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Effects of Jigsaw on Teaching Chemical Nomenclature

Kimyasal Bileşiklerin Adlandırılması Konusunun Öğretilmesinde Jigsaw Tekniğinin Etkileri

İlker TURAÇOĞLU* Şenol ALPAT** A. Murat ELLEZ***
Dokuz Eylul University

Abstract

In this study, the objective was to determine the effects of the jigsaw on the academic achievements of the students in chemical nomenclature of the general chemistry course and to specify the student opinions with respect to the learning process. Research sampling was composed of the students of two different classes attending the general chemistry course at the department of secondary school science and mathematics education of a university in Turkey during 2008-2009 academic year by using an experimental pattern including a pre-test & post-test control group. At the end of the research, a positive difference was observed in favour of the experimental group between the academic achievements of the students to whom Jigsaw and traditional teaching method were applied. As a result of the semi-structured interviews with the students, students of the experimental group stated that "they did not think that they could be successful to this extent with the traditional teaching method". Furthermore, incomplete information and frequent faults were observed in the students of both groups concerning the chemical nomenclature after their responses to the achievement test applied prior to and following the application were examined.

Keywords: Chemistry Education, Chemical Nomenclature, Cooperative Learning, Jigsaw

Öz

Bu araştırmada, genel kimya dersi kimyasal bileşiklerin adlandırılması konusunda jigsaw tekniğinin öğrencilerin akademik başarılarına etkileri ve öğrenme sürecine yönelik öğrenci görüşlerinin belirlenmesi hedeflenmiştir. Araştırma öntest - sontest kontrol gruplu deneysel desen kullanılarak 2008–2009 eğitim-öğretim yılında Türkiye'deki bir üniversitenin ortaöğretim fen ve matematik alanları eğitimi bölümünde genel kimya dersini alan 2 farklı şubedeki öğrenciler ile yapılmıştır. Araştırmanın sonucunda, jigsaw tekniği ve geleneksel öğretme yöntemi uygulanan öğrencilerin akademik başarıları arasında deney grubu yönünde olumlu bir fark olduğu bulunmuştur. Öğrenciler ile yapılan yarı yapılandırılmış görüşmeler sonucunda, deney grubunda bulunan öğrenciler, "geleneksel öğretme yöntemi ile bu derece başarılı olacaklarını düşünmedikleri" yönünde görüş belirtmişlerdir. Ayrıca deney grubunda bulunan öğrencilerin uygulama öncesinde ve sonrasında yapılan başarı testine verdikleri cevaplar incelenerek kimyasal bileşiklerin adlandırılması konusunda öğrencilerin bilgi eksiklikleri ve sıklıkla yaptıkları hatalar tespit edilmiştir.

Anahtar Sözcükler: Kimya Eğitimi, Kimyasal Bileşiklerin Adlandırılması, İşbirlikli Öğrenme, Jigsaw Tekniği.

* İlker TURAÇOĞLU, Buca Education Faculty, Secondary Science and Mathematics Education, Dokuz Eylul University; turacogluilker@hotmail.com

** Doç. Dr. Şenol ALPAT, Buca Education Faculty, Secondary Science and Mathematics Education, Dokuz Eylul University; senol.alpat@deu.edu.tr

*** Yrd. Doç. Dr. A. Murat ELLEZ, Buca Education Faculty, Department of Educational Sciences, Dokuz Eylul University; murat.ellez@deu.edu.tr

Introduction

When the developments in the field of education throughout history are examined, it is seen that pre-admissions regarding the nature of the information influence the learning-teaching process. Behaviourist, cognitive, social cognitive and constructivist learning approaches emerged out of these pre-admissions. While the learner was regarded to be passive in the behaviourist approach which was dominant in the education practices until 1970s, cognitive processes gained importance after 1970s and as a result, constructivist learning approach emerged due to the increasing interest in how we learned (Dewey,1972; Piaget, 1963; Vygotsky, 1978; Wittrock, 1978).

Constructivist approach to education supports that information is structured by each learner as social learning that is firstly executed individually since students do not perceive information reaching to them in the same format, background, and personality of the individual are considerably important in the learning (Dufy & Jonassen, 1991; Hand & Treagust, 1991). As traditional teacher centered methods do not offer activities leading students to think and search, no opportunity is available for the individual to restructure the information. This causes the students to graduate only with their superficial information that they memorized.

