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TEACHING ELECTROLYSIS OF WATER THROUGH DRAMA

Hakan Saricayir

Abstract. *The purpose of this study was to evaluate the effects of drama on the teaching of electrolysis of water to middle school students. The randomized pre-test and post-test control group design was used. Data collection methods included pre-test, post-test 1 and 2, and the data were analyzed by using the SPSS/PC program. This study was carried out at a private school with 40 seventh grade students. Based on the pre-test results, the students were randomly assigned to drama and control groups. Findings suggest that the drama group performed better than the control group both on post-test 1 and post-test 2. Similar studies in different contexts with different student samples may be conducted to investigate the effects of drama in chemistry education.*

Key words: *chemistry education, drama in science education, electrolysis of water.*

Hakan Saricayir
Marmara University, Istanbul, Turkey

Introduction

Electrolysis is generally considered to be a topic hard to grasp, and drama is proven to be an effective tool in teaching difficult topics. Previous research implies the potential effects of drama on understanding electrolysis, an implication that is addressed by this study. This study aims to examine the effects of teaching electrolysis through drama on the success of middle school students.

Drama, one of the most popular forms of art, is a creative activity performed with the personal experiences of individuals. When used as a teaching technique in educational settings, drama provides the participants with the opportunity to make their understanding concrete and individualize the whole process rather than to simply transmit knowledge from the textbook to students through the intermediary of an instructor. By incorporating drama into the curriculum, instructors can teach more effectively and efficiently. By making learning more exciting, relevant, and meaningful (Fuller, 1973), drama could become a major contributing factor in the teaching and learning of any topic since it helps students to learn what is covered in the classroom in an associative manner, which, in turn, increases the likelihood of information to be stored in long term memory and to be retrieved better in the future.

Equally as important as retention is drama's potential to help people understand difficult concepts and thus change their misconceptions. A popular misconception is about chemistry which goes 'chemicals are bad, so must be chemistry.' People fear or at least feel indifferent towards what they do not understand. However, when taught through drama, even students majoring

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in arts and humanities can get inspiration from chemistry (Lerman, 2005). In addition, drama can present an alternative assessment tool to written tests, a source of anxiety for students. By using drama in student assessments teachers do not only have students participate in the evaluation process but also encourage them to be creative (Lerman, 2003).

Dramatic techniques such as role-plays and simulations are well documented in social studies and history, especially in foreign language teaching and counseling. Referring to the use of drama in science education, Alrtuz (2004) claims that it is unfortunate that drama is not effectively used. However, a number of studies on drama and science education at middle school level show that when guided by reflective science teachers, drama may provide empowering learning environments for students (Teveita, 1996; 1998; Bailey and Watson, 1998; Carlsson, 2003; Odegaard, 2003; Lerman, 2005).

Researching into the impact of drama project on young pupils' reading, mathematics, attitude, self-concept and creative writing in primary schools, Fleming, Merrell, and Tymms (2004) found that the pupils in the drama group had higher/more positive value added scores than those in the control group.

In their experiential and semi-structured drama, Bailey and Watson (1998) implemented a dramatic model of the complex interplay in ecosystem. Post-test differences in children's understanding of ecological concepts proved significant between students who had been taught through the Eco Game approach and those who had not. The drama group showed an increased level of understanding, particularly, of the concepts of the population relations and pyramids of numbers/biomass, subjects that normally require an in-depth understanding of biology.

Tveita (1996, 1998) used a drama model of electricity with teacher trainees and students at lower secondary school. Structured by the teacher, this experiential drama model gave the students concrete and hands-on experience with the representation of voltage current and resistance, thus facilitating a better understanding of these basic concepts.

Carlsson (2003) created structured dramatization of photosynthesis in order to help students understand the particle model and material transformation, which she argued was successful because students as a whole found learning through drama amusing and engaging.

