Global Educational Research Journal: ISSN-2360-7963: Vol. 4(3): pp 480-489, September, 2016.

Full Length Research Paper

Lesson plan on teaching Chemistry implementing Metaphorical Thinking

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Accepted 1st September, 2016

Metaphorical thinking is a soft thinking technique connecting two different universes of meaning. The teachers are instructed to prepare Lesson plan implementing Metaphorical thinking by following the three domains of learning mentioned in the Bloom's Taxonomy of learning. Lesson plan implementing Metaphorical thinking would enhance the information processing ability among learners as it builds higher order thinking skills. The learners would able to understand, apply, analyze, synthesize and evaluate the knowledge presented to them. Metaphorical thinking initiates' synaptic activity in the axons which in turn enhances coordination between right and left hemispheres of the brain thus it brings activation in the cerebral cortex, enabling quick understanding of the information.

Keywords: Metaphorical thinking, Lesson plan, Bloom's Taxonomy, Synaptic activity and Cerebral cortex.

INTRODUCTION

Researchers have identified that metaphorical thinking is the ability of an individual to associate the present information with what has already been stored in the memory, by initiating metaphorical thinking practice in teaching –learning process by the teachers during teaching- learning process would enable the learners to optimize their learning ability (Robert S. Siegler and Christopher Shipley, 1995). Another research report by (Lakoff, G. 1993) revealed the usage of metaphorical thinking develops mind patterns which would influence the cognition of the individuals. (Miller, 2011) proposed that learners capable of making more associations are proved to be better in understanding the given information through cognitive architecture where the brain senses the information processes it by comparing it with previously stored information (cognitive structure that already exists) transforms to new cognitive structures to store in the long term memory. The present paper work is attempted to enrich teachers to prepare Lesson plan implementing Metaphorical thinking by following the three domains of learning mentioned in the Bloom's Taxonomy of learning. The Lesson plan implementing Metaphorical thinking would enhance the information processing ability among learners as it builds higher order thinking skills. The learners would be able to understand, apply, analyze, synthesize and evaluate the knowledge presented. The original Bloom's taxonomy of cognitive domain the six cognitive tasks as represented in the following order starting from simpler tasks to complex tasks namely: knowledge, comprehension, application, analysis, synthesis and evaluation. Considering Bloom's taxonomy as the guiding principle an attempt has been made to develop lesson plan in Chemistry for duration of 45 minutes on basic principles namely: Laws of Chemical Combinations, Chemical Formulae, Mole concept etc. The idea is to integrate Metaphorical thinking in every cognitive task mentioned by Bloom. The following model explains how the integration of Metaphorical thinking statements in the lesson plan promotes to establish an improvised attainment of cognitive tasks playing an important role in learner's information processing ability.

On careful observation of figure 1 reveals that the learner's ability to analyse the given content improves which is considered to be the height cognitive task in accordance to the Bloom's taxonomy compared to the rest of the cognitive tasks. The lesson plan implementing Metaphorical thinking by following the

