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Role of Analogy Based Teaching to Enhance Higher Order Skills in Chemistry Learning at Grade IX

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ABSTRACT

Aim of the Study: The current research was piloted to explore the impact of analogy-based classroom teaching to enhance higher order skills in chemistry at IX Grade. It was experimental research.

Methodology: The study was designed on true experimental basis. This target was completed by selecting two groups of grade IX learners, through randomization. Each group was comprised of 40 participants. Intervention was involved teaching of selected subject matter of text book of grade 9th issued by Punjab Curriculum and Text Book Board, Lahore for area of chemistry. Through 16-week period of intervention, each group was provided an identical extent of lessons. Control group was taught by simple lecture method of teaching and treatment group was educated through analogical practices. Data collection was completed through pretest and posttest. Analogy Based Teaching Achievement Test (ABTAT) was developed by the investigator and used to find the variance of achievement level between traditional group and treatment group. SPSS was supported analysis of data.

Findings: Pretests achievement scores were shown that performance of both groups was not significantly different. While significant difference between two groups proved the constructive outcome of role of analogies in teaching to enhance higher order skills of experimental group. First term assessment was the major limitation of the study to encircle it only for subject of chemistry and Grade IX.

Conclusion: The outcomes of this work exposed the positive role of analogies in classroom teaching at school level. So, it was proposed to teachers to incorporate simple, interesting and related to actual concept analogies in lesson strategies for operative learning.

Keywords: Analogy, Analogy Based Teaching, Chemistry, Higher Order Skills.

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Introduction

Today, the world is in front of the difficult task of transformations in didactic standards of public schooling predominantly in areas of skillful science learning and teaching (Faize & Dahar, 2011). Renovations in education begin with questions that how teachers teach and how students learn instead of

this that what learners acquire and what teachers instruct. A significant element of constructive teaching is to develop conceptual understanding (Kim, 2002). Chemistry is well-thought-out an essential subject at school level science that contracts with numerous zones of creative knowledge. It is one of the sets of course of school science that can encourage the logical development of the learners through its operative renovations. (Lavaqui, 2007). The nonconcrete reality of chemistry along with gratified learning problems means that chemistry session entails advanced level of capabilities and effective approaches of schooling (Taber, 2002).

Content of chemistry and the method of teaching its abstract concepts, make chemistry problematic to learn. Methods of classroom teaching that indorses hypothetical learning are in conflict with reality of science, i.e. outdated and deficiency of innovative skills (Johnstone, 2000). To make possibilities of concepts easier to recall according to situations, pupils enthusiastically essential to find, manage and generate associations that grasp the material organized. Teaching through analogies is one of the instructional methods in science that includes a concept, a situation or a procedure is corresponding to another same perception (Harrison & Treagust, 2006). According to Gentner (2003) analogy is a plotting of familiarity between two fields. To apply analogical practices, commonly used realm is every so often called as the base, source, or "analog" whereas the fewer in practice notion, or the material to be educated, is generally known as the "target". The code of applying analogies in classroom teaching is, to plan for an innovative, characteristically intangible part of concepts, in other field of ideas of why, how, and when to put on this information to resolve difficulties in alternative situation (Pellegrino & Hilton, 2012).

In educational viewpoint use of analogies in teaching is striking that highlights pre knowledge of learners as an initial idea for teaching and focuses on creation of knowledge by the students as a result of meaningful learning, which finally improve higher order skills of the students (Deborah, 2014).The process of analogy derivation and its practice in classroom situation encompasses higher order psychological progressions i.e. to analyze diverse learning patterns, apply suitable prospects to resolve situations, evaluate finest resolutions and to conclude and generate innovative concepts (Blake, 2004). Occasionally conditions comprise of analogical replicas, allegories and images used in methodical framework. The fact significant is to initiate process of teaching by creating the links amongst the described and the rational instrument of apprentice' thoughts before applying analogical practices for operative understanding (Walton & Hyra, 2018).

Objective of the Study

Study the role of analogy-based teaching to enhance higher order skills i.e., applying, analyzing, evaluating and synthesizing towards chemistry learning of grade IX students.

Literature Review

The idea of analogy is a source of perception in classroom situation, development of new ideas related to preexisting thoughts and to support learners to relate the new material with pre structured knowledge in cognitive pattern (Hartmann., et al 2017). According to Hofstadter & Sander (2013), analogy practice is influential logical procedure, a source of mental learning and dynamic progression that prepares individuals to recognize and handle the diverse learning circumstances (Jick & Holyoak. 2001). It contains detecting of shared collaborative scheme between two learning settings and producing more interpretations according to these interconnections (Glasersfeld 2009).

Peterson (2020) explained his point of view about analogy that it is a concept that exhibits likeness of two ideas with purpose of creating expressive knowledge. The role of analogy is not merely outward, but also to clarify phenomenon or learning situation. This is the fact that makes analogy more elaborative than allegory or a metaphorical situation in literature. Judy Blume (2018), demarcated analogy is an idea that gives some specific explanatory argument for example, Life is similar to a container full of sweets that you cannot identify how can get your share. Analogy is practice of finding comparable ideas between two

items, or organizations of ideas that high spot situations in which they are supposed to be comparable (Barth, 2010).

Role of Analogical Practices in Teaching Science

In classroom teaching of science concepts, analogical practices have been broadly used as method of teaching. Generating and applying analogies facilitate the learners to recognize of terminology and thoughts by increasing their understanding capability and uplifting higher order thinking skills (Duit, 2001). Hence, analogies may be labelled as valued instrument for theoretical transformation in teaching of science concepts.

Researches done in past exhibited the usefulness and constructive role of analogies in science education for example the work "effect of theoretical change on students' perceptions on chemical kinematics (Cerit. 2008). In similar framework Pekmez (2010) applied analogical practices to avert students' misunderstandings related to chemical equilibrium. Aykutlu & Sen. (2011) studied the role of analogy on learners' conceptual change to find the effect of active mass and external temperature on rate of chemical changes.

Constructive role of analogies on conception and retaining of knowledge have been known particularly in topics including atoms and molecular species (Harrison & Treagust, 2006), types of circuits (Lemmens, 2005), inheritance (Barker & Millar, 2000), Earth sciences (Blake, 2004), procedures of chemical separations (Novak, 2008), synthesis of amino acids (Pittman, 1999) solid state physics (Duit, 2001), characteristics of matter (Sharma, 2016), role of enzymes in biological reactions (Taber, 2014) and facts of electrical current (Houser, 2018). More than 5 analogies were used to elaborate movements of atoms by Ansar et al., (2013).

Schooling of science areas not only comprehend transmission of concepts but also to penetrate the ideas in cognitive structure and long-life learning over employing operative instructional procedures. Science concepts, laws, and thoughts are learnt effectively through experiential practices, Ausubel (2001). A significant aspect affecting learning is preexisting structure of knowledge in learners' cognition. That leads to progress idea of expressive learning and "advance organizers". Later creation of knowledge commences through learners' capability of observing and recognizing of process and matters through the perceptions they previously collected. Learners develop ideas by raising link of thoughts and multiplying them frequently through reasoning in a systematic means (Weller, 2016).

Use of Analogies, a Constructive Process

Theory of constructivism is founded on scientific education about how people learn. When new concepts fuse with preceding knowledge and practices, innovative knowledge produces consequently. Learners are active creators of novel ideas. It involves asking challenging questions, search and evaluate what they know related to current ideas (Sharma 2006). In the light these thoughts in this work, use of analogies supported by constructivist learning method and its inferences to enhance higher-order thinking skills and profound thoughtfulness, are well-thought-out significant property of constructivist school of thought.

Analogy is a Source of Effective Education

Eloquent and operative learning was a notion introduced in 1960s in the boundaries of constructivism. It varies from memorization of knowledge in that a link is attained in prior data and the afresh knowledge, whereas rote ideas are based on remembering concepts lacking of understanding (Sadiq, 2003). Suggestive knowledge permits learners to assist attained material with prior information and practices that provides bridge while gaining current knowledge. The process empowers them to gain comprehensive and long-lasting conceptual knowledge (Venville, 2006).

Role of Analogy to Enhance Higher Order Skills

Global modifications in expertise, the progresses of the cyber space, the international marketplace economical variations and public demands to proper schooling, have reformed the areas and meanings of prescribed teaching (Yener, 2012). Hypothetical knowledge in numerous arenas has instigated a series of skills often termed as higher order thinking skills that are different from conventional academic instruments of knowledge e.g., mathematics, science and history and that are considered more logical to develop qualitative educational and useful products in up-to-date economical market (Gick & Holyoak, 2007). Perceptive skills that support the character of knowledge to classify, simplify, find declarations, and convert it according to required situation may be highly important to effective academic functions as well as to extended social and profitable involvement may be named as higher order skills (Yener, 2012).

The present study investigated that in what ways analogies may help like an integrating device to enhance higher order skills, both as an instrument for approving value of learned material and a fundamental cognitive device for consuming knowledge effectively. Nakleh (2002) studied the use of cognition by Maxwell mechanical processes to produce analogies to explain concept of electromagnetism. He specified that analogies are frequently applied in textbooks and classroom instructions to facilitate active teaching-learning mechanism.

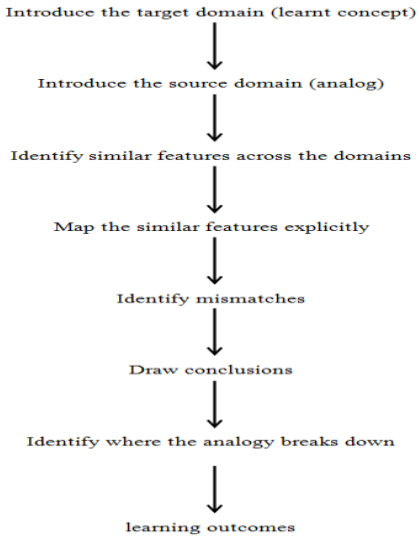
Richland (2015) described the role of analogies in reorganization of learners' conceptual understanding in science. He observed the influence of interactive- involvement and enhancement of self-efficacy through teaching with analogies of high school chemistry learners.

