TEACHING CHEMISTRY BY USING "PROVERBS"

Zahra Arzani [a]
[a] Beheshty School, Azymeyeh Mehran squre, Karaj, Iran.
[a] Corresponding author: zarzani2111@yahoo.com

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Abstract: An analogy is a comparison between two domains of knowledge, one familiar and the other less familiar. The familiar domain is often referred to as the "source," or "analog"; the less familiar domain, or the domain to be learned, is usually referred to as the "target".[11] Three major teaching models are presented in the analogy literature: Teaching-With-Analogies (TWA), General Model of Analogy Teaching (GMAT), and FAR (Focus, Action, Reflection). In this research, these three methods of teaching analogy where used. The FAR method was found to be sufficient and easier for teaching.

According to researches, analogies increase motivation, and meaningful learning. They help students visualize concepts and clarify their way of thinking. In this research, three chemistry subject concepts for grade 11 students (high school) and one in an organic chemistry class (collage) were taught by using new analogies, mostly proverbs. A "Proverb" is a rich and short sentence, which enjoys a high potential for penetrating deep into people's minds. Once learned, the opinions of students were collected and the effect of analogy on their ability to remember the information was investigated. According to students' opinions, teaching chemistry by using proverbs is fun and proverbs are helpful especially in memorizing chemistry rules. On the other hand, Students with lower abilities, use proverbs as a means of answering questions in exams.

Keywords: Teaching Chemistry, Analogy, Proverbs, High School

Introduction

An analogy is a comparison between two domains of knowledge, one familiar and the other less familiar. The familiar domain is often referred to as the "source," or "analog"; the less familiar domain, or the domain to be learned, is usually referred to as the "target" .[11]Indeed, it is a special kind of comparison that is defined by its purpose and by the type of information it relates. According to Gentner (1989), an analogy is a mapping of knowledge between two domains such that the system of relationships that holds among the objects in the analog domain also holds among the objects in the target domain. Thus, the purpose of an analogy is to transfer a system of relationships from a familiar domain to one that is less familiar (Mason and Sorzio, 1996). The strength of an analogy, lies less in the number of features the analog and the target domains have in common, rather than in the overlap of relational structures between the two domains (Gentner, 1983). For example, the strength of the lock-and-key analogy for enzyme/substrate complementarity is not simply in the fact that the lock corresponds to the enzyme and the key corresponds to the substrate. The strength of that particular analogy is that the relationships between the lock and the key (for example, the shape of the key is complementary to the shape of the lock, and part of the key fits inside the lock) correspond to relationships between the enzyme and the substrate (the shape of the substrate is complementary to the shape of the enzyme, and part of the substrate fits "inside" the enzyme).

Many studies have reported that using analogies resulted in beneficial outcomes (Beveridge and Parkins, 1987; Brown and Clement, 1989; Cardinale, 1993; Clement, 1993; Donnelly and McDaniel, 1993; Fast, 1999; Glynn and Takahashi, 1998; Hayes and Tierney, 1982; Holyoak and Koh, 1987; Simons, 1984; Solomon, 1994; Treagust, Harrison, and Venville, 1996)[11]. In a study by Treagust and Harrison [6] (1996), for example, a teacher explained what happens to light when it obliquely enters a more dense medium (refraction) by comparison with what happens to a set of Lego wheels when they roll, unaided, from a hard floor onto a carpeted surface. The trajectory of the light (wheels) is bent toward the normal as it passes through a denser medium (the carpet) because the light (the wheels) slows down. After the instruction, the students were interviewed,

and each seemed, in general, to understand the concepts being taught—both the analogical concepts and the targeted concepts in optics. In addition, most of the students were able to transfer their analogical reasoning to a completely new situation. They were able to correctly predict what will happen to light as it moves from a denser medium to a less dense medium (it bends away from the normal).

Researchers believe analogy can help students in deferent ways such as[11]: (1) Increasing learning in complicated subjects. (2) Increasing motivation (3) Promoting meaningful learning (4) Making the novel seem familiar by relating it to prior knowledge. (5) Helping students visualize abstract concepts, orders of magnitude, or unobservable phenomena. (6) Analogies clarify thinking.