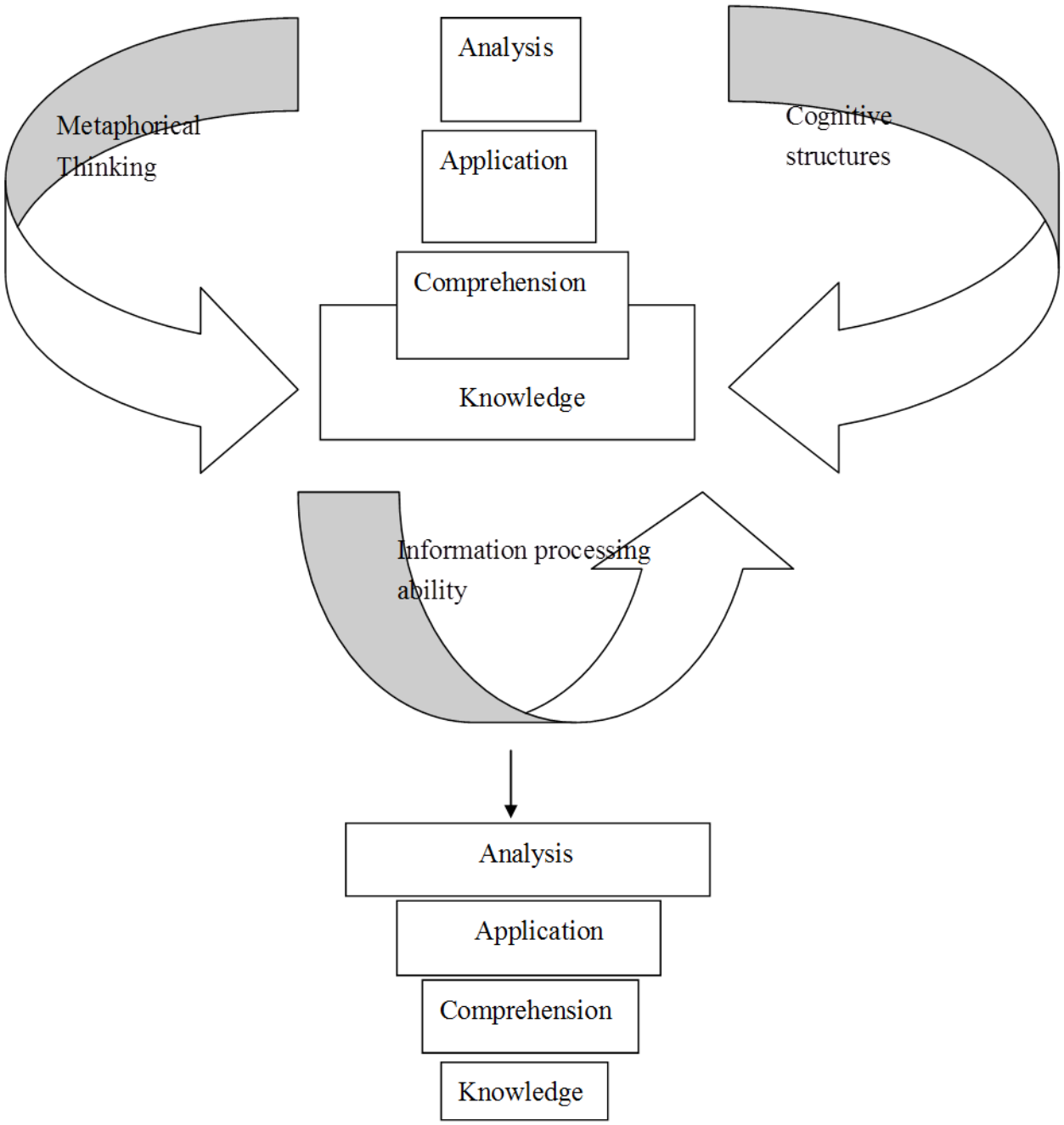


Figure 1: shows the transformation of acquired cognitive task as the result of implementing lesson plan integrated with metaphorical thinking statements

three domains of learning mentioned in the Bloom's Taxonomy as mentioned in the three steps:

Step 1: The teacher should decide the topic to be taught and the target group. This would enable the teacher to build the concept from the knowledge the students are familiar with.

Step 2: The teacher should frame the learning objectives of the topic to be taught keeping in mind three domains that is knowledge, application and synthesis.

Step 3: The teacher should write minimum five statements on each domain with respect to the learning objectives based on knowledge, application and synthesis.

Lesson plan implementing Metaphorical thinking would enhance the information processing ability among learners as it builds higher order thinking skills. The learners would be able to understand, apply, analyse, synthesize and evaluate the knowledge presented to them.

A template lesson plan

- **Subject: Chemistry**
- **Topic**: Chemical Bonding
- **Class:** 9th grade **Duration**: 50 mins
- The topic Chemical Bonding explains the meaning of the term Chemical Bond, Types of Chemical bond, Formation of Chemical Bonds.

Step1: Introduction

Do you know that there are a few naturally occurring elements when compared to the number of compounds. What could be the reason for such a large number of compounds when compared to the number of elements? What is the nature of force that holds two or more elements together? How do these forces come into existence? What is the name given to these types of forces? Therefore, Chemical bond is defined as the attractive forces that exist between two or more elements.