Glynn's Model of Analogy Based Teaching

Zeitoun (2004) established the General Model of Analogy Teaching (GMAT) comprised of multi'hase model to conduct teaching process through analogical practices in a series of constant modification and perfection. This model is involved various actions to implement analogy as instructional method in classroom:

Glynn and fellows have reviewed and adapted the Teaching with Analogies (TWA) model given by Zaitoun (2004). The model offers guiding principle for creating analogies scientifically and apply purposefully in teaching to clarify significant perceptions in conducts that are expressive to learners. The model elaborated the procedure to construct effective analogies for teachers and book authors and facilitate students to generate their applicable ideas by energizing, shifting, and replacing it to new information learnt from schoolbooks.

Figure 1: *Analogy Based Teaching model adopted from Glynn's Model (2004)*



Theoretical Frame work

Theoretical frame work of the study was constructed on prevailing philosophy associated to objectives of the study (Linn, 2006). The study was influenced by constructivist concept of learning and Glynn's model of teaching with analogies.

Figure 2: *Theoretical frame work*

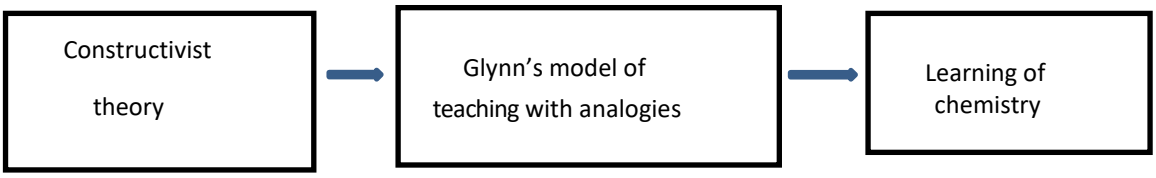
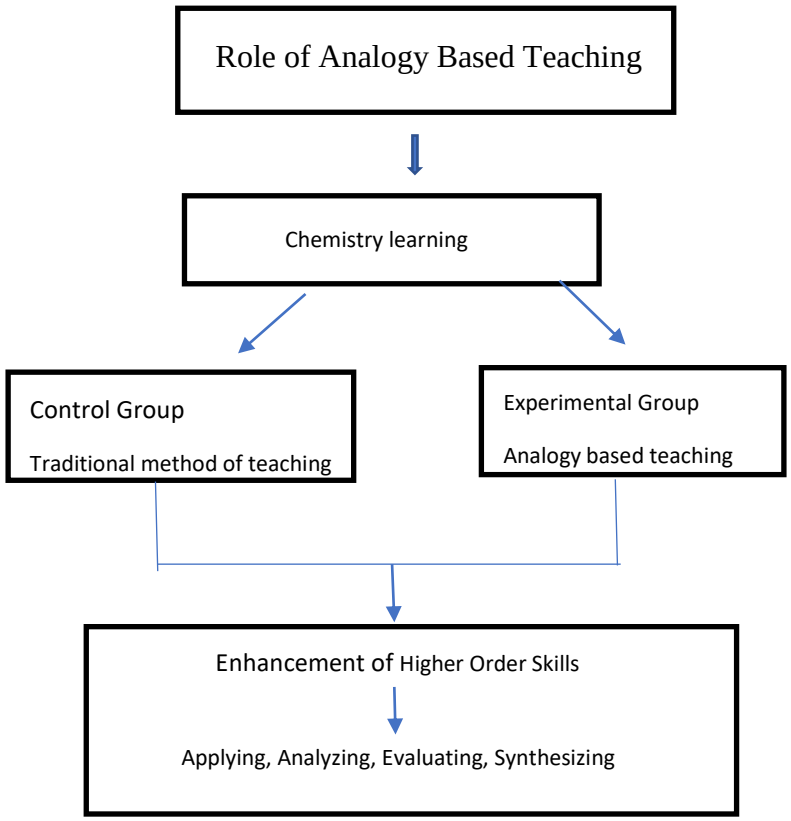


Figure 3: *Conceptual framework*

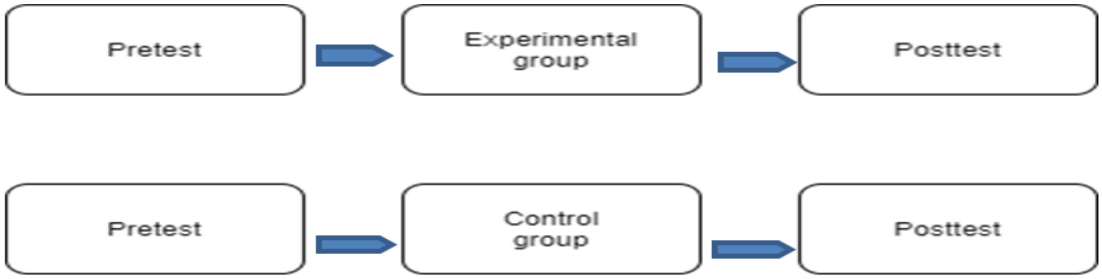


Research Methodology

To investigate the role of teaching through analogy improve higher order skills i.e applying, analyzing, evaluating and synthesizing, this study was conducted. Pretest posttest control group design was selected to collect data for the study. This research design fits well in the experimental setting of the study. Due to random selection of participants, divided into control group and treatment group. Intervention was provided to experimental group whereas other group participants were taught through traditional lecture

method. Pretest posttest were administered for both groups to examine the variance of achievement level among both groups. Flow chart given below provides the information of research design.