Active learning methods should be used when preparing education programs based on the constructivist approach since active learning activates the student physically and mentally during learning process and enable students structure the information according to them by using their cognitive, affective and behavioural characteristics (Açıkgöz, 2004). Cooperative learning, problem-based learning and project-based learning are instructional strategies where students are in the centre of the learning process. To this end, all countries throughout the world pursue their researches as regards to learning techniques within the framework of their education programs. One of the mostly-employed techniques among these methods is cooperative learning (Bowen, 2000; Ramsay, Hanlon, & Smith, 2000; Stockdale & Williams, 2004).

Cooperative learning is defined as an instructional strategy based on cooperation of the students by helping them recognize one another in small mixed groups (Johnson & Johnson, 1992). Success of the group depends on the performance of the group members. Therefore, it is a need for the members of the group to fulfill their personal aims (Slavin, 1990). These facts lead to the creation of a positive dependence between the members of the group.

Cooperative learning should not be considered as a single method. It has various application techniques. These can be listed as Co-learning (Johnson & Johnson, 1992), Academic Conflict (Johnson & Johnson, 1987), Student Teams Success Parts (Slavin, 1978), Team-Game-Tournament (Slavin, 1978), Jigsaw (Aranson et al., 1978), Jigsaw II (Slavin, 1991), Group Research (Sharon ve Hertz-Lazarowitz, 1980), and Cooperation-Cooperation (Kagan, 1985). Common characteristic of these techniques is that cooperative learning principles can be applied to them. They show differences only in such matters as their learning experiences and their forms to ensure the cooperation within the group.

Among cooperative learning methods, the technique that is most frequently favoured in theoretical as well as practical studies is the jigsaw (Colosi, Zales & Rappe, 1998; Doymuş, 2008a, 2008b; Eilks, 2005; Slavin, 1990; Şeşen & Tarhan, 2008). Jigsaw is a technique that creates a high level positive dependence among students. Moreover, it offers the opportunity to evaluate the students both individually and as a group.

Jigsaw was developed by Eliot Aronson and is one of the purest cooperative learning techniques (Aronson et al., 1978). Processes take place during the application of Jigsaw are as follows. Firstly, groups of 3-7 are formed and materials are distributed to them. Leaving their own groups, the students form specialization groups with the other students responsible for the preparation of the same topic. Turning back to their own groups, they teach the topic which they study in the specialization group to the members of the group which come together again. In this step, group members are obliged to teach the topic they study on and prepare to one another. At the end of a certain period, students are taken into exam individually.

Chemical Nomenclature

One field of interest in chemistry is to examine the relations between elements and compounds. Internationally-accepted symbols and formulas are used so as to ensure the practical expression of these relations. While all elements existing in the nature are expressed with different symbols, compounds composed of elements are expressed with formulas. All rules related to the nomenclature of the elements and compounds are adopted by an international institution called IUPAC (Burns, 1999; Leigh, 1998). According to these rules, the resulting systematic names explain which elements constitute the compounds and even in some situations, in which order the atoms are arranged. Therefore, it is essential to abide by these rules as regards to the chemical nomenclature. Faulty or insufficient apprehension of these rules can lead to both incorrect formulation and nomenclature of the chemicals. Furthermore, lacking information concerning this issue can potentially cause misinterpretation of the expressions showing the relations of the compounds with each other. Due to these reasons, correct nomenclature and formulation of the compounds are considerably essential and basic issues in the field of chemistry.

Topic of chemical nomenclature is regarded as a non-systematic, unimportant and memorization-based issue by the students. Hanson (2002) and Shaw (2003) used computer-based materials in their study to facilitate the learning of nomenclature rules. On the other hand, many researchers designed various games and activities to render the Chemical Nomenclature topic more interesting and exciting (Caps, 2008; Chimeno, 2000; Chimeno et al., 2006; Crute, 2000; Lind, 1992; Rabson, 1983; Sevcik, Hicks, & Schultz, 2008; Wirtz, Kaufmann, & Hawley, 2006)

Studies on the chemical nomenclature are generally about the nomenclature of the ionic compounds. Among the studies that were analyzed, no study was found concerning teaching the rules regarding the nomenclature of all anions, cations, ionic and covalent compounds and oxygen acids that are parts of the topic. It was thought that the topic could be learned more effectively by firstly dividing it into separate topic parts and then combining them all through Jigsaw due to the fact that different nomenclature rules are available for each ion and compound species. To this end, the objectives of the study that was carried out were specified as comparing the effects of the traditional teaching method and cooperative learning Jigsaw technique on teaching the topic of chemical nomenclature of the general chemistry course and revealing the opinions of the students participating in the study with regard to the learning process. Furthermore, responses of the students of both groups to the tests applied prior to and following the empirical processes were examined. In this way, lacking information and frