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Effectiveness of Analogy Instructional Strategy on Undergraduate Student's Acquisition of Organic Chemistry Concepts in Mutah University, Jordan

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Abstract
This study aimed at investigating the effectiveness of analogy instructional strategy on undergraduate students' acquisition of organic chemistry concepts in Mutah University, Jordan. A quasi-experimental design was used in the study; Participants were 97 students who enrolled in organic chemistry course at the department of chemistry during the academic year (2015–2016) at Mutah University in Jordan, both classes of the same teacher, one was randomly considered to be the experimental group (n=38) while the other was considered to be the control group (n=44). Ten analogies were used in the experimental group, the topics of alkanes, alkenes, alkynes, ethers, carbonyl compounds, aldehydes, ketones and carboxylic acids have been studied in chemistry course. All of the analogies were prepared by the researcher. During four-week period; each group received an equal amount of instruction. The chemical concepts achievement test consisted of 20 multiple-choice questions was administered as pre-test, post-test. The results showed that the students in the experimental group showed significantly greater achievement than the students in the control group.
Keywords: Analogy, Instructional Strategies, Organic Chemical Concepts, Undergraduate Students.

1. Introduction

An analogy is a way of stating a comparative relationship between two sets of terms related to each other in the same way that another two terms are related to each other. For example, the governor is the elected head of a state in the same way that the mayor is the elected head of a city. This comparison can be represented in this analogy: governor: state= mayor: city.

Studying and creating analogies help students develop comprehension of vocabulary and concepts as they improve their reasoning ability and their critical thinking skills. Analogies are double-edged swords, they can foster understanding, but they can also lead to misconceptions (Duit, Roth, Komorek, and Wilbers, 2001). Understanding analogies can be challenging for students because the nature of the relationship may not be immediately obvious, for this reason, it's important for teachers and students to state the nature of the relationship explicitly when discussing an analogy.

There are several methods used in teaching of chemistry such as concept mapping, V-Mapping, dry laboratory, simulations, laboratory activities, conceptual change texts, animations (Cengiz, 2010, Josephsen & Kristensen 2006, Samara, 2013). Analogies are one of these methods, which are useful to enhance learning of key concepts, develops and refines students' understanding of the specific vocabulary and concepts that are used in analogies, helps identify and analyze relationships and develops critical thinking abilities and helps students relate the new information to their already existing knowledge structure (Kawthar, 2012; Eman, 2007; Glynn, 2007; Nwankwo and Madu, 2014).

Many Studies have shown that analogies as Instructional Strategy causes a significantly better acquisition of scientific concepts than the traditional instruction and help students integrate knowledge more effectively (Al-Agha, 2007; Kawthar, 2012; Aybuke and Omer,2012; Refik .and Bahattin, 2008;).

In chemistry, organic chemistry occupies a central place. Although there are several concepts about which students have difficulty, organic chemistry is considered to be one of the most difficult topics in chemistry curriculum, because of its abstract character, its demand of a mastery of a large number of related concepts and the essential role in developing an understanding in other areas of chemistry such as types of bonding, reactions, conformational and isomerism, Derivatives of organic compounds.

Although there have been many studies investigating the students' understanding and alternative conceptions related to chemical subjects and attitude towards chemistry, but there is a lack of studies that focus on studying the concepts of different organic compounds and understanding its chemical reactions. Recently, many studies focuses on different approaches in analogy as instructional strategy, for example:

Deborah (2014) investigated the effects of interactive-engagement and analogy enhanced instructional strategies on self-efficacy of senior secondary school chemistry students. The study also found that the analogy-enhanced instructional strategy was most effective in enhancing the self-efficacy of chemistry students. Results revealed that gender and interaction effects between treatment and gender had no significant main effect on students' self-efficacy. The analogy-enhanced instructional strategy was most effective in enhancing the self-

efficacy of chemistry students.

Ugwumba and Bitrus (2014) studied the effects of analogy instructional strategy, cognitive style and gender on senior secondary school student's achievement in some physics concepts in Nigeria. The results showed that analogy instructional strategy is more effective treatment than the cognitive style.

Fathi, Mansor, Shahram and Vahideh (2013) studied the effect of instructional analogies in interaction with logical thinking ability on achievement and attitude towards chemistry, The results showed that students with concrete thinking at knowledge level of chemistry achievement test in the experimental group had better performance than control groups and the use of teaching with the analogy model had no significant effect on the students' chemistry achievement.

Aybuke & Omer (2012)conducted a study to investigate the effectiveness of conceptual change oriented instruction on students' conceptual understanding of chemical bonding concepts. Results revealed that conceptual change oriented instruction caused better understanding.

Ayanda1, Abimbola and Ahmed (2012) examined the effects of teachers' use of analogies on the achievement of Senior School Biology Students. Findings of the study showed that there is a significant difference in the achievement of the experimental group exposed to analogies and the control group exposed to the conventional method.