Figure 4: *Research Design*



Treatment group	R	O_1	X	O_2
Control group	R	O_1	C	O_2

Here X represents the group related to experimental variable, the difference of achievement level was to be measured according to the objectives of the study. O_1 mentions to the Pretest and O_2 for Posttest. X specifies experimental group and C directs to control group. Data composed by pretest and posttest was evaluated through SPSS.

For this study, content was selected from chemistry book 9 suggested for grade IX by Punjab curriculum wing titled as independent variable and improvement of higher order skills through effective learning of chemistry content was nominated as dependent variable.

Participants were selected through random sampling from 8 group sections and at subsequent phase 40 participants were selected from each group through hat and lottery method according to the instructions provided by the supervisor.

Rendering the nature of title of the research and its objectives, the instrument "Analogy Base Teaching Achievement Test" (ABTAT) for grade IX learners, was developed by the researcher. ABTAT was created under the directions of supervisor and subject professionals to assemble the data, the basic construction was structured on four self-reliant higher order learning skills i.e. application, analysis, synthesis and evaluation. It was comprised of 50 multiple-choice items from nominated topics for analogy- based teaching after eliminating outliers. Table of specification was developed according to instructions of subject specialists for items distribution related to four higher order skills to construct ABTAT. The table of specification was developed for selected topics by following Bloom 's taxonomy learning objectives.

Table 1: *Table of specification to prepare chemistry learning achievement test.*

Cognitive level according to blooms taxonomy	**Objectives**	**Item No.**	**Total items**	**Weightage %age**
Application	Study the role of analogy-based teaching to enhance applying skill.	18, 21, 22, 23, 24, 29, 30, 33, 42, 44, 45, 47, 49	13	26%
Analysis	Study the role of analogy-based teaching to enhance analyzing skill	1, 2, 3, 6, 12, 14, 15, 17, 19, 20, 25, 32, 34, 38,	13	26%

Synthesis	Study the role of analogy-based teaching to enhance synthesizing skill	7, 10,11,14, 28, 29, 31, 36, 40, 41, 43, 48	12	24%
Evaluation	Study the role of analogy-based teaching to enhance evaluating skill	4,5,8,9,13,16,19,2 735, 37, 39,46	12	24%
Total no. of items		50	50	100%
Total marks			50	

Procedure of Experiment

The study was conducted through an experiment of 16 week on Grade 9th learners to apply treatment i.e. teaching through analogy practices. It was directed at urban public school. Prior to start of intervention the objectives, list of topics, possibility and procedure of the activity was explained and discussed to all group participants. Five classes were planned per week by school coordinator for both control group and experimental group.

Pretest was administered at the beginning stage of intervention. All topics were taught in 15 weeks as per schedule for both groups. Experimental group was taught whole content through analogies whereas, control group was delivered the same content by traditional lecture method. Scholar has enough exercise to produce analogies of theoretical based topics

Table 2: *Content of the study*

Sr no	Topics
1.	Types of mixtures
2.	Symbols of elements
3.	Formation of Chemical formula
4.	Radical and free radical
5.	Atomic Structure
6.	Arrangement of elements in Periodic table
7.	Formation of chemical bond and its types
8.	Matter and its states
9.	Types of Solutions
10.	Properties of gases

From above-mentioned topics 45 lectures were imparted through self- developed analogies by the researcher to accomplish the study objectives. Table 3,4 shows the few topics with suggested analogies used for respective topics; remaining analogies would be provided on request of the readers.

Table 3: *Topics & proposed analogies*

Sr.no	Topis/sub topics	Proposed Analogies
1	Periods and groups In periodic table horizontal and vertical arrangement of elements is called groups and periods.	Sitting arrangement of students in class in rows and columns like periods and groups in periodictable
2	Shielding effect the number of electrons present between outermost shell and nucleus, high atomic	Movement of Prime Minister on the road with lotof security all around. This mass of security

	number more shielding effect	with authoritative persons is like shielding effect of electrons around nucleus…more authoritative people have more security and more shielding effect.
3	Topic: Chemical bond (Binding force between two Atoms)	Our relationships are binding force between each other like bond of love and affection of parents for their kids, family, colleagues, friends, studentand teacher etc.
4	**<u>Sub Topic</u>** Duplet rule and octet rule (struggle for getting stable position by the completion of number of electrons in valence shell).	Story of every living being to get stable position by completion of studies, good job making family and struggle for stable social status.
5	Ionic bond Complete transfer of electrons produces strong ionic bond between two atoms.	Maria is needed of some money for her hostel dues she sent message to her friend for this purpose so her friend transferred 20 thousand on her request. She obliged her for this favor and this act of kindness gave strength to her bond of associationand loving interaction.
6	Covalent bond Equal sharing of electrons between atoms so that both atoms between two atoms so that both atoms will get equal influence of pair of electrons.	It was birthday of Maria. Her friends planned forher birthday party. They planned to arrange it by equal sharing of money and activities so that no one have any burden and every one will enjoy.
7	Brownian movement Irregular movement of molecules in all directions.	Movement of children in school ground during break time.

