is characteristic of constructivist learning. In the present study, it was resulted high retention among learners in chemical science (i.e. meaningful learning) than individual learning. Therefore, concept map is a constructivist approach.

Discussion

The finding of the present study supports, cooperative spider concept map is more effective than individual modes of spider concept map and it provides meaningful learning in science. Due to collaboration among learners, concept map is a constructivist approach, which provides meaningful learning in science. Evidence like, the study of Novak, 1988; Roth & Roy Choudhury, 1994; Russo, Scheurman, Harred & Leubka, 1995; have supported the finding that concept mapping as a constructivist approach. Concept mapping helps students to think more effectively as a group without losing their individuality. It helps groups to manage the complexity of their ideas without trivializing them or losing detail. Novak & Gowin(1984) claimed that concept mapping is a useful tool both for the teaching and for learning strategy, which facilitates meaning making in learning science. Cooperative hierarchical concept map was more effective than individual mode and it provides meaningful learning in science. This result supported by the studies conducted in *Biology* (Pearson & Hughes, 1986); *Chemistry* (Wilson, 1998; Markow & Lonning, 1998); *Physics (*Pankratius, 1990; Roth & Roy Choudhury, 1994). All have a found that concept map directly influence on achievement and retention. It was found from the study that the collaborative spider and hierarchical concept maps were better over both of individual maps on achieving meaningful learning in science because cooperative learning is favoured among students. Therefore, cooperative modes of Spider concept map and Hierarchical concept map have found meaningful in chemical science than individual modes of learning. Their t-value is significant at 0.01 and 0.05 level. It means, there existed significant difference in individual modes through Spider concept map and Hierarchical concept map learning as recorded from their immediate and delayed map scores and it is cleared that retention level was low among individual learners as comparable to cooperative modes of learning through spider concept map approach and Hierarchical concept map approach. Hence, the cooperative modes of Spider concept map and Hierarchical concept map were meaningful in chemical science than individual modes of learning (Lumpe, Haney, & Czerniak, 1998). It was cleared that collaborative learning is useful than individual learning and the study is in a right direction, means collaborative learning is characteristic of constructivist learning and in the present study it gives high retention (i.e. meaningful) than individual learning.

Conclusion

Concept map is a kind of constructivist approach, provides group activity in science learning. Where, students are active, and teachers are passive. Learner's cooperative learning gives better performance than individual activity. In the recent study, it is found cooperative learning is better than individual learning and out of two concept maps (e.g. spider and hierarchical), spider concept maps are more helpful to enlarge knowledge structure than hierarchical map. From the research, the investigator showed students feel better on both spiders concept map and hierarchical concept map. So far, assessment of concept map is an easy technique however, traditional assessments are mostly measures the objectivity of the learning, and evaluate the student's achievement in the form of marks. Nevertheless, concept map assesses student's subjectivity and it interprets in the form of marking and grading. Concept map is a prominent assessment tool and its scoring technique assesses the actual knowledge structure of the students. For that, expert concept map is the standard, it assesses the maximum number of concepts, links, and propositions, and it helps the student's map to count number of propositions and concepts at their level. In this assessment technique, the score represent the student's actual understanding and their subsequent knowledge structure. Some evidence from other researchers, like; Goodman, 1984; Mason, 1992; Minstrell, 1989; are found that concept mapping helps in meaning mapping in science learning and has directly put impact on achievement. Therefore, the present study has come under the Novakian area of search and the finding also importance to the world of education. Hence, the cooperative (collaborative) learning an important attribute in the curriculum so as to educating students for coping in today's world.