Turk, Ayas and Karsli (2010) investigated the effectiveness of analogy technique on students' achievement for effect of concentration and temperature on reaction speed. Experimental group was taught by using the analogy based laboratory approach, the study showed that Experimental group students had better scores on concept achievement test.

In addition, other studies investigated the effect of conceptual change tests on students' understanding of chemical equilibrium (Canpolat et al. 2006, Ozmen, 2007). At the same context Pekmez (2010) used analogies to prevent students' misconceptions of chemical equilibrium.

In this paper we used several analogies including organic concepts and its reactions such as: alkanes, alkenes, alkynes, aromatic compounds, cycloalkanes, aldehydes, ketones and carboxylic acids, based on the assumption that analogies may help students learn these abstract concepts by modulation.

The main aim of this study is to investigate the effectiveness of analogy instructional strategy on undergraduate students' acquisition of certain organic chemistry concepts at Mutah University, Jordan. To achieve this aim, these research sub questions were addressed;

1. Is there significant difference in the use of instructional analogy teaching strategy on undergraduate students' acquisition of organic chemistry concepts when compared with traditional method?
2. Is there significant difference in the use of instructional analogy teaching strategy on undergraduate students' acquisition of organic chemistry concepts regarding the gender?
3. Is there interaction effect of gender and instructional analogy teaching strategy on undergraduate students' acquisition of organic chemistry concepts?

2. Methodology

2.1. Method

A quasi-experimental design was used in this study. The study utilized "a pre-test/post-test", one control group and one experimental group was used. Each group is given both a pre-test and a post-test, measuring the dependent variable before and after exposure to the independent variable.

2.2. Sample

The study was carried out in two different classes in the department of chemistry during the academic year 2015–2016 at Mutah University in Jordan. Participants were 82 university students who enrolled in the organic chemistry course, both classes of the same teacher. One class was randomly assigned to be experimental group (n=38) while the other formed the control group (n=44). Table 1 below shows the distribution of the sample according to gender and group.

Table 1: Distribution of Students Located in the Experimental and Control Group

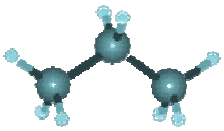
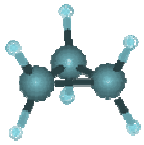
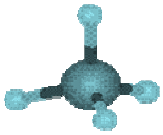
Groups	Experimental group	Control group
Female	24	26
Male	14	18
Total	38	44

2.3. Instruments

Nomenclature of Organic Compounds Achievement Test (NOCAT) consisted of 20 multiple-choice items was used to collect data. The questions were prepared by the researcher, drawn from selected topics in organic chemistry (1) curriculum, Ten conceptual areas, namely: alkanes, alkenes, alkynes, aromatic compounds, cycloalkanes, aldehydes, ketones, ethers, organic halogen compounds and carboxylic acids were evaluated in the

study. Two chemistry educators and two experienced chemistry Faculty members examined the instrument for content validity. The reliability of the achievement test based on Cronbach's alpha was 0.79. One example of the test questions is presented below.

Question: one of the following compounds is classified as cycloalkane?

A.  B.  C.  D. 

3. Procedure

While the experimental group was taught with the analogical strategy, the control group was taught with traditional method. During a six-week period; each group received an equal amount of instruction. Duration of the lecture was 45-minute periods three times a week. Ten analogies were used in experimental group.

The same topics were covered for both experimental and control groups. In general, the control group received traditional instruction using lecture methods to teach the concepts. Teaching strategies based on instructor explanation and textbooks, with no direct consideration of the students' alternative conceptions. Students in the experimental group worked with analogical instruction. At the instruction time, the step-by-step teaching with analogy model was used and ten analogies were analyzed (Syllabus of Organic Chemistry Course). During the instruction, some analogies were showed directly to students in classroom by using the needed tools; for example; Balls, Tubes, u-pipe and vehicles analogies. However, the pictures of other analogies were either drawn on the blackboard or printed in manual to be presented to the students. During the presentation of the analogies in the classroom, students were assisted to both join the lesson and make relation between concepts of organic compounds and analogies by the help of some questions, so the students who found incorrect relation between analog and target concepts re-organized their opinions. By this way, we contributed to maximum participation of students in the lessons.

4. Data Analysis

In the analysis, each question was given 1 point, so a student can get maximum 20 points totally if he/she answers all questions correctly. Independent t-test and ANCOVA were used for the statistically analysis.

5. Results and Discussion

To find out the effects of the use of instructional analogy teaching strategy on undergraduate students' acquisition of organic chemistry concepts when compared with traditional methods, data were treatment statistically.

The results from Table 2 below show that students were homogeneous academically before the treatment (pre-test) with mean scores of 11.73 and 11.37 for control and experimental groups respectively. The results revealed that ($t = -1.162$, $Sig = 0.249 > 0.05$) this result implies that there is no significant difference in the student's achievement between both groups before the treatment.

After the treatment (post-test), experimental group had mean score of 15.05 while control group had 14.29. The results in Table 2 showed that there is significant difference in achievement between those students taught using analogy instructional strategy and those who were taught using traditional method ($t = 3.278$, $Sig. = 0.002 < 0.05$).

