The effect of analogy-based teaching on students' achievement and students' views about analogies

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Received 18 Mar., 2013
Revised 5 Sept., 2013

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Abstract

The purpose of this study is to determine the effect of the analogy-based teaching on students' achievement and students' views about analogies. In this research, Solomon group design which is one of the experimental designs, was implemented.

The sample of the research consists of 108 students in four 6th grade classes in Turkey. The achievement test was implemented as pretest and posttest. After processing the basic parts and organelles of a cell in the lessons, the students were asked to form their own groups' analogies. After the groups had done analogies, they were asked to describe their analogies. Then, analogy of the class was determined. After application, Achievement Test and Analogy Opinion Scale (AOS) were administered to collect the data. The results proved that analogy-based teaching was more effective on the increase of students' achievement score than conventional training. The majority of students claimed that using analogies in lessons was useful. Because using analogies helped the students to understand invisible concept. The students stated that using analogy technique in science lessons was useful and it provides permanent learning. They said that some abstract concepts and invisible objects were often the most difficult to explain and learn. Some of the students stated that using analogies in the lessons was enjoyable and interesting. They said that while learning with analogies they had so much fun.

Keywords: Jigsaw, Analogies, views of students, science education.

Introduction

Concept learning and teaching is important in science education. Concept learning is the point of the other learning process (Ülgen, 2001). Therefore, individual-based approach is required to teaching concepts (Köksal, 2006). Concepts are categories of stimuli that have certain features in common. Gagne (1985) divided concepts into two classifications: concrete concept and abstract concept. Concrete concepts are associated with tangible things in everyday life, things that can be seen and touched. Chair, bird and ball are examples of concrete concepts. Each of these examples is a thing that can occur in a wide variety of forms, but the words "chair," "bird" and "ball" evoke common understanding. Such easily remembered examples of concrete concepts are prototypes, the "clearest cases, the best example" (Rosch & Mervis, 1975).

Abstract concepts are words for things that cannot be experienced by any of the five senses. For this reason they cannot be tasted, seen, smelled, heard or touched. Some examples are: love, freedom, crime, happiness, sadness, anger, work, hope and help. It is difficult to define these concepts. Furthermore, some concrete concepts too small to be seen are difficult to teach in education.

There are various approaches to visualization in education. For example, students might use analogies (Gabel, 2003; Yerrick, Doster, Nugent, Parke, & Crawely, 2003), computer animations (Bukova-Güzel & Cantürk-Günhan, 2010; Çelik, 2007;Daşdemir, 2006;Daşdemir & Doymuş, 2012; Elmstrom Klenk, 2011; Gil & Paiva, 2006; Gökhan, 2011; Iskander & Curtis, 2005; Kauffman, 2003; Powell, Aeby & Carpenter-Aeby, 2003; Santos, 2009), illustration (Hibbing, & Rankin-Erickson, 2003), slowmotions (Ekici & Ekici, 2011; Hoban, Loughran &Nielsen, 2011; McKnight, Hoban & Nielsen, 2011; Vratulis, Clarke, Hoban & Erickson, 2011) and concept maps (Andersen-Inman & Diston, 1999; Anderson-Inman & Horney, 1996; Anderson-Inman & Zeitz, 1993; Aykanat, Doğru & Kalender, 2005).

Notwithstanding each of these approaches is established from different perspectives, each shares the goal of helping students create visuals using prior experience and knowledge to build conceptual understanding. Visualization, without attention to approach, has been shown to be effective as a metacognitive strategy for students (Cifuentes & Hsieh, 2003).

Analogies are a powerful learning tool, but they must be used with care. Simons (1984) cautioned against the use of analogies in cases where the learners could not comprehend the subject matter involved. The use of analogies in these instances could increase the encoding time and thereby slow the learning process. Analogies can also lead to improper over generalization. However, as long as the instruction carefully identifies the limits of the relationship and the points at which the analogy breaks down, an analogy can be a strong and effective strategy component (Reigeluth & Stein, 1983; 360). Analogies help to establish relations between familiar information and new information (Schustack & Anderson, 1979). Analogies describe new concepts or ideas by linking them to "familiar ones that are outside of the content area of immediate interest" (Reigeluth & Stein, 1983; 360). This linking provides a level of comfort to those who are faced with new information. The use of analogies is "a means of establishing conceptual bridges between the known and the unknown" (Nichter & Nichter, 1986; 63). Just as we use bridges to travel from one place to another, we use analogies as "bridges" from known to unknown information.