Lerman (2001) employed dancing in workshops for public school teachers, who reported favorable results when they used dancing in chemistry classes; the achievement of these teachers excelled those who did not attend the workshops.

Considering its potential impact on education, we can conclude that drama has somewhat been unnoticed in Turkey. One exemplary work, among others, on the history of drama education in Turkey highlights certain efforts such as seminars to inform educators about drama and suggests future plans in this direction (San 1998). Several experimental studies on the impact of drama on preservice teachers showed its potential and recommended that drama be used for effective teaching. Ozdemir and Cakmak (2008) found that drama increased the creativity of the preservice teachers in all dimensions of a creativity test. Another study with 73 undergraduate students show that drama education given once a week for 14 weeks significantly developed students' empathetic skills. (Akyol and Hamamci 2007) In another study Ozdemir and Ustundag (2007) used the life stories of famous scientists to introduce scientific concepts through drama and concluded that drama helped participants internalize these concepts. Erdogan and Baran (2009) found that mathematic teaching based on the drama method has a positive effect on the mathematical ability of six year of children.

Methodology of Research

Sample

In Turkish National Education system, the concepts of atom, molecule and electrolysis of water are covered in the seventh grade. The research was carried out at a state-run primary school where there were eight classes of seventh graders, to all of whom the pre-test was applied. Based on the results of the test, two classes were selected randomly. Statistical analyses were performed by the SPSS/PC (Norusis 2008). Mann Whitney U test was used to assess the equivalence of the groups before the training. These two classes had close mean scores and had no significant difference in the pre-test scores. The total number of students in these classes was 40. Before the training was done, Mann Whitney U test was used to assess the equivalence of the groups in terms of content knowledge of electrolysis of water. Once this test was completed, these two groups were randomly assigned as drama and control groups.

The drama group had 19 students, who were first taught the formation and decomposition of water in the class setting and then introduced to the drama method. For the drama activity, the class was divided into two, performing students and audience. Eight students took part as actors in the drama: two students represented oxygen atoms; four students hydrogen atoms; one student electricity current, and one, a "curious" boy who wanted to decompose water. The other eleven students became the audience and watched the performing students. The drama activity lasted 90 minutes, followed by a 40-minute discussion on electrolysis. The discussion was particularly about single bonds between hydrogen molecules, double bonds between oxygen molecules, the size of these molecules, and the way H_2O forms when they collide. Also discussed are the gases that go to anode and cathode as a result of electrolysis and the reason why pure water does not conduct electricity. The control group consisted of 21 students, who were instructed in the traditional way. That is, formal instruction was used with the teacher lecturing and students only listening. A schema was drawn on the board, and the students were told of the gases that collected at the anode and cathode and their ratios. Later example questions were solved. Both the control group and the drama group were taught by the same teacher who covered the same subject in 3 weeks and 12 class hours.

Methods

Tailored to the needs of the classroom settings in science education, drama can be used in three different ways: structured, semi-structured and explorative drama (Odegaard 2003). On the one end of the continuum is structured drama, which places the teacher as a central figure who presents and directs the activity. The students simply do what the teacher tells them to do. On the other end is explorative drama in which students develop the activity spontaneously, directing it the way they wish to. Semi-structured drama, combining both, gives the teacher a less active role than his or her role in structured drama, and students have less independence than their counterparts in explorative drama. In this study, structured drama was the preferred type.

Of true experimental designs, randomized pre-test-post-test control group design was used (Best and Kahn 2006). Three tests were given: a pre-test, post-test 1 and post-test 2. Pre-test and the post-test 1, consisting of 10 multiple choice questions prepared by the researcher, were the same but the students were not informed that both tests were identical. The pretest was given 10 days before the intervention. Pre-test and post-test 1 were constructed to measure students' achievement in atom, molecule, compound, chemical reaction, anode, cathode, electrolysis, chemical bond, physical method, and chemical method concepts at the beginning and end of the treatment. The content validity of the test was checked by two science teachers at school and two instructors at university. In addition, the validity of the test was found by giving the test to 40 students at the same grade level in another school. The 40 students were selected by their teacher who identified twenty successful and twenty unsuccessful students in science classes. Mann Whitney U test done after the test revealed a significant difference in favor of the successful students. This shows that Post test 1 distinguished children with strong and weak science achievement. The reliability of the test was done in the same school with 52 seventh graders and its reliability coefficient (α) was found to be 0.76. The items in Figure 1 exemplify the kinds of problems included in the pre-test and post-test 1. Each question was given five points, the total of which made 50 points.