On the other hand, most researches indicated that analogy can have negative result such as:
(1) Students may resort to using the analogy mechanically, without considering the information the analogy was meant to convey. (2) An analogy never completely describes a target concept. analogies have limitations. Unfortunately, students usually do not know enough about the target concept to understand those limitations. For this reason, they may either accept the analogical explanation as a statement of reality about the target concept or incorrectly apply the analogy by taking the analogy too far. (3) Analogies may be misinterpreted or misunderstood by students. (4) Using Analogy may decrease Students reasoning abilities.

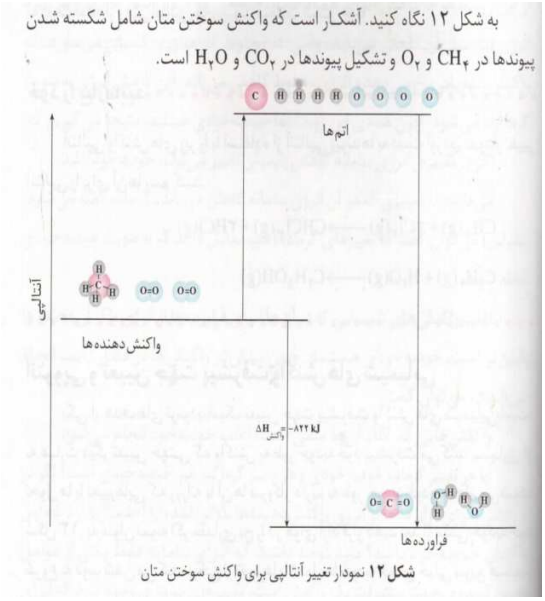
Orgill and Bodner recommended that analogies should be used when a difficult or challenging concept that cannot be visualized is introduced. However, they warn against the use of analogy when the target concept is overwhelming or has to be memorized. To be most effective, the elements of an analogy must be made clear and its limitations need to be explained. For example, water flowing through a pipe is often used as an analogy for blood flowing in a blood vessel. Assuming that the comparison is taken beyond the "a blood vessel is a pipe" metaphor, the objects in the base are (water, pipe), and a relation between them might be the flow, which depends on both the viscosity of the water and the diameter of the pipe (which are attributes of the corresponding objects). The objects in the target are (blood, blood vessel), and, again, the flow of blood depends on the viscosity of blood and the diameter of the vessel. However, like all analogies, the (water, pipe) → (blood, blood vessel) analogy does not completely map all of the relevant relations of the target concept. For example, elasticity is an important attribute of blood vessels but not necessarily of the sorts of pipe a student might visualize, leading to misconceptions about the behavior of blood vessels. Similarly, blood and water differ in their mechanical properties (water is a Newtonian fluid, whereas blood is not), which means that they respond differently to changes in conditions, which is important for blood as it passes through capillaries.

Three major teaching models are presented in the analogy literature: the Teaching-With-Analogies (TWA) model, the General Model of Analogy Teaching (GMAT), and the FAR (Focus, Action, Reflection) model. Each model explains different steps for teaching.
The TWA steps are: (1) Introduce the target concept, (2) Present the analog concept (3) Identify the relevant features of the target and analog concepts, (3) Explicitly map the similarities between the target and analog concepts, (4) Indicate where the analogy breaks down, and (5) Draw conclusions about the target concept based on the analog concept.