The role and importance of analogy in learning has been extensively researched in science education. The main purpose of the using analogy as a strategy deployed in teaching is that of developing an understanding of abstract phenomena from

concrete reference. While such an objective is desirable, it is ground on the assumption that there is an agreed commentary of the particular phenomena under review to which all subscribe (Heywood, 2002). Analogy has a very specific and somewhat limited role to scientists and they are fully aware of this. Scientists are aware that analogies contain irrelevant attributes and therefore all have weaknesses (Nottis, 1999). Despite these weaknesses, analogy is freely used to explain quantum physics as in Hawking's A Brief History of Time. According to Dreistadt (1968) noted scientists such as Poincaire, Newton, Maxwell, Bhor, Einstein, and Darwin made extensive use of analogy in their work.

When analogies are not linked to prior knowledge they are not as effective in facilitating conceptual understanding (Galloway, 1990; Gilbert, 1989). When limitations of the analogies or disanalogous features of source and target (known and unknown concepts) are not explicitly stated, learners may be misled (Thagard, 1992). Sometimes this can lead to analogy induced misconceptions (Reigeluth & Stein, 1983; Zook & Maier, 1994).

Studies have examined or described the effectiveness of instructional analogies used in the classroom. Although they have primarily used qualitative research methodologies, relying heavily on observation and interview (Thiele & Treagust, 1994), some other assessments have been used as well. For example, Gilbert (1989) used multiple choice achievement tests to detect whether the addition of analogies resulted in greater retention of important concepts, attitude scales, and a short answer test. In the short answer test, the number of analogies used in responses was counted.

Radford (1989) used content and evaluation tests to examine concept recall and achievement after using written analogies, while Bean, Searles, Singer, and Cowen (1990) used matching and short essay tests to assess conceptual understanding after using pictorial analogies.

Because of the potentially beneficial effects of analogies to explain difficult-to-understand concepts, serious consideration of ways to maximize their instructional effectiveness needs to be considered seriously. In addition, a variety of assessments (both qualitative and quantitative) need to be considered as evaluation tools to determine whether analogies increase, decrease, or do not affect conceptual understanding, and under what conditions or not.

One of the most common areas investigated by analogy researchers is the goal of using the analogy: the target concept. Pittman (1999) stated that analogies have weaknesses and that communicators need to exercise care when developing and using analogies to express ideas related to any topic. Poor analogies can often make an otherwise successful science lesson completely ineffective. Analogies allow learners to use prior knowledge to assimilate and eventually accommodate new knowledge.

In some of the studies carried out at the effect of analogies, (Akamca, 2008; Çalık & Kaya, 2012; Heywood, 2002; Kılıç & Umdu-Topsakal, 2011; Ören et.al, 2011) indicated that the use of the analogy technique has positive influence on learning. Further in some of the studies which were carried out about the students' views (Demir, Önen & Şahin, 2011; Ekici, Ekici & Aydın, 2007; Ören et.all, 2010), it was concluded that the students determined the analogies enjoyable, useful and interesting. It was seen that in some of the studies which were carried out using by teachers (Akpnar, Yıldırım, & Dönder, 2012; Güler &Yağbasan, 2008; Hulshof & Verloop, 2002; Oliva, Azcarate & Navarrete, 2007), the use of analogy in courses was preferred. However some of the students had conceptual mistakes in this study. In the studies which were carried out relating to many courses (Aykutlu & Şen, 2011; Aykutlu & Şen, 2012; Bilgin & Geban, 2001; Dilber; 2006; Kılıç, 2007), it was concluded that analogies were effective in eliminating conceptual mistakes and in the retention of knowledge. In the studies which were carried out by means of using analogy in courses (Akar, 2007; Akyüz, 2007; Cerit, 2008; Günel, Kabataş-Memiş & Büyükkasap, 2009;Kayhan, 2009; Kılıç & Umdu-Topsakal, 2011; Lancor, 2012; Sagirli, 2002; Saygılı, 2008; Şahin, Akbulut & Cepni, 2012), it was concluded that the use of analogical models positively affected the achievement of the students.