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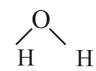
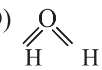
1. Which of the following shows the structure of an oxygen molecule?
A) O – O B) O C) O = O D) O ≡ O

2. Which of the following shows the structure of a water molecule?
A) H – O – H B) H = O = H C)  D) 

3. Which of the following statements is correct for the comparison of oxygen and hydrogen atoms by volume?
A) Oxygen atom is larger than hydrogen atom.
B) Hydrogen atom is larger than oxygen atom.
C) Both are the same by volume.
D) Both are too large.

4. Which gas is deposited at the anode, when water is decomposed into its elements?
A) Hydrogen B) Oxygen C) Nitrogen D) Natural

Figure 1: Item examples from the achievement tests.

Post-test 2 was applied to the same students immediately after post-test 1. After they took post-test 1, the students were individually evaluated through a hands-on activity as post-test 2, which was based on a total of 50 points. The students were asked to form a water molecule out of the play dough and toothpicks in various colors given them and then to decompose this molecule. The students who formed water molecules properly (i.e. oxygen atoms were bigger than hydrogen atoms, had different colors, and were placed at the correct angle) got 25 points and those who decomposed the molecule properly (i.e. decomposed two water molecules then produced two mol H_2 and 1 mol O_2) got 25 points. Post-test 2 was scored out of 50 points. The students were allowed about 30 minutes for both post-test 1 and post-test 2, but additional time was given to students who needed.

Application of the Drama Activity

In this study, the formation and decomposition of water was displayed on the scene. In the drama, two students acted as oxygen atoms; four students acted as hydrogen atoms; one student acted as electricity current; one student acted as a curious boy who wanted to decompose water, and the chemistry teacher acted as himself. Totally, eight students participated in the drama. Assuming that on average there were 20 students in the class, at least 40 % of the students could participate in the drama actively.

Special costumes were designed and provided for these players by the teacher: blue costumes for hydrogen atoms bearing the letter 'H' on their chests and white costumes for oxygen atoms with the letter 'O' on them. The colors white and blue were especially chosen for their resemblance to water. The student who played electric current wore an apron with electricity sign on it. The chemistry teacher and the curious boy had their casual clothes on them. The teacher also brought to the class a plastic hammer, a plastic handsaw, and a bottle with an acid label on it. The stage which the drama was presented was 15-m^2. Labels of anode and cathode were stuck on stands 20 cm in height and 50x100 in width in the background of the stage.

The teacher explicitly told students what their roles were and gave them the scripts of the drama he had written before. He explained that oxygen molecules that have double bonds and hydrogen molecules that have a single bond combine and form water molecules. Also, he added that atoms should be suitably positioned for a successful reaction. After this explanation, the students were given time to discuss their parts. They decided where they should stand and when and how they should enter the stage. The audience also took part in these discussions. Meanwhile, the teacher supervised the students, helping them like a stage director. Because he had a minor role in the drama, the teacher stayed among the students, but interfered as little as possible. Student dialogues during the play were recorded and transcribed verbatim. Parts of these dialogues are transcribed in the following section.

Student Dialogues in the Drama Activity

There are two oxygen atoms. They grabbed each other's hands, which represents double bond between oxygen atoms. They talk to each other.