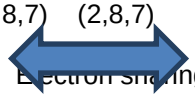
Step 2: Learning Objectives

- The pupil will be able to
- Define the term Chemical Bond.
- Acquire the knowledge of formation of Chemical Bond.
- Understands the condition of formation of Chemical bond.
- Analyses the types of Chemical Bond.
- Applies the knowledge to synthesize new compounds.

Step 3: Metaphorical statements based on Learning Objectives given in the Learning experience column of the rubric.

Specific objectives	Content	Learning Experience	Evaluation
Recalls	Introduction: Teacher introduces the concept of the term Chemical bond by explaining the fact there are large number of compounds compared to the number of elements in nature, making them think the reason for it.	➢ What is the nature of force that holds two or more elements together? ➢ How do these forces come into existence? ➢ What is the name given to these types of forces? ➢ In nature bees are attracted to flowers by an unknown force, is this force of attraction similar to the attractive forces that exist between elements. In what way they are similar as well as dissimilar. ➢ Can you come to the conclusion that the attractive forces that exists between elements are given the term “Chemical Bond”.	Define the term Chemical Bond. List out some of the common compounds in nature.

Step 3: Metaphorical statements based on Learning Objectives given in the Learning experience column of the rubric. Cont.

Specific objectives	Content	Learning Experience	Evaluation
Recognizes	The teacher explains the conditions of formation of chemical bonding similar to the conditions for making ice cream from milk and explains that different elements combine in the presence heat, light and electricity to form a number of compounds	How do elements combine in different ways? You would have observed in blood donation camp someone donates the blood and others in need of it accepts blood if the same thing happens in elements where one element transfers the electrons completely to the other element what is the name of the bond for e.g: Na + Cl ⟶ NaCl (2,8,1) (2,8,7)  Transfer of one electron from Sodium to Chlorine Consider a situation in which two friends or two siblings sharing an accommodation which equally common to both of them. Is this situation similar to mutual sharing of electrons between atoms of the same or different elements? What is the name given to the type of bond? For e.g Cl + Cl ⟶ Cl2 (2,8,7) (2,8,7)  Electron sharing	Define Ionic bond. Name some compounds containing Ionic bond and identify the number of electrons transformed from one element to the other. What is the name of the bond formed by mutual sharing of electrons between the same or different elements? List out a few compounds formed by sharing of electrons.
Understands	The teacher explains basic criteria for the formation of Ionic and Covalent bonds by considering the nature of the elements for e.g Electro positive+ Electro negative = Ionic bond Electronegative+ Electronegative= Covalent bond	What is meant by Electropositive elements? Can you compare Electropositive element with a rich man capable of donating money to charity? Can you compare Electro negative element to a poor man capable of accepting money from a donor as well as sharing with fellows of the same status.	Define the term electronegative and electro positive elements. List out the names of a few electropositive and a few electronegative elements.

Step 3: Metaphorical statements based on Learning Objectives given in the Learning experience column of the rubric. Cont.

Specific objectives	Content	Learning Experience	Evaluation
Formulates	The teacher explains the characteristics of Ionic and covalent compounds	Can you consider common salt as example to ionic compound and Diamond as example to Covalent compound? Do you think that all ionic compound have high melting point? Similarly all covalent compounds have low melting point.	Give a few examples for ionic and covalent compounds.
Synthesizes	The teacher lists out symbols of few elements asks the pupil to find out various combinations of elements forming ionic and covalent bonds.	Can you compare the combinations of compounds you synthesize with natural semi-precious stones like ruby, emerald, topaz etc to find out the type of chemical bond present in them?	List out examples of compounds containing both ionic and covalent bonds.

Assessment

1. An element “A” is present in group 1A of the periodic table another element “B” is present in group VII A of the periodic table. What type of bond is formed between them?
2. An element “A” has atomic number 6 another element “B” has atomic number 17. What type of bond is formed between the two? Give its chemical formula.
3. Compare and contrast the properties of common salt and diamond.