Results

Statistical analysis is grounded on various tests, outliers' diagrams, Statistics report and data consistency numeric. It also portrays hypotheses' statistical support. Owing to the personal efforts, a 100% response rate was achieved. According to difficulty level, majority of items properly fit in the reasonable range (p-values 0.40–0.80) and they showed positive item discernments (Ds), signifying the fact that majority of participants selected accurate responses at posttest as compared to pretest. The data were evaluated through frequencies, means, standard deviations and the practice of independent sample t-test to compare the performance of both groups in pretest and posttest. Related tables are given below.

Table 4: *Summary Statistics: Achievement Scores of Grade IX Students of Control and Experimental Groups before treatment (n=80)*

Factor	**Conventional Group**			**Experimental Group**			**Independent Sample *t*-test**	
	N	***M***	***SD***	***N***	***M***	***SD***	***t*-value**	***p*-value**
Achievement Scores before Intervention	40	19.60	4.63	40	19.78	5.30	-0.16	0.88

According to table 4, independent sample *t*-test was directed to examine the variance in achievement scores of conventional group and experimental group before treatment. Table indicates that no significant difference was observed in scores of control group (*M*=19.60, *SD*=4.63) and experimental group (*M*=19.78, *SD*=5.30). The *p*-value (0.88) for *t*-value (-0.16), is higher than 0.05. So, it was determined that control group and experimental group were existing nearly at equal level before any treatment.

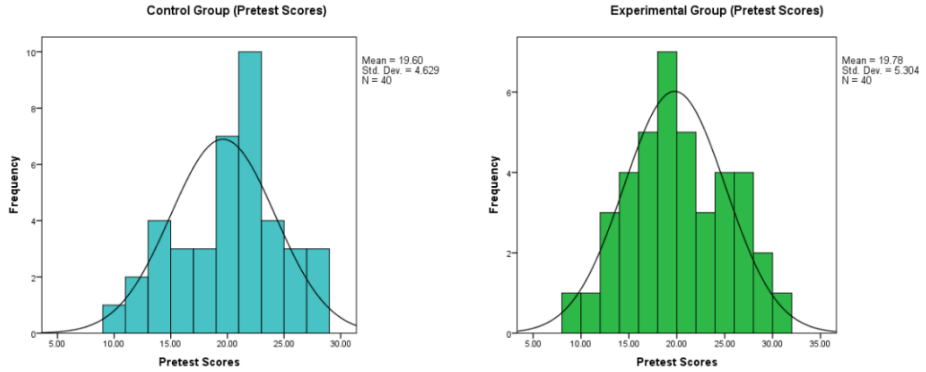


Figure 2: *Distribution Curves regarding Pretest Scores in Group Categories (n=80)*

was exposed to observe the difference in achievement scores of conventional group and treatment group after intervention. Table indicates that a significant difference was found in achievement level of control group (*M*=20.85, *SD*=5.62) and experimental group (*M*=30.35, *SD*=6.70). The *p*-value (0.00) for *t*-value (-6.87), is lesser than 0.05. So, it was decided that the achievement level of experimental group participants was better than those of control group as a consequence of intervention of analogy-based practices.

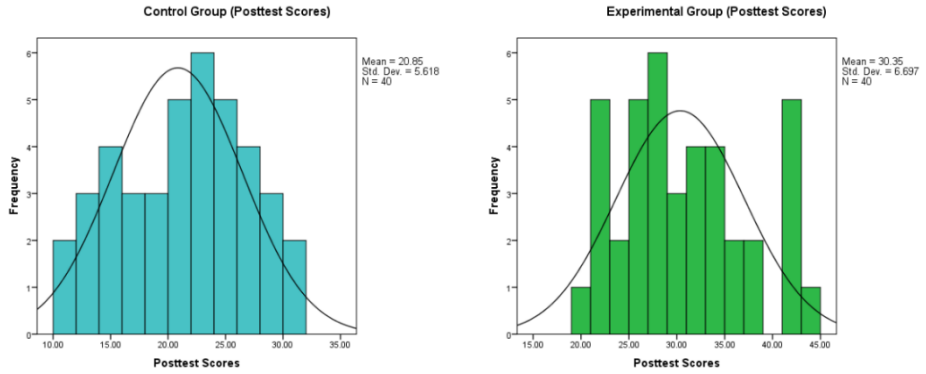


Figure 3: *Distribution Curves regarding Posttest Scores in Group Categories (n=80)*

Table 5: *Comparisons of Pretest and Posttest Achievement Scores of Grade IX Students of Control Group (n=80)*

Factor	**Control Group (Pretest)**			**Control Group (Posttest)**			**Independent Sample *t*-test**	
	N	***M***	***SD***	***N***	***M***	***SD***	***t*-value**	***p*-value**
Achievement Scores	40	19.60	4.63	40	20.85	5.62	-1.09	0.28

Table 5 reveals, an independent sample *t*-test was conducted to find comparison in pretest and posttest achievement level of control group. Table indicates that no significant difference was found in pretest (*M*=19.60, *SD*=4.63) and posttest (*M*=20.85, *SD*=5.62) scores of conventional group as the *p*-value (0.28) is greater than 0.05. So, it is concluded that there was no significant difference between the achievement scores of pretests and posttest of control group.