O1: "Huh! I am too bored today."
O2: "What happened? Why are you so bored?"
O1: "Look. Our life is too ordinary so it is boring"
O2: "Please speak honestly. Are you bored of me?"
O1: "Of course not. You are my best friend. We have a good double bond, but I want to meet new atoms and form new molecules with new properties."
O2: "Yeah. You are right. In fact I think so, but I couldn't explain."

At this moment, hydrogen atoms (H1 and H2) enter the stage slowly. These hydrogen atoms are smaller than oxygen atoms. They are hand in hand, which represents a single bond. Having the similar conversation, Hydrogen atoms decide to make a new compound. They start talking with each other. Hydrogen and oxygen atoms talk as follows:

O1: "What do you think about forming a new molecule? Do you want to form a covalent bond by sharing our two electrons? "
H1+ H2: "Okay"
O2 (to O1): "You forgot me. What will I do if you leave me?"
O1 (to O2): "Ah yes, I forgot about you."
O1 (to H1 and H2 atoms): "Just a moment. If I form a new molecule with you, my friend will be alone, and a single oxygen atom cannot survive."
H2: "It is not a problem. We can call a hydrogen molecule for your friend."
H1: "Wait a minute. We will call our friend."

H1 and H2 walk away to call their friend. At this moment, oxygen atoms start talking to each other.

O2: "I don't know what to do? How can I form a bond?"
O1: "It is too easy. You will share your electrons, thus you will form a covalent bond."
Hydrogen atoms walk towards them.
O1: "Ah, they've come. Are you ready to form a new molecule?"
O2 + H1 + H2 + H3 + H4: "Yes, we are."

Hydrogen and oxygen atoms walk towards each other and collide to form water molecules. Now, there are two water molecules. The water molecules that are produced can be decomposed only by a chemical method, electrolysis. We helped students realize that the decomposition of the water molecules cannot occur by physical means. The curious boy tries to decompose the water molecules by physical methods.

Curious: "Can I separate them? "
Teacher: "If you can break these bonds, you can. But it is a little difficult."
Curious: "Oh! I am strong enough to break these bonds. Watch me carefully, I will separate them easily."

Curious student tries to separate them but he cannot succeed in doing so.

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Curious: "It seems difficult, but I will. Maybe, I can break these bonds by using a hammer. But, how can I find it? Do you have one?

Chemistry teacher gives a hammer to the curious student.

Teacher: "Here you are. Try with this please"
Curious student tries to separate them by using a hammer but he fails again.
Curious: Yeah, I found it! I will cut these bonds by using a handsaw. Buy how can I find it? Do you have one?

When the curious boy wants help from the teacher to decompose the water molecules, the teacher points the electricity among the audience. But electricity wants something from the curious student.

Curious: "Can you decompose this molecule?"
Electricity: "Of course I can. That is very easy for me. Even I can decompose you, but there's one problem."
Curious: "I'll solve all your problems. What do you need?"
Electricity: "Pure water does not conduct electricity, so you have to show me a road that contains ions."
Curious: So you need a road with something on it. Is it an acid?
Electricity: Absolutely!

When the curious boy gives acid to electricity, it decomposes water to oxygen and hydrogen. Then oxygen goes to cathode and hydrogen goes to anode.

Results of Research

The results showed that there were no significant differences between the drama and the control groups in the pre-test before the study. The mean rank of the control group was 21.00 while the mean rank of the drama group was 19.95 (U=189, 00 z=0.789, p>0.05). After ensuring that the groups were equivalent, the teaching of electrolysis of water was done in two different ways, and the posttests were given to both groups.

Table 1. **A statistical comparison of the post test 1 results of the groups.**

Post-test 1	N	Mean rank	Sum of ranks	Mann Whitney U	Z	p
Drama group	19	25.53	485.00	104.00	2.680	0.009
Control group	21	15.95	335.00			

There was a statistical difference between the drama and the control group with respect to post-test 1 scores after the study (p<0.05). Test score means are shown in Table 1. The results indicated that the mean scores of the drama group students were higher than those in the control group at a statistically significant level.