The purpose of this study is to determine the students' views about analogy which was formed by students. For this purpose, the analogies were formed by students after the teaching concepts.

Limitations

This research is limited with; four classes of Fatih Elementary School in Bartın, fall term of 2012-2013 academic year, the unit called "reproduction, growth and development of organisms," of the sixth class of elementary training, the gain of

this unit and the activities during the treatment of this unit, achievement test with 30 items.

Purpose of study

The aim of this study is to determine the effect of the analogy-based teaching on students' achievement and students' views about analogies. The research questions are:

- Is there any significant difference between the means of achievement scores of analogy-based teaching and the means of achievement scores of conventional training approach in the lesson of science "reproduction, growth and development of organisms" unit?
- Do student centered analogies help them to learn concepts?
- How do students describe the learning with analogy?
- What do students think about using analogy in courses?

Method

In this research, one of the experimental designs which provide quantitative data about the problem called "Solomon Four Group Design" was implemented. The Solomon four-group design is an attempt to eliminate the possible effect of a pretest. It involves random assignment of subjects to four groups, with two of the groups being pretested and two not. One of the pretested groups and one of the unpretested groups is exposed to the experimental treatment. All four groups are then posttested (Fraenkel, Wallen and Hyun, 2012; Karasar, 2012). A diagram of this design is as follows:

Table 1. Solomon Four Group Design

Groups	Pretest	Treatment	Posttest
Treatment group	T1	Analogy-Based teaching	T1, AOS
Control group	T1	Conventional training approach	T1
Treatment group		Analogy-Based teaching	T1, AOS
Control group		Conventional training approach	T1

"Parts of cell" and "organelles" contents were taught to the students according to the analogy-based teaching. The experimental groups were asked to make an analogy. The students compared the cell to their schools. Then, the students which were at the experimental group completed the Analogy Opinion Scale (AOS) and achievement test.

Sample

The sample of the study consists of 108 students in four 6th grade classes in Turkey. 6-A and 6-B classes were chosen as the control group and 6-C and 6-D classes were chosen as the experimental group at random.

Table 2. The number of the students in classes

Class	Total
6 A	26
6 B	26
6 C	28
6 D	28

Data Collection

Achievement Test: It was prepared and developed by the researcher. It was implemented as pretest and posttest 30 items were implemented in the research and the items were four choices. 65 items were prepared totally and they were sent to experts to get their opinions. They made their decision and suggestions about base of question, the choices, content validity in the cases where the questions measured the success of students. After getting these recommendations, items of test was checked again, changed and 45 questions were created. The pilot study of test was applied for four classrooms which have 115 students. Item analysis was made at the end of this application. It was calculated item difficulty index (pj) and item separation power index (rb) were calculated for each item. The power of high separation was considered in the choice of items. And the items which had smaller than 0.21 points in separation power index were eliminated. They were corrected and included in test if they had 0.20-0.30 points in separation power index. If they had bigger than 0.30 points they were included directly in test. Thus, test form

included 30 questions was created. Items of test were related to understanding, application and analyze level. KR-20 reliability of final test was found 0.79.

Analogy Opinion Scale (AOS): It was administered to collect the data. This scale was prepared taking into account of Doymuş, Şimşek and Bayrakçeken (2004). This scale which is applied in order to determine students' views about analogies consists of three sections. The first section is consisted of a question which is asked to students in what level the analogies are useful. In the second section, the question which is graded from 1 to 5 defined using analogies useful, instructive, enjoyable, informative and stimulating. In the last section, there is open-ended question including students' views about using analogies in the courses.

Findings

a. The results belong to the achievement test

Table 3. The Mean Value of the Pretest Grades, Standard Deviations, "t" Value of Experimental and Control Groups

Groups	N	$\bar{X}$	S	sd	t	p
Experimental1	28	9,00	2,34	52	,311	,756
Control1	26	8,81	2,19			

p= .756 p>0,05

As seen on the table 3, the mean value of the science lesson grades of groups at sixth class is 9,00 for experimental group; 8,81 for the control group. In order to determine the significance of the difference between the experimental group and the control group, the t test of the independent groups was applied by using SPSS statistical analysis program. Related to the mean value of the science lesson grades of groups at sixth, ,311 "t" value was not found significant with .756 p value, with 52 degree of freedom and 0.05 significant level. It can be said that both groups are equivalent to teach other as for the mean value of the science lesson grades of groups at sixth class.