The above lesson plan implementing metaphorical thinking statements taking into consideration Bloom’s taxonomy of learning objectives kindles teachers to consciously think to use metaphorical thinking during teaching-learning process. As the teacher gets acquainted with the technique of implementing metaphorical thinking the same would be reflected upon the learners. According to information processing theory developed by several cognitive Psychologists come to a conclusion that the processing of information storage takes place through several cognitive components for e.g when information received by an individual through sensory input, the raw information is captured in a sensory buffer for a short duration with in this period it is transferred to short-term memory (STM).During this short span of time the receiver should pay attention on the information. At this juncture metaphorical thinking statements help to build cognitive structures encoding the information in a meaningful way in long term memory (LTM) which has unlimited storage (Mayer1981). Meaningful learning occurs when knowledge stored in long-term memory is shifted to short term memory to integrate new information into the mind by cognitive associations when individuals relate stored knowledge to sensory input and encode the stimuli into long term memory (LTM) (Bell-Gredler, 1986).

Table 2, the lesson plan implementing metaphorical thinking practiced consciously by teachers would help in meaningful learning every time as it kindles sensory input to associate new connections with the past knowledge. The lesson plan implementing metaphorical thinking follows constructivist approach in building the lesson to draw the attention of the students in engaging them to connect the prior knowledge with new knowledge. One of the important aspect of implementing metaphorical thinking lesson plan is that the teacher should be familiar with the content (Borko. H andLivingston.C 1998). (Herrmann Ned 1999) suggested in his Brain dominance model that activities involving metaphorical thinking would promote different types of thinking namely: Analytical thinking, Sequential thinking, Interpersonal thinking as well as Imaginative thinking. Further it is observed that the implementation of metaphorical thinking statements in the lesson plan is in the form of thought provoking statements it is expected that it would facilitate the following learning outcomes among the students.

1. Creating questions of their own based on the information given.
2. Obtaining supporting evidence to answer the question(s) by comparing with another universe which differs in their meaning.
3. Explaining the evidence collected relevant to the questions.