This result is similar to that reported in the literature, which suggest that analogy-based teaching improves student achievement and understanding toward chemistry (Ugwumba and Bitrus, 2014; Ayanda1, et al., 2012; Kawthar, 2012; Pekmez Sahin, 2010).

Table2. Independent group t-test results for pre and post test scores of NOCAT

	Pre-Test		Post Test	
	Cont. Group	**Expt. Group**	**Cont. Group**	**Expt. Group**
N	44	38	44	38
Mean	11.73	11.37	14.29	15.05
Standard Deviation	1.51	1.28	1.047	1.038
T	-1.162		3.278	
Sig.	.249		0.002	

To find out if there is significant difference in the use of instructional analogy teaching strategy on undergraduate students' acquisition of organic chemistry concepts regarding the gender. Table 3 below showed that there are obvious differences between means scores of both males and females in the post achievement test.

Table3. Means scores of males, females & groups of post achievement test

	Gender		Group	
	male	female	Expt.	Cont.
N	32	50	38	44
Mean	14.41	14.80	15.05	14.29
Standard Deviation	1.103	1.088	1.038	1.047

The mean score of the male students is 14.41 while of female students is 14.80, as indicated in Table 3. But analysis of covariance in table 4 below shows the significance value is 0.144. This implies that there is no significant difference between females and their male counterparts in the post achievement test of organic concepts administered to them irrespective of the instructional method used. This result is however agreed with Deborah study (2014) which reported that gender has no significant effect on students' achievement in the sciences, and agree with the study of Ayanda, Abimbola and Ahmed (2012) which revealed that there is no statistically significant difference in the achievement of males and females taught using analogies. It is then clear that the analogy strategy is the factor that can be contributory to students' performance in the achievement test of organic chemistry concepts.

Table4. Analysis of Covariance (ANCOVA) of students' Achievement in post exam

Source of Variance	Sum of Squares	df	Mean Squares	F- Value	Sig.	Decision
Group	11.654	1	11.654	10.814	0.002	S
Gender	2.342	1	2.342	2.173	0.144	NS
Group X Gender	.445	1	.445	.413	0.522	NS
Error	84.054	78	1.078			
Total	17689.00	82				

To explore the interaction effect of gender and instructional analogy on students' acquisition of organic chemistry concepts, results in table 4 indicated that the significance value is 0.522 which greater than 0.05, It was therefore concluded that the interaction effect of gender and instructional analogy on students' acquisition of organic concepts is not significant. This result agrees with Okoronka and Wada (2014) who reported that interaction effects between students' gender and instructional strategy was not significant on students' achievement in post test of some physics concepts.

6. Discussion

The use of analogies to teach concepts of chemistry, in general, has been discussed widely in the literature, there were different analogies for the explanation of chemical concepts, but these analogies represented specific aspects, such as effect of concentration and temperature on reaction speed (Turk, et al. , 2010), dynamic aspect of Le Chatelier's principle (Raviolo & Garritz, 2009), understanding of chemical equilibrium (Canpolat et al. 2006, Ozmen, 2007). In other words, a few analogies demonstrate other aspects of chemical reactions like equality of rates, reversibility, catalyze effect.

On the other hand, our study tries to explore the effect of using instructional analogy teaching strategy on undergraduate students' acquisition of organic chemistry concepts.

The findings of this study proved that although there were no significant differences between experimental and control groups before starting the instruction (sig = 0.249, $p>0.05$), significant differences were found between groups after the instruction (sig = 0.002, $p<0.05$). According to the results of the post-test, mean scores of experimental groups were higher than the control groups. These results showed that teaching with analogies has a positive effect on students' acquisition of organic chemistry concepts and that teaching with analogies is an effective method on raising students' achievement.

Previous studies in that an analogical instruction can facilitate learning of scientific concepts supports these results (Ayandal, et al., 2012; Refik and Bahattin, 2008; Al-Agha, E., 2008). Teaching with analogies allows students to actively participate in the learning process. Analogies can help students relate new information to prior knowledge, to integrate information for one subject area into another, and to relate classroom information to everyday experiences. In this process, students observe shapes, models and structures record and conclude that these skills are important in terms of converting abstract knowledge into concrete knowledge, learning and overcoming alternative conceptions. Previous researchers have also emphasized that analogies support meaningful learning and help students to construct topics easily; these are referred to as hard issues and include abstract concepts like organic nomenclature, shapes of organic compounds and types of bonds.

The results of this study shed some light on the impact of analogy on learning organic chemistry concepts. Analogy, in this case, takes advantage of similarities between the analog (model, ball, tube) and target (organic chemical concepts), using the familiarities as a basis for generating inferences that enhance comprehension of the novel subject.

When students are asked to make a generalization or prediction about subject analogy terms help them

to answer. Therefore we may say that by the analogies students can see causal connections on familiar domain so that they can make causal explanations or understanding about the subject.

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