Table 4. The Anova Results of Posttest Grades

	Sum of Squares	df	Mean Square	F	p	Sig.
Between Groups	360,375	3	120,125	24,578	,000	6/A-6/C 6/A-6/D 6/B-6/C 6/B-6/D
Within Groups	508,291	104	4,887			
Total	868,667	107				

According to the result of Anova, it is seen that there is significance difference between groups. There is significance difference between experimental group and the control group. In order to determine the significance of the difference between the groups, Scheffe test was applied by using SPSS statistical analysis program. Related to the mean value of the science lesson grades of groups at sixth, experimental groups' achievement results were higher than control groups'.

Table 5. The Mean Value of the Posttest Grades, Standard Deviations, "t" Value of Experimental and Control Groups

Groups	N	$\bar{X}$	S	sd	t	p
Experimental	56	22,64	2,56	106	8,621	,000
Control	52	19,00	1,72			

p= .000 p<0,05

As seen on the table 5, the total mean value posttest grades are 22,64 for the experimental group; 19,00 is the control group. In order to determine the significance of the difference between the mean values of the total post-test grades for the experimental and control groups, the t test of the independent groups was applied by using SPSS statistical analysis program.

The following data have been provided at the end of the analysis. Related to the total mean values of the post-test grades, 8,621 "t" value was found significant with .000 p value, with 106 degree of freedom and 0,05 significant level. According to the data, it may be said that there is a significant difference in the mean values of difference between pretest and posttest grades of the experimental and the control groups and the analogy-based teaching is more efficient than the conventional approach.

b. The results belong to the AOS

The results of the sample on which the student centered analogy technique are performed are given in the tables.

In the first section of the scale, the question “What level do analogies help students to learn subjects?” was asked to the students. Rates of students’ answers to this question are given in Table 6.

Table 6. What level do analogies help students to learn subjects?

	Points (%)					Mean Score	
	1	2	3	4	5	$\bar{X}$*	
Very few	3,70	0,93	11,11	46,30	37,96	4,14	Very good

* Five Points out Average

In the second section the students were asked to explain features of using analogies in science lesson. Rates of students’ answers to this question are given in Table 7.

Table 7. Using Analogy in science lesson

	Points (%)					Mean Score	
	1	2	3	4	5	$\bar{X}$*	
Not Fun	0,93	3,70	8,33	42,59	44,44	4,26	Very Fun
Not Encouraging	0,93	8,33	6,48	47,22	37,04	4,11	Very Encouraging
Not Informative	3,70	1,85	10,19	33,33	50,93	4,26	Very Informative
Not Useful	1,85	3,70	4,63	39,81	50,00	4,32	Very Useful
Not Instructive	2,78	5,56	6,48	38,89	46,30	4,20	Very Instructive
Not Creative	1,85	3,70	7,41	41,67	45,37	4,25	Very Creative
Not Good	0,93	1,85	9,26	31,48	56,48	4,41	Very Good
						4,24	Mean

* Five Points out Average

In the third section, there is open-ended question which was asked students’ views about using analogies in the courses. Students defined the analogy as demanding activity. They stated that organelles which are invisible are difficult to simulate.

But they said that making an analogy with group was easy and useful. They stated that making an analogy whit discussion was more appropriate.

Student 64 (S64) expressed that “I had a headache during making an analogy. We thought a lot. But it was fun”. S67 “we struggled very much. But I think, we made the most beautiful analogies”. S71 “We made a difficult study. We’re tired. However, I think that is very instructive. Making an analogy is very enjoyable”. S92 “I’m tired when making an analogy. But it was fun. We have enjoyed very much. I think we’ve done very nice analogies. Although it was strenuous we discussed with my friends. We re-examined the functions of organelles. We have reviewed again the lesson. We found suitable concepts for all organelles. It was hard, but it was nice”.