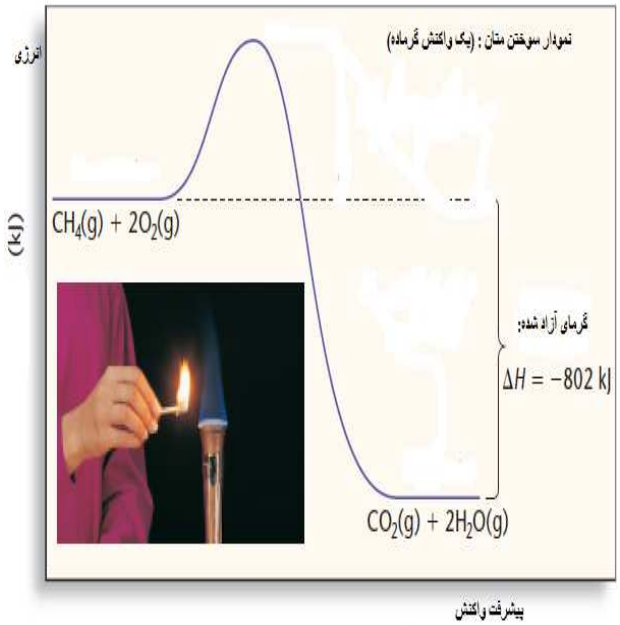
The GMAT model consists of the following steps: (1) Measure some of the students' characteristics related to analogical learning in general; (2) Assess the prior knowledge of the students about the topic; (3) Analyze the learning material of the topic; (3) Judge the appropriateness of the analogy to be used; (4) Determine the characteristics of the analogy to be used; (5) Select the strategy of teaching and the medium of presenting the analogy; (6) Present the analogy to the students (including its purpose, the analogous attributes, the transfer statements, and the irrelevant attributes); (7) Evaluate the outcomes of using the analogy in teaching (determine whether students use the analogy to study the topic, assess the students' knowledge of the attributes of the topic, and identify the misconceptions that result from the analogy); (8) Revise the stages of the model if needed.

The FAR method suggests the following steps: (1) FOCUS on the concept being taught and the analog to be used. Is it difficult, unfamiliar, or abstract? What do students know about the concept? Are students familiar with the analog? (3) ACTION. Explicitly connect the similarities between the analog and target concepts and discuss the limitations of the analogy. (4) REFLECTION. Evaluate how the analogy came across to the students and make improvements as needed.

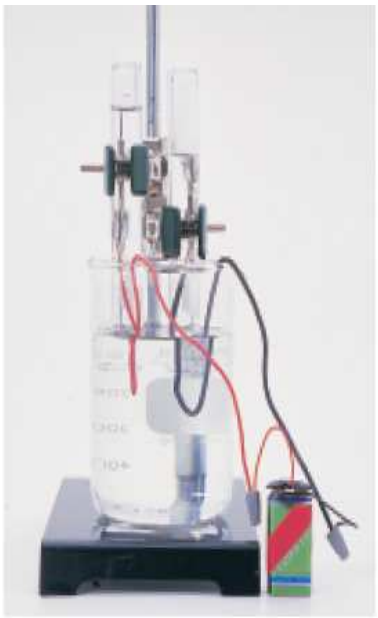
This study shows, analogy can help students recall information even after a long time. On the other hand, this study shows, Student with low ability, use analogy in order to compensate for that lesser ability instead of using it in order to develop a correct understanding of that concept.

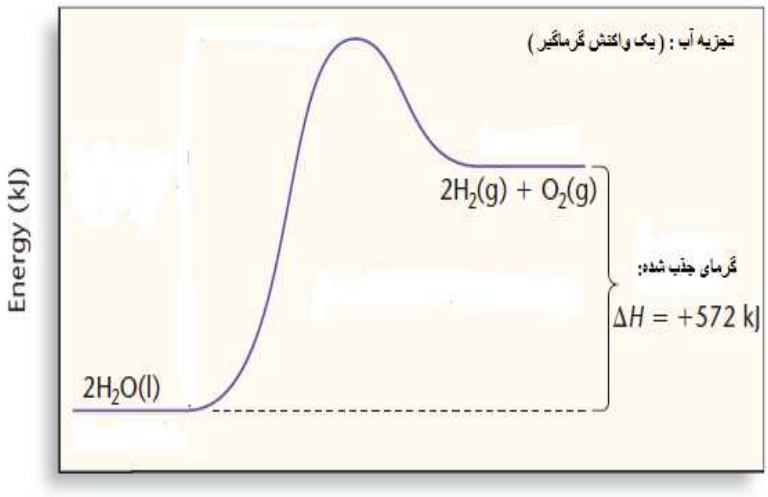


شکل ۱۲ نمودار تغییر آنتالپی برای واکنش سوختن متان



In the same way of endothermic reaction:





Method

In this study, different methods of teaching with analogy were examined and the FAR method was found to be easiest to use and it proved to be sufficient. The TWA model put too much attention on analogy whereas the objective of teaching is not to cover the concept of analogy itself. In the GTMAT model, I believe students do not need to use that analogy again, the main point is that they get the teaching idea better and sometimes just enjoy the comparison between analogy and concept. In FAR, as the literature review shows, the first step of the method (Focus) is necessary otherwise using analogy is just a waste of time. The third step (Reflection) can be seen through the reaction of students and how they

answer to the related question which shows that they understand the target domain.

In this study, three new analogies were used in teaching different subjects of chemistry in grade 11-(high school) and then the opinions of students were collected. Also in the Organic chemistry class for students who were science teachers for more than 20 years (6-8 grade), (The University of Farhangyan) Markovnikov's rule was taught by analogy (proverb) and Zaitesev's rule (with almost similar difficulty) without it and both were tested in the final exam and a month later and the results were interpreted.

Analogies 1 (proverbs) in teaching chemistry:

A "Proverb" is a rich and short sentence, which enjoys a high potential for penetrating deep into people's minds and thoughts due to its cultural roots, and its metaphoric and rhythmic language. In the Iranian folk literature proverbs have a particular stature and most of them have been formed and created on the basis of an event or story. Each parable has its individual story. In fact each story is rooted in the treasury of the Iranian culture and has been rewritten for story–telling. As a matter of fact, the proverb is as functional and valuable as logical reasoning. The proverbs have been used ever since the early ages, changing and developing through the passage of time and helping the cultural potentials to find their way into our present. All sacred books including the Avesta are full of such guiding proverbs.

In this study for introducing exothermic and endothermic reaction to young students the following story were used: A long time ago, a man called mola nasredin had a neighbor who interrupted him all the time to borrow things. One day Nasrodin thought of a plan to teach his neighbor a lesson. He borrowed a cooking dish from him and the day after he returned it, adding a small dish. When neighbor asked why he was giving him two dishs instead of just his own, Nasredin explained: the extra is of your dish's baby. The neighbor was surprised but did not say anything and took the dishes happily. (1).

The day after Nasrodin returned to neighbor to borrow a dish again. However, the next day, he returned only the small dish. When the neighbor angrily asked why he was only getting the small dish, Nasredin replied that the mother had died while delivering this child (2). He then continued to say "If one can give birth, she can die too" (this story is known as a proverb).

In the first case we have an exothermic situation where the reaction gives us more than what we had taken. In the second we have an endothermic situation where the reaction gives us less than what we had taken.

In the curriculum of chemistry for grade 11 of Iranian high schools, three methods for calculating enthalpy of a single reaction are discussed. These are: using Hess's law, standard heats of formation, and use of the average bond dissociation energies. Students will learn about reaction mechanisms in more depth in their next grade (12). The graph is used to show the calculation of enthalpy of reaction by the average bond dissociation:

Analogy 2 in teaching high school chemistry grade 11:
The heat of combustion for three hydrocarbons is shown as follow:

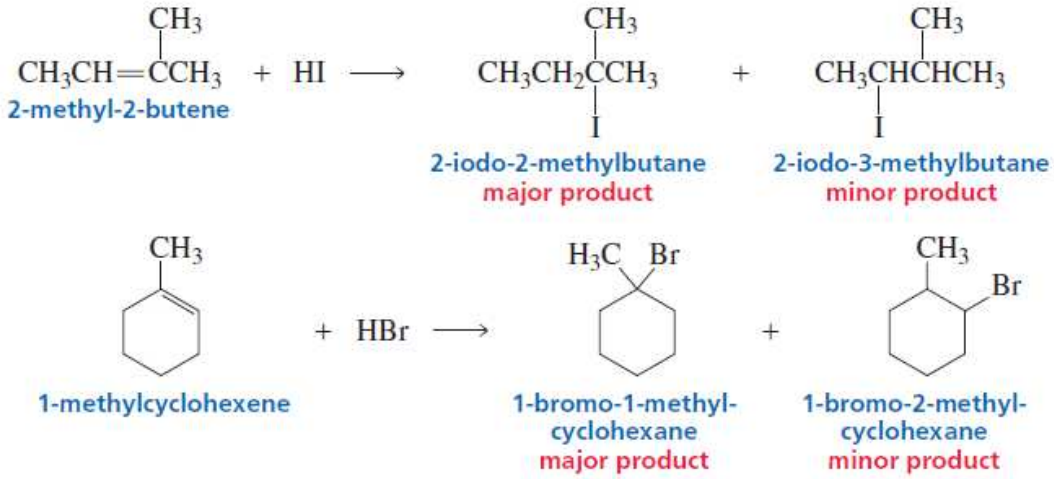
$$C_2H_6 + \frac{7}{2}O_2 \rightarrow 2CO_2 + 3H_2O + 1560\,KJ \qquad \frac{1560}{5}$$

$$C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O + 1409\,KJ \qquad \frac{1409}{4}$$

$$C_2H_2 + \frac{5}{2}O_2 \rightarrow 2CO_2 + H_2O + 1299\,KJ \qquad \frac{1299}{3}$$

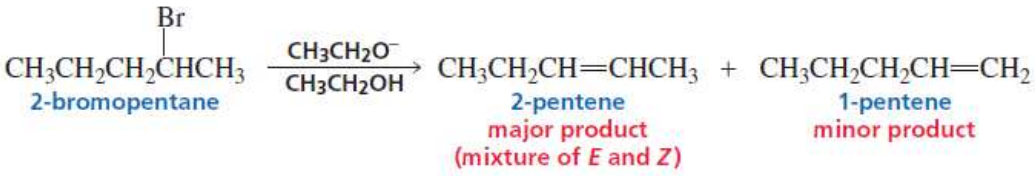
Although the heat of combustion for ethane > ethylene>acetylene, the flame degree is the opposite: ethane < ethylene<acetylene.
To understand why, one can refer to family populations. A packet of chips in a crowded family will result in fewer chips for each person. "Have less kids, have a better life" is also an Iranian proverb. And we can conclude: Due to the increasing costs of health care, concerns of overpopulation, and the increasing (costs) cost of raising a child, less crowded families are preferred.

Analogies used in teaching Markovnikov's rule and Zaitesev's rule (organic chemistry):
The major product obtained from the addition of HI to 2-methyl-2-butene is 2-iodo- 2-methylbutane; only a small amount of 2-iodo-3-methylbutane is obtained. The major product obtained from the addition of HBr to 1-methylcyclohexene is 1-bromo- 1-methylcyclohexane:



Markovnikov's rule: "When a hydrogen halide is added to an unsymmetrical alkene, "*The* hydrogen *attaches to the carbon that is bonded to the greater number of hydrogens."*
Iranian proverb: People, who have more, want more.

Zaitesev's rule is poorly similar but it relates to situations where elimination reactions occur and the major product is to obtain the more substituted alkene. For this reason, an E2 reaction is *regioselective*, which means that more of one constitutional isomer is formed than the other. For example, the major product formed from the E2 elimination of 2-bromopentane is 2-pentene.



This rule was taught without analogy.

Results

According to students' opinions, teaching chemistry by using proverbs is fun and they are helpful in memorizing chemistry rules. 56% of those students believe no misconception was made and even some of them try to make analogy in next lessons to explain the subjects. Unfortunately as other researchers have shown, students with lower abilities use the proverb itself instead of the main topic, which is what they should be remembering.

Data:

A- In High School:

Question 1: In your Opinion, How the analogies (1 , 2) can be useful?