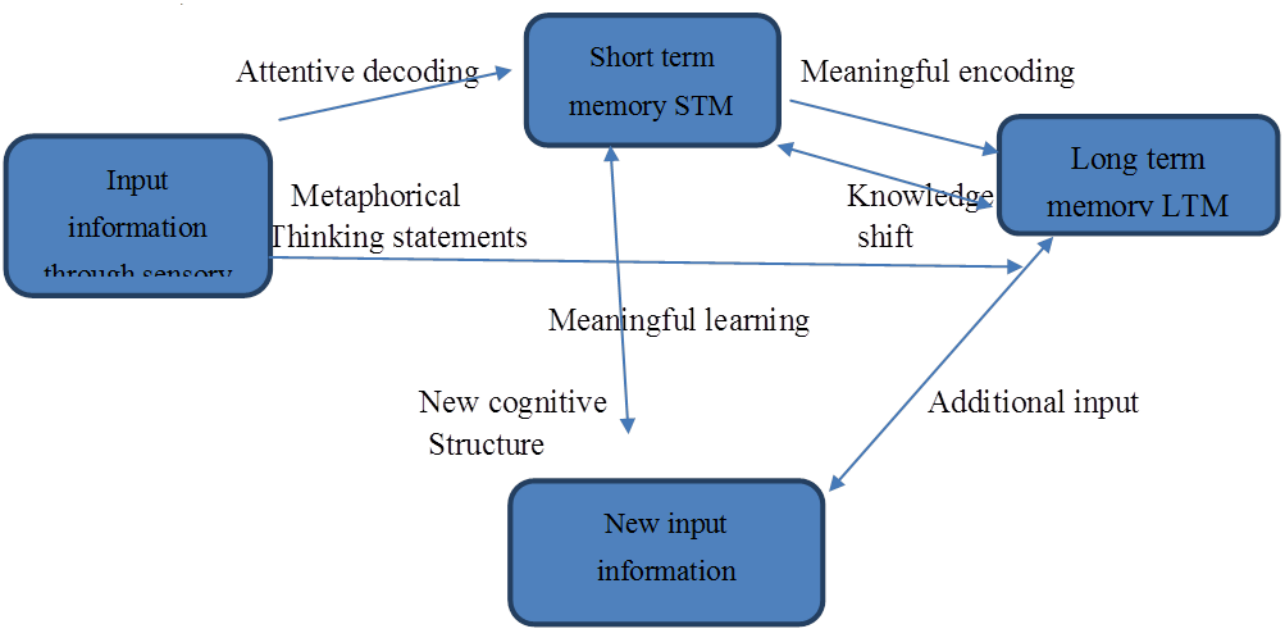


Figure 2: Represents how information is processed via cognitive structures or mental schema

4. Connecting the explanation to the knowledge obtained from the investigative process as mentioned in the second and the third step.
5. Creating an argument and justification for the explanation given.

Lesson plan implementing metaphorical thinking in accordance to Bloom's Taxonomy develops the ability to analyze, synthesize, and evaluate information or new understandings indicates a high level of thinking. Hence, the teacher should practice planning the lesson consciously so that the learners develop divergent thinking which would help them to ask their own questions and to learn the effective strategies for discovering the answers. Several research studies by (Chu, K.W.S.2009) proposed teacher training session by the process of using inquiry learning to ensure the maximal amount of resources creating the best learning scenarios.

Objectives of the study

- To find the impact of implementing metaphorical thinking lesson plan on the academic performance of the learners.

- To find the teacher effectiveness in developing cognitive structures based on their teaching experience.

Research Questions

- Is there a significant difference between pre and post-test performance among learners?

- Is there a significant association between the numbers of years of teaching experience and development of cognitive structures among learners?

METHODOLOGY

The research was carried out in two stages. In the first stage an experiment was conducted by selecting school children in the age group 13 to 15 years studying in IXth grade in Government School, Chennai district. Forty children are selected for the study. These children are taught Chemistry subject on topics namely: Laws of Chemical Combinations, Chemical bonding, Atoms, Molecules, Chemical Formulae, Moe concept, Atomic structure etc. All the topics were taught implementing metaphorical thinking lesson plan in order to achieve better understanding of the subject so that at every step the learner connects the present experience with the past building to construct concrete learning outcomes. The validity of the experiment is tested by conducting pre and post-test in the subject. The experiment was carried out for one trimester.

Sample

IX grade school children both boys and girls in the age group 13 to 15 years were selected for the study, the mean age group is (14.85) years. A total of 80 children were selected for the study. 80 children were grouped into two based on the academic performance

Table 1: To show the significant difference between "t" values for the pre and post test scores of the students of the experimental and control group

Type of group	Type of test	N	Mean	Std. Dev	"t"	L.S
Experimental	Pre	40	25.65	9.958	11.805	0.001
	Post	40	52.88	14.467		
Control	Pre	40	70.63	17.422	5.644	0.001
	Post	40	82.60	12.900		

*P<0.05, **P<0.01, ***P<0.001, , N.S=Not significant

Table 2: to show Chi -square values expressing the association between teaching experience and the development of cognitive structure.

Teaching Experience	**N**	**Mean**	**S.D**	**X^2 = Chi-Square**	**L.S**
Group 1 above 10years	20	153.20	23.41	20.00	0.0001
Group 2 equal to 6 years less than 10 years	6	161.33	28.49	6.00	0.016
Group 3Equal to 3 years less than 6 years	6	149.33	14.43	6.00	0.014
Group 4 Equal to 1 year less than 3 years	4	162.25	24.51	4.00	0.046

*P<0.05, **P<0.01, ***P<0.001, , N.S=Not significant

before starting the experiment. Students who scored "c" and "D" and "E" grades were grouped as experimental group and the students who scored "B" "A" and " A^+ were grouped as control group. The children in the experimental group were taught implementing metaphorical thinking lesson plan for one trimester to kindle interest in the subject for a duration of one hour per week by the investigator. The rest of the days they attended their regular Chemistry class along with the control group of students. Post test was conducted based on the training given to the students. The control group of students are as such high achievers in the subject, they are self-motivated students and were not exposed to teaching –learning process involving metaphorical thinking. They were exposed to regular teaching practice. The pre and post test scores were collected and subjected to statistical analysis using SPSS 20.0 version. Paired sample "t" test was performed to understand statistical significance and the results are tabulated.