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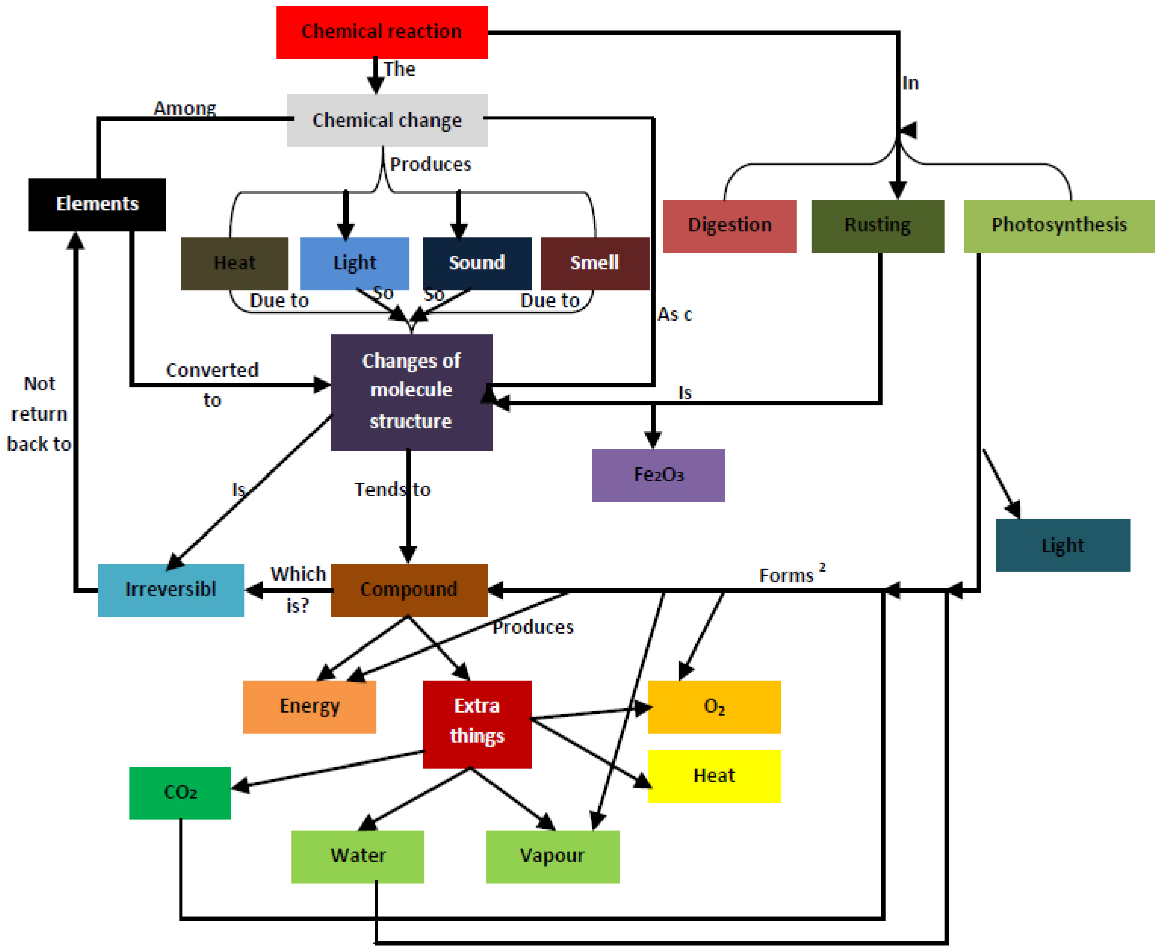
Appendix