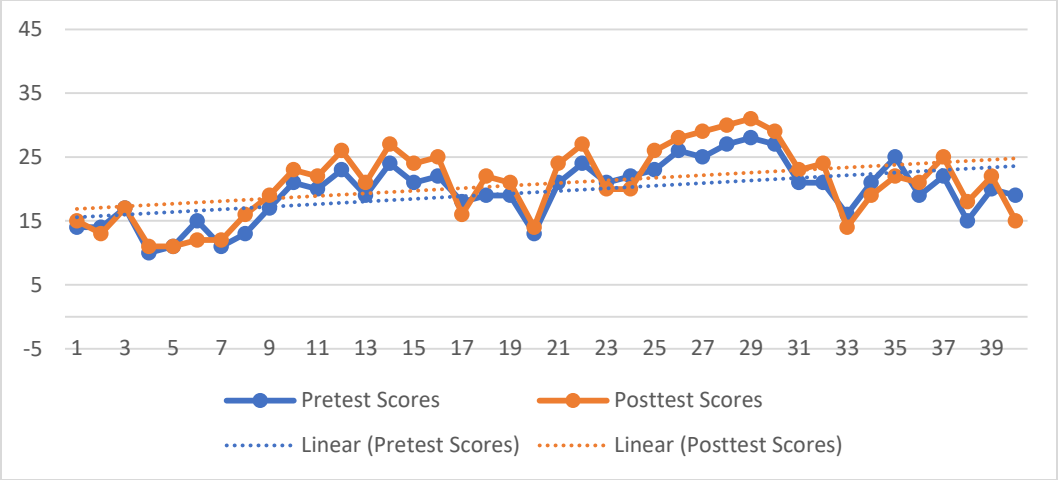


Figure 4: *Line Chart Comparing Pretest-Posttest Achievement Scores of Control Group (n=80)*

Table 6: *Comparisons of Pretest and Posttest Achievement Scores of Grade IX Students of Experimental Group (n=80)*

Factor	**Experimental Group (Pretest)**			**Experimental Group (Posttest)**			**Independent Sample *t*-test**	
	N	***M***	***SD***	***N***	***M***	***SD***	***t*-value**	***p*-value**
Achievement Scores	40	19.78	5.30	40	30.35	6.70	-7.83	0.00

Table 6 reveals, an independent sample *t*-test was directed to compare achievement level of pretest and posttest of treatment group. Table indicates that there was significant difference among pretest (*M*=19.78, *SD*=5.30) and posttest (*M*=30.35, *SD*=6.70) scores of participants belong to treatment group as the *p*-value (0.00) is less than 0.05. So, it is determined that there was significant difference between the achievement scores of pretests and posttest of experimental group as a result of intervention by using analogy-based teaching practices.

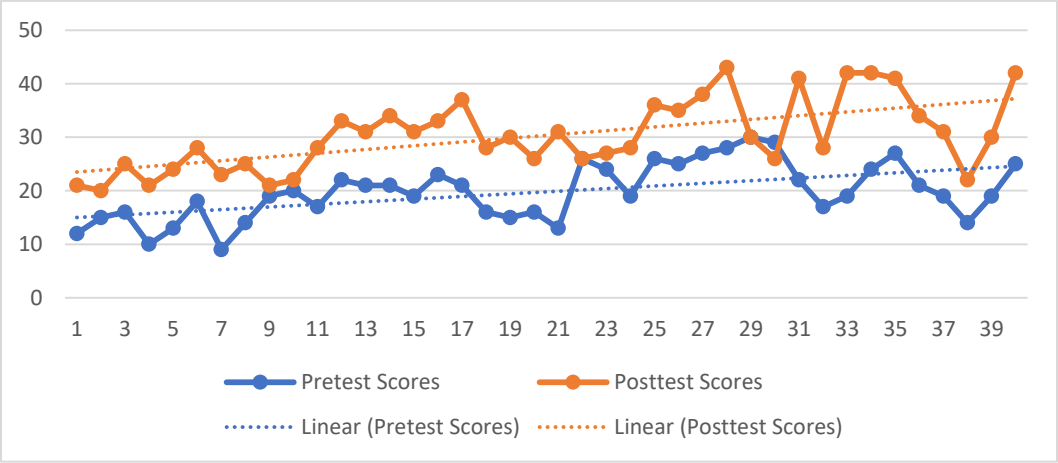


Figure 6: *Line Chart Comparing Pretest-Posttest Achievement Scores of Experimental Group (n=80)*

Table 7: *One-way ANOVA for Effect of Analogy based Teaching on Students' Chemistry Learning against Group wise Pretest-Posttest Scores of Students by Grades Achieved in Last Class (n=80)*

Group	Test	Variance	*SS*	*Df*	*MS*	*F*	*P*
Control Group	Pre-test	Between Groups	245.19	3	81.73	4.98	0.01*
		Within Groups	590.41	36	16.40		
		Total	835.60	39			
	Post-test	Between Groups	257.54	3	85.85	3.17	0.04*
		Within Groups	973.56	36	27.04		
		Total	1231.10	39			
Experimental Group	Pre-test	Between Groups	455.40	3	151.80	8.52	0.00*
		Within Groups	641.58	36	17.82		
		Total	1096.98	39			
	Post-test	Between Groups	303.74	3	101.25	2.52	0.07
		Within Groups	1445.36	36	40.15		
		Total	1749.10	39			

**p<0.05*

Table 7 indicates that there is significant difference of achievement scores of students at pretest-posttest level of control group and pretest level of experimental group into the categories of students' grades in previous class (i.e. 8th class). Otherwise, no significant difference of achievement scores of students was found at posttest level of experimental group.