Students expressed that analogies provided permanent learning. According to them permanent learning was emerged when it was established similarity between concepts. S89 “Thinking is hard work. We discussed too much. To learn features of organelles which are invisible is difficult. But I learned the tasks of organelles thanks to analogies. Now I think I will ever forget them. I will not have to work again this matter. I know I will be successful in the exam. As long as the teacher asks me questions about analogies, I will be successful”. S96 “When you learn the concepts by analogy, you would remember them easily. So I couldn’t forget organelles and parts of cell”. S85 said that “We easily learned parts and organelles of cell thanks to analogy. I can answer all of question in the exam”.

An analogy which students formed is given in Table 7. They simulated cell to their school. Students tried to make the best analogy by discussing in group.

Table 8. Analogies which students formed

Organelle	Location	Function	Students’ Analogy
Cell Wall	Plant, not animal	support (grow tall), protection, allows H_2O, O_2, CO_2 to pass into and out of cell	Iron railing on the garden walls
Cell Membrane_	Both animal / plant	Support, protection, controls movement of materials in/out of cell, barrier between cell and its environment, maintains homeostasis	Garden walls
Nucleus	Both animal /	controls cell activities	Manager

	plant		
Cytoplasm	Both animal / plant	supports /protects cell organelles	School Garden
Endoplasmic Reticulum (E.R.)	Both animal / plant	carries materials through cell	Corridors
Ribosome	Both animal / plant	produces proteins	Teachers
Mitochondrion	Both animal / plant	breaks down sugar molecules into energy	School Canteen
Vacuole	Plant - few/large animal - small	store food, water, waste (plants need to store large amounts of food)	School Archives
Lysosome	Plant - uncommon animal - common	breaks down larger food molecules into smaller molecules, digests old cell parts	Rubbish Bin
Chloroplast	Plant, not animal	uses energy from sun to make food for the plant (photosynthesis)	Trees in Garden
Centrioles	Animal, not plant	plays an important role in cell division	Manager Assistant

Conclusions and Discussion

The aim of this study is to determine the effect of the analogy-based teaching on students' achievement and students' views about analogies. This study was carried out with the primary school 6th class students. The students were requested to form their own analogies as a result of the study in which the student centered analogy technique was used.

As a result of this research, experiment and control group's academic achievement posttest scores was found significant difference in favour of experiment group ($t(106)=-8.621$, $p<.05$). In the study, both experiment and control groups' achievement test scores indicated significant difference in favour of posttest. In the literature, there are studies about the improvement of academic achievement in experiment groups which carried out analogy-based teaching (Şahin, Akbulut & Çepni, 2012: Daşdemir, 2006). When experiment and control groups were compared, it was found that analogy-based teaching is more effective for improving students' academic achievements than conventional training approach. Correspondingly to this finding, similar results were found out also by some other researchers in literature (). In the light of the researches' and this research's

findings, it can be thought that analogy-based teaching is effective in improving academic achievement.

According to the results of the study, students stated that learning with analogies has positive contributions. The vast majority of students expressed that they thought about using analogies in courses is a useful and effective method. It was observed that they had difficulty in forming their analogies. According to the results of the research, vast majority of students stated that they had difficulties in establishing the relationship between similar –likened. As a consequence, we could say that the student centered analogy technique is an effective technique in the concept learning process which ensures the active participation of the students in the class by establishing correlation between the daily knowledge and the scientific knowledge by means of revealing the pre-learning of the students.

These results agree with other studies in the literature where it is argued that analogies are beneficial in learning science (Akamca, 2008; Akar, 2007; Akyüz, 2007; Dilber, 2006; Kayhan, 2009; Radford, 1989; Sağırcı, 2002; Saygılı, 2008). Findings emerged in this study showed that creating analogies by students is helps them to understand science concepts. At the same time, this study is compatible with studies on the identification and rectification of misconceptions (Aykutlu & Şen, 2011; Aykutlu & Şen, 2012; Bilgin & Geban, 2001; Dilber, 2006; Kılıç, 2007).

Many researchers stated that an analogy which was prepared by students is more effective than prepared by teachers (Atav, Erdem, Yılmaz & Gücüm, 2004: Kaptan & Arslan, 2002: Yerrick , Doster, Nugent, Parke & Crawley , 2003).

The use of an analogy provides a learning experience in which the students were not required to expose their own alternative concepts. So teachers should encourage their students to make analogy. But in this process they should be very careful. To concrete abstract concepts and to have deep understanding of the activities analogy could be used together for other concepts in other studies.

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