1.Cooperative hierarchical concept map on chemical reaction



2. Cooperative spider concept map on chemical reaction

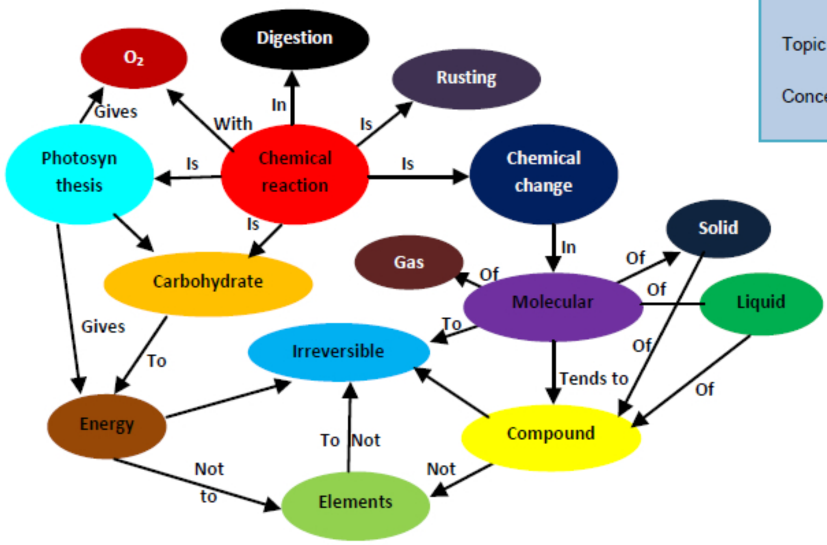
Concept mapping a – 54

Subjects – Science

Class – VII

Topic – Physical and chemical changes

Concept – Chemical reaction



TABLE

Table-1 illustrates M, SD, SEm and t-ratio of SCMA group of students with respect to their cooperative and individual modes of learning in chemical science with regards to their Immediate Map Test (AIMT) and Delayed Map Test (DMT) scores.

Groups	Modes	Tests	N	M	SD	SEm	df	t-ratio	p
SCMA	cooperative	IMT	20	22.55	1.605	0.358	19	0.000	Not significant
		DMT	20	19.9	2.403	0.537			
	Individual	IMT	14	18.714	0.726	0.149	13	3.677	Significant at 0.01 & 0.05
		DMT	14	11	0.877	0.234			

Table-2 represents One-way Analysis of Variance (ANOVA) on Immediate Map Test (IMT) & Delayed Map Test (DMT) among SCMA group of chemical science with respect to their cooperative and individual modes of leaning.

Source of variation	df	Sum of squares	Mean square	F	Level of significance
Treatments (between columns)	3	281.64	93.881	30.248	Significant at

Residuals (within columns)	64	198.64	3.104		0.01 & 0.05
Total	67				

Table-3 illustrates the M, SD, SEm and t-ratio of HCMA group of students with respect to their cooperative and individual modes of learning in chemical science with regards to their Immediate Map Test (IMT) and Delayed Map Test (DMT) scores.

Groups	modes	Tests	N	M	SD	SEm	df	t-ratio	significance
HCMA	cooperative	IMT	15	22.333	1.759	0.454	14	0.017	Not significant
		DMT	15	20.866	1.884	0.486			
	Individual	IMT	15	19.867	1.533	0.395	14	5.134	Significant at 0.01 & 0.05
		DMT	15	12.666	1.345	0.347			

Table-4 represents One-way Analysis of Variance (ANOVA) on Immediate Map Test (IMT) & Delayed Map Test (DMT) among HCMA group of chemical science with respect to their cooperative and individual modes of leaning.

Source of variation	df	Sum of squares	Mean square	F	Level of significance
Treatments (between columns)	3	181.34	60.446	31.204	Significant at 0.01 & 0.05
Residuals (within columns)	56	112.35	1.937		
Total	59	293.69			

Table-5 illustrates the M, SD, SEm and t-ratio of SCMA & HCMA group of students with respect to their cooperative and individual modes of learning in chemical science with regards to their Immediate Map Test (IMT) and Delayed Map Test (DMT) scores.

Multiple comparison	modes	Tests	N	M	SD	SEm	df	q-value	significance
SCMA vs. HCMA	Cooperative	IMT	20	22.55	1.605	0.358	33	0.353	Not significant
			15	22.333	1.759	0.454			
SCMA vs.	Individual	IMT	14	18.714	0.726	0.149	27	0.016	Not significant
			15	19.867	1.533	0.395			

HCMA									
SCMA vs. HCMA	Cooperative	DMT	20	19.9	2.403	0.537	33	0.103	Not significant
			15	20.866	1.884	0.486			
SCMA vs. HCMA	Individual	DMT	14	11	0.877	0.234	27	0.000	Not significant
			15	12.666	1.345	0.347			

Table-6 represents One-way Analysis of Variance (ANOVA) on Immediate Map Test (IMT) & Delayed Map Test (DMT) among SCMA & HCMA group of chemical science with respect to their cooperative and individual modes of leaning.

Source of variation	df	Sum of squares	Mean square	F	Level of significance
Treatments (between columns)	7	450.56	64.366	25.048	Significant at 0.01 & 0.05
Residuals (within columns)	120	308.37	2.570		
Total	127	758.93			