Analysis of Cognitive Level-wise Students' Achievement Scores in Chemistry

Table 8: *One Sample Statistics and Independent Samples t-test against Group wise Pretest-Posttest Scores of Students Achieved on the basis of Cognitive Levels of Test Items (n=80)*

Group	Test	Cognitive Level	*No. of Items*	Mean	*SD*	*df*	Independent Sample *t*-test	
							t-values	*P*
Control Group	Pre-test	Applying	13	6.13	1.60	39	-1.09	0.28
		Analyzing	13	7.20	1.30			
		Evaluating	12	4.17	1.40			
		Creating	12	2.10	0.33			
	Post-test	Applying	13	7.20	2.10	39		
		Analyzing	13	7.17	1.60			
		Evaluating	12	4.27	1.40			
		Creating	12	2.21	0.52			
Experimental Group	Pre-test	Applying	13	7.34	1.32	39	-7.83	0.00
		Analyzing	13	6.33	1.65			
		Evaluating	12	4.32	1.13			
		Creating	12	1.79	1.20			
	Post-test	Applying	13	7.81	2.20	39		
		Analyzing	13	7.90	1.17			
		Evaluating	12	8.11	2.23			
		Creating	12	6.53	1.10			

Total Items = 50 | Max Marks = 50

Table 1.8 shows that students performed better on the test items measuring higher order thinking skills at posttest level after intervention. It clearly indicates that analogy-based teaching technique has constructive role to enhance higher order thinking skills.

Summary of Hypothesis Testing

First hypothesis (H1) developed is "there is no significant effect of analogy-based teaching on students 'chemistry learning at secondary school level". In this regard, independent samples *t*-test results reveals that analogical practices have important influence on students 'chemistry learning because it has the *p*-value (0.000) < α (0.05) so Ho rejected.

Second hypothesis (H2) is "there is no significant effect of analogy based teaching on application skill of secondary school students." So with the help of one-sample statistics and independent sample *t*-test, it has been found that analogy method has significant effect on students' application level skill because it has the *p*-value (0.000) < α (0.05) so Ho rejected.

Third hypothesis (H3) is "there is no significant effect of analogy based teaching on analysis skill of secondary school students." So with the help of one-sample statistics and independent sample *t*-test, it has been found that use of analogies in classroom teaching has significant effect on students analyzing skill because it has the *p*-value (0.000) < α (0.05) so Ho rejected.

Fourth hypothesis (H4) of the study is "there is no significant effect of analogy based teaching on evaluating skill of secondary school students." So with the help of one-sample statistics and independent sample *t*-test, it has been found that teaching with analogies has significant effect on students evaluating skill because it has the *p*-value (0.000) < α (0.05) so Ho rejected.

Fifth hypothesis (H5) of the study is "there is no significant effect of analogy based teaching on creating skill of secondary school students." So with the help of one-sample statistics and independent sample *t*-test, it has been found that teaching throug analogies has significant effect on students creating level skill because it has the *p*-value (0.000) < α (0.05) so Ho rejected.

Self-Generated Analogies

Self-generated analogies are a source of encouragement for learners and teachers for effective learning of abstract concepts or ideas. Zeitoun (2004) proposed the impression of self-generated analogies in classroom teaching for meaningful learning.

As a result of analogy practices, participants of experimental group created analogies and presented in front of other fellows. They were directed by the researcher to progress analogies by succeeding the phases as described in Glynn's model. The activity resulted to improve the higher order skills of participants. Few of the analogical situations given below generated by the students during intervention.

Table 9: *Analogies created by the participants:*

Topic	**Analogies generated by the students (Respondents name were given in brackets)**
Homogenous & heterogenous mixtures	Mango shake is a homogenous mixture of milk, sugar, mango pulp and cardamom. (Khadija)
	Steel is a homogenous mixture of different metals. (Maryam)
Symbols of elements	Road signs, facial expressions to show our moods. (asma)
Free radicals	Unmarried person (abida)
Shells and sub shells of atomic structure	School building is our shell and classroom is subshell (Shazia)
	My study room is subshell (bushra)
Blocks in periodic table	Blocks in university campus administration block, accounts block, examination block. (Hadia)

Topic	Analogies generated by the students (Respondents name were given in brackets)
Shielding effect	Security gates and fences around military camps (maria)
Chemical bonding	Family relations and friends (zoya)
Ionic bonding	Old book and uniform bank at our school (huma)

Summary

Main objective of this research was to explore the role of analogy-based teaching to enhance higher order skills of learners at grade 9th. An experimental study was directed founded on pretest-posttest control group design. 80 students of class IX from an inner-city school of Lahore were nominated for this work. They were divided into two equal groups. A standardized Chemistry learning achievement test was developed to examine the achievement level of participants of control group and experimental group at pretest and posttest. Data was collected personally by the scholar. At the outset, pretest was conducted and then treatment of 16 weeks was provided to experimental group before posttest while control group was treated through traditional teaching.