1- Increase understanding of chemistry 2- help to memorizing chemistry concept

3-Both 4- none

Chose	1	2	3	4
percentage	11%	41%	49%	0%

Question 2: In your opinion, how much the analogies made misconception?

1- High 2- Medium 3- Low 4- No misconception was made

Chose	1	2	3	4
percentage	0%	3%	38%	59%

Question 3: How much do you like to make analogy in chemistry by yourself?

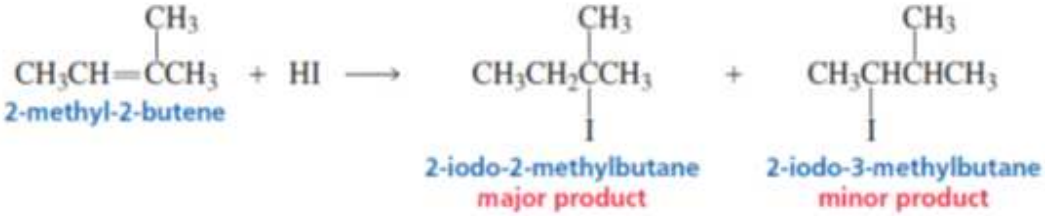
1- High 2- Medium 3- Low 4- None

Chose	1	2	3	4
percentage	30%	59%	0%	11%

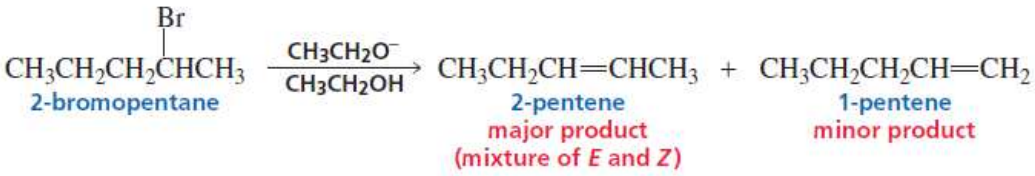
B- In Collage :

Table: B-1: Students marks in two exams [final exam(1) and four months after (2)]

Question A: Markovnikov's rule with proverb:

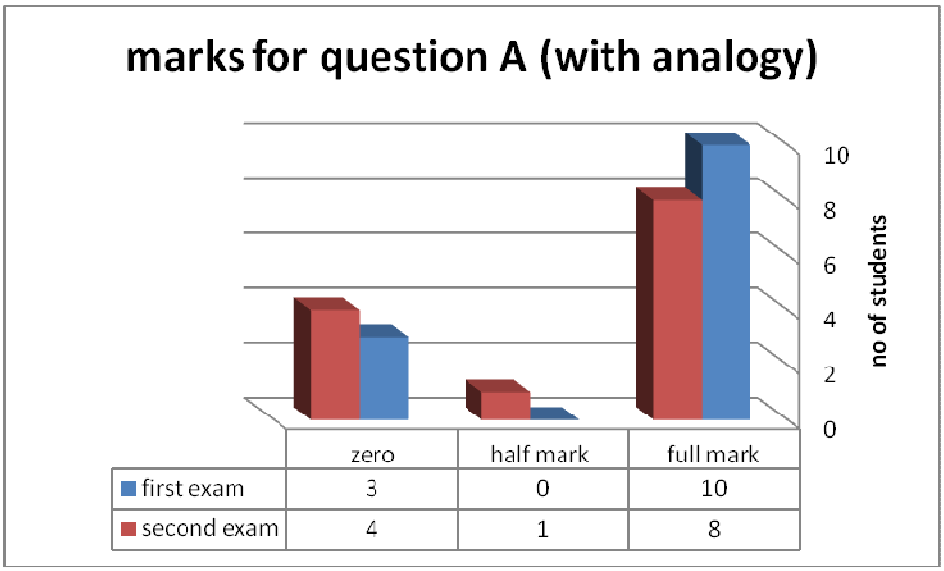


Question B: Zaitesev's rule without analogy:

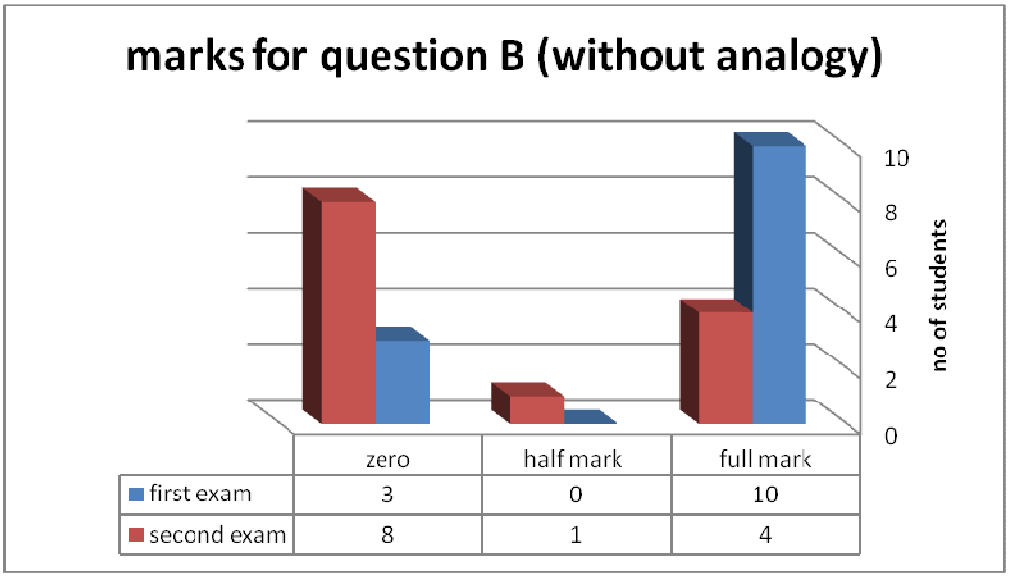


	Mark in second exam	mark in first exam	Student Id.	No
	1 – A 0 -B	uestionqA - 1 questionB – 1	A1)H.M.(	1
	1 – A 1 -B	1 - A 1 –B	A2(Kh.A)	2
	0 – A 0 -B	1 – A 1 -B	A3) M.R.(	3
	1 – A 0 -B	1 – A 1 -B	A4)F.K.(	4
	1 – A 0 -B	0 – A 1 -B	A5) L.M. (.	5
	1 – A 0 -B	1 – A 1 -B	A6)N.A (	6
	1 – A 0 -B	1 – A 0 -B	A7)S.M. (	7
	0 – A 1 -B	1 – A 1 -B	A8) R.F.(.	8
Using Analog as answer	0 – A 0 -B	0 – A 0 -B	A9) M.A(	9
	0– A 1 -B	1 – A 1 -B	A10) K.A (.	10
	1 – A 0 -B	1 – A 0 -B	A11) M.J. (.	11
	– A0.5 -B 0.5	1 – A 1 -B	(H.R) A12	12
	1 – A 1 -B	0 – A 1 -B	A13) H.M.(.	13

Graph1: Marks of Question A in two exams



Graph 2: Marks of Question A in two exams



Conclusion

Proverbs are short sentence which are very common in the Iranian community. They have been made from a long time ago and passed along through many generations. Most of them are from real life of old peoples and have special meanings. In this study, two different chemistry classes were chosen and some complicated chemistry subjects were taught by using analogies especially proverbs. The subjects were examined during the final exam for the course and again, after four months had passed in the following semester. The students' opinions were collected. Interpreting the data indicates that using proverbs is very useful especially in teaching chemistry rules. The class will be more motivated and students will have more fun. On the other hand, as other researches have shown, some students will use them incorrectly.

In this research, three methods of teaching analogy where used (the Teaching-With-Analogies (TWA) model, the General Model of Analogy Teaching

(GMAT), and the FAR model). The FAR method was found to be sufficient and easier to use.

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