Table 2. **A comparison of the post-test 2 results of the groups.**

Post-test 1	N	Mean rank	Sum of ranks	Mann Whitney U	Z	p
Drama group	19	26.16	497.00	92.00	3.139	0.003
Control group	21	15.38	323.00			

A significant difference was determined between the performances of the students according to the Mann Whitney U test (Table 2). The students who properly performed water molecules out of the playing dough in the final part were given twenty five points. Those who managed to decompose it properly were also given twenty five points. When the results of the practical part in the test were analyzed, it was clearly seen that the students of drama class conceived atom and molecule concepts and visualized these concepts in their minds more clearly. 16 students out of 19 in the drama group drew the molecule model of a water molecule correctly. However, the number is not that high in the control group; 7 students out of 21 in the control group could draw the water molecule correctly.

Discussion

A focus on finding ways to promote the active participation of students in classroom tasks can facilitate teaching and learning. Active participation provides a sense of meaning for learners and is useful especially when the subject matter is complicated and abstract. The task of teaching students chemistry concepts, which students often find complicated, is too often not fulfilled (Ownu and Randall, 2006). For instance, teaching an abstract process such as electrolysis, atom electron, molecule, and chemical bond, concepts considered for advanced learners (Shwartz Ben- Zvi and Hofstein, 2006), offers a high level of challenge to teachers in that they may have a hard time generating student interest and engagement. Teaching through drama offers a way of overcoming this challenge and such an approach can lead to genuine student understanding of the particular concept (Carlsson, 2003).

Research data from the current study suggest that the students in drama class conceived atom and molecule concepts and visualized these concepts in their minds more clearly. Being engaged in many activities (i.e., H_2 molecule bonds, oxygen double bond molecules, electrolysis of water, and who goes to anode and cathode during electrolysis; the size of oxygen and hydrogen atoms) might have helped the students in the drama group integrate theory and practice and get nearly three times as high achievement scores as those of the control group students. Also, as observed, one of the key benefits of the drama was that it promoted student conversation and the use of language associated with chemistry.

It was observed in this study that the students either watched the drama attentively or actively participated in the process from aside by giving stage directions or correcting their peers. The teacher later reported that the students were enthusiastic in subsequent classes and wanted to have more drama in class. He also added that students gave examples of how they would use new chemistry subjects in drama. The students' enthusiasm and active participation in the drama may have helped them concentrate longer and better on the subject matter. When questions in the test were analyzed in general, drama class students outperformed those who were instructed in the subject of electrolysis of water in a traditional class setting. This was the case especially with subjects such as the number of chemical bonds or the volume of atoms which cannot be shown theoretically or experimentally but can relatively easily be shown through drama.

Conclusions and Implications

If chemistry subjects, especially those that cannot be demonstrated in a classroom setting or in the laboratory, can be taught by using the drama technique, learning chemistry may become easier and more satisfactory. For example, radioactivity concepts cannot be shown in laboratory conditions, and students usually have difficulty understanding this challenging topic. Drama may also be employed as a means to teach more abstract chemistry subjects such as radioactivity. Further research may focus on drama use in the teaching of different areas of chemistry.

Although the fact that the sampling in the study does not readily lend itself to generalization, results may be considered indicative of a positive effect drama may have on middle school students learning water electrolysis. However, it is hoped that this study may lead other researchers to conduct similar studies with different student samples in different contexts. As a number of studies, including this one has shown, drama is a promising technique to optimize learning. By its nature, drama places students in the center of teaching, which is what most recent educational reform initiatives aim for.

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Hakan Saricayir	Phd, Instructor, Marmara University Ataturk Education Faculty, Chemistry Education Department, Goztepe, Istanbul, Turkey. E-mail: hsaricayir@marmara.edu.tr Website: http://abb.marmara.edu.tr/cv/174/hakan-saricayir