The results of the analysis in table 1 shows that the experimental and the control group differ significantly in the statistical analysis of "t" values. The Analysis answers the research question that there is significant difference between the pre and post test scores. The following explanation based on the analysis is

The experimental group shows in mean values of pre and post-test indicating that the implementation of the metaphorical thinking lesson plan has played a significant role in improving the academic performance of the students which is also evident from the "t" value. The standard deviation value for the post test score is on the higher side indication that there appreciable variation from the mean as compared to the pre-test standard deviation. This indicates that the experimental group of students showed remarkable improvement in the post-test performance compared to pre-test.

The control group of students are self-motivated high achievers and showed significant differences in academic performance though they were not exposed to metaphorical thinking implemented lesson plan, however careful examination of the pre and post-test mean as well as the standard deviation values indicate that there is some difference but the variation of standard deviation for post-test from the mean is less compared to pre- test. Hence, it could be interpreted that the students being good achievers showed marginal difference between pre and post test scores.

The second stage of the experiment involves survey method, the cognitive structure questionnaire was distributed to a sample of 37 male and female teachers in the age group 25 to 60 years as a means of pilot study. The questionnaire consists of 45 statements evaluating the ability of the teacher to develop cognitive structures based on the delivery of the content, activity and assessment. Every statement formulated to evaluate the development of cognitive structure involves metaphorical thinking which is otherwise known as associative thinking. Each of 15 statements evaluate content, activity and assessment having options ranging from not important to extremely important in five point Likert scale. The teachers were asked to read the statements carefully and tick the appropriate option according to individual's understanding. The scores were collected and the results were analysed using SPSS 20.0 version. As the sample size is small non parametric test was performed on the data to evaluate the association between the teaching experiences of the teachers with the development of cognitive structures among learners. The results of the analysis is expressed in the form of a tabular column below.

The table 2 shows that the Chi-square value for the

Table 3: to show Chi -square values expressing the association between the age of the teachers

Age(Years)	Gender	N	Mean	S.D	X 2 =Chi-Square	L.S
>25	Male	9	155.00	21.71	9.00	0.003
	Female	3	173.67	15.14	3.00	0.083
>35	Male	6	151.00	27.36	6.00	0.01
	Female	5	163.80	19.24	5.00	0.025
>45	Male	8	141.25	26.25	8.00	0.005
	Female	1	169.00	-	-	-

*P<0.05, **P<0.01, ***P<0.001, N.S=Not significant

Table 4: To show the comparison among male and female teachers in developing cognitive structures based on content, activity and assessment performing ROC analysis.

Gender	N	Dimensions of cognitive structure	Area under the curve for each dimension	% of the area	Significance of the dimensions
Male	16	Content	0.476	47.6	65% of male teachers are activity oriented
		Activity	0.651	65.1	
		Assessment	0.603	60.3	
Female	20	Content	0.549	54.9	54.9% of female teachers are content oriented
		Activity	0.396	39.6	
		Assessment	0.187	18.7	

Table 5: To show the relation between cognitive structure and content, activity and assessment of male and female teachers.

Gender	N	Correlation coefficient "r" between cognitive structure and content	Correlation coefficient "r" between cognitive structure and activity	Correlation coefficient "r" between cognitive structure and assessment	Correlation coefficient "r" between content and activity	Correlation coefficient "r" between content and assessment	Correlation coefficient "r" between activity and assessment
Male	16	0.854	0.807	0.821	0.551	0.693	0.483
Female	20	0.788	0.865	0.680	0.684	0.178N.S	0.445

*P<0.05, **P<0.01, ***P<0.001, N.S=Not significant

group 1 teachers whose teaching experience is above 10 years showing maximum association between the developments of cognitive structures with teaching experience compared to other groups based on experience. It is quite evident that the experience of the teacher counts in delivering the content, activity and assessment more effectively.

Table 3 shows that as the age advances the ability of the teachers to develop cognitive structures among students' increases as it is shown by the Chi-square values that the association between developments of Cognitive structures with the age of the teachers is more significant compared to rest of the age groups.

Table 4 shows the comparison among male and female teachers in developing cognitive structures based on content, activity and assessment performing ROC analysis

Receiver Operating Characteristic (ROC) curve analysis reveal that male teachers possess more tendency to developing cognitive structures concentrating on the activity dimension whereas female teachers have more tendency to develop the same concentrating on the content dimension. Male teachers while concentrating in the activity dimension implement metaphorical thinking in the activity part of the information while female teachers concentrate implementing metaphorical thinking on the content part of the information.

From the table 5: it could be stated from the correlation coefficient values that a significant relationship exists between cognitive structure with the content , activity and assessment dimensions of the

information. Therefore, when the information is delivered integrating metaphorical thinking statements helps in developing cognitive structures in the case of both male and female teachers in general, however the delivery of content and assessment correlation coefficient values of male and female teachers differs significantly probably due to the fact that female teachers give more importance in delivering the content as compared to assessment.

Research studies conducted by survey as well as experiment reveal that metaphorical thinking plays a significant role in developing mental schema among the students.

DISCUSSION

Lakoff.G and Johnson 1980) in their research mentioned that the use of metaphors can be powerful aids in education because they can help learners begin to understand novel concepts. They observed that the students used metaphors in science content for better understanding by comparing the living cell to an urban city where the organelles of the cell is compared to different locations in the city. Kahneman, 2011supported the theory explaining the involvement of Metaphorical thinking help in developing cognitive structures by mentioning that the brain unconsciously and automatically filters ,decodes , interprets and categorizes signs and signals during communications. Therefore, to learn a new concept, the learner must use new experiences, if available, and connect them to already existing experiences or portions of previous experiences in the mind. According to (Carey, 2010; Clement, 2010; Nersessian, 2008) learning engages processes like thought experimentation, analogies and visualization Tobin and LaMaster (1995) described that the idea of using metaphors in class- room teaching is not new, as it was seen in one case where a struggling middle school science teacher used the metaphors during teaching –learning and noted marked progress in the classroom atmosphere and effectiveness of her teaching. John Dewey(1934) in his learning theory has mentioned that educators must engage students with statements to think metaphorically that they become familiar with their own imaginations that they try to understand new information by relating with the old by enhancing their instructional practice. He further suggested that Students exhibit a deeper understanding of the learning process through the creation of metaphorical connections. The practice of introducing metaphorical thinking statements does not only encourage dialogue among classmates but also lead to better class room interaction. Teachers should set the learning bar higher by expecting higher-level thinking to flourish in the classroom. Hence pre-service teachers must be encouraged to use metaphorical thinking statements in the class room. Opening dialogue between student-to-student and student-to-teacher can only lead to enhanced learning for everyone. Cozolino, (2002) in his research mentioned that practice of using metaphorical thinking influences affective cognitive domain, hence the learners develop a sense of powerful insight to learning.

CONCLUSIONS

1. Lesson plan is one of the important aspect in teaching –learning process.
2. Teachers should have open mind in the development, implementation, and evaluation of innovative lesson plan which would help the learners in understanding of goals and actions of the given information.
3. Teachers need to understand the importance of metaphorical thinking statements to be implemented in the lesson plan. They need to identify the appropriate metaphorical thinking statements explicitly and discuss the implications of their usage effectively in the teaching-learning process.
4. Appropriate usage of metaphorical thinking statements for teaching –learning will give a more robust understanding for the teacher as well as the student in constructing the knowledge, understanding and application.
5. The teachers should be encouraged to develop effective lesson plan and make it as one of the tools for best teaching practice.

The implications of this research and the recommendations made in light of its results open the door for teachers to analyse the metaphorical thinking statements that guide their understanding of teaching, learning and knowledge that strengthen reform-based teaching practices. This could lead to teachers developing and utilizing effective lesson plan to attain higher cognitive skills.

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