Reliability of achievement scores of students on Chemistry learning was found at 0.96 for control group while 0.75 for experimental group. Moreover, means scores, standard deviations, and mean differences were calculated in descriptive statistics. However, to investigate the role of analogy-based teaching on higher order thinking skills, independent sample *t*-test was applied. Major findings of the study are as under.

Findings

All the respondents participated in this study were female having average age of 14 years. As per last academic year results, majority of respondents' (47.5%) from control group achieved grade 'C' in 8th class. Whereas, from experimental group, majority of respondents (42.5%) achieved grade 'B'. Overall, majority of respondents (40%) were achieved grade 'C' in 8th class results.

Similarly, out of 80 students, 50% (n=40) were allocated to control group while other 50% (n=40) were allocated to experimental group. According to the results of pretest (before intervention), it was revealed there was no significant difference in achievement level of control group (M=19.60, SD =4.63) and experimental group (M=19.78, SD=5.30). Whereas, results of posttest showed (after intervention), that there was a significant difference in the scores of control group (M=20.85, SD=5.62) and experimental group (M=30.35, SD=6.70). The achievement level of experimental group was improved than control group after intervention.

Outcomes of the study further exposed that no significant difference was noted in pretest (M=19.60, SD=4.63) and posttest (M=20.85, SD=5.62) achievement level of control group. Whereas, in experimental group, a significant difference was noted in pretest (M=19.78, SD=5.30) and posttest (M=30.35, SD=6.70) achievement scores of students.

Results shows that at posttest level in experimental group, no significant difference of students' achievement scores was found as it indicates that analogy-based teaching method has positive effects on students' learning either their parents are educated or not.

Results further shows that students performed better on the test items measuring higher order thinking skills at posttest level after intervention. It clearly indicates that analogical practices has constructive role to enhance on students' higher order skills. So findings of the study clearly revealed that analogy-based teaching plays significant role to improve secondary schools' students' learning and their higher order thinking skills as well.

Discussion

In this section, all arguments regarding role of analogy-based teaching to improve higher order skills of grade ix learners are going to be complete according to the findings of this study.

The study concluded that role of analogy-based teaching is sinificant on students 'chemistry learning (p = .000). Further analysis explained that there was highly significant difference (p = .000) between the posttest achievement level of control group and experimental group. So, it was assumed that experimental group participants performed well than conventional group in the posttest. That means that analogy-based teaching has significant positive effect to enhance higher order skills of students and effective learning. So findings rejected the first hypothesis that was there is no significant effect of analogy-based teaching on students' chemistry learning.

The study also concluded that use of analogy has significant positive effect on students' higher order thinking skills including application level skill, analysis level skill, eveluation level skill, and creating level skill (p = .000). So findings rejected the next four hypothesis that was; "there is no significant role of analogy based teaching on application skill of secondary school students, there is no significant effect of analogy based teaching on analysis skill of secondary school students, there is no significant role of analogy based teaching on evaluating skill of secondary school students", and no effective role of analogy based teaching on creating skill. So, findings of the study further concluded that analogy-based teaching has positive role to enhance their higher order thinking skills as well.

Previous studies such done by Harrison and Treagust (2000), Johnston (2000), Ausubel, (2001), Gentner (2003), Taber (2002), Bartha (2010), Zeitoun (2004), Holyak and Thagard (2009), Zook (2009), Yener (2012), Currie (2013), Deborah (2014), Sarah (2015) and Wylie (2016) supported these above findings. According to the above arguments, the current study has achieved its investigation objectives.

Conclusions

According to findings, that no significant difference was found (p=0.88) in achievement scores of students at pretest level of control group and experimental group. It means that students of both groups have same aptitude and performance level. However, posttest results showed significant difference in achievement scores of control group and experimental group as outcome of intervention by using analogy-based teaching technique. So, it is concluded that the individual performance of students at posttest level improved against conventional group.

Hence, it is concluded that role of analogy-based teaching was significant to improve higher order thinking skills.

Recommendations

Based on the results of the study some recommendations are given here.

1. School authorities should take initiatives to provide proper teaching trainings to learn about to develop their subject related analogies and the process to apply analogy practices in class room teaching.
2. Special emphasis should be given to the development of teaching staff of public and private sector schools with reference to effective analogy-based teaching techniques.
3. The present study was conducted on Grade IX students of an urban public school of Lahore City. More researches in same framework should be done through wide ranging and diverse dimensions in terms of SED, PEF, PEIMA and other private schools across the layers of male-female, urban-rural and district and province wise.

4. This study has verified the significant role of analogy-based teaching to improve learning situations. But it is difficult to manage the subject matter with the analogy-based teaching. Therefore, the concerned figure heads are suggested to chalk out strategies for need-based training sessions of teachers under this teaching method to get the improved performance of students in science subjects.

5. This study was designed on the basis of quantitative data. In order to improve its generalizability other studies constructed on mixed method approach should also be pursued.

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Conflict of Interest

Authors declared no conflict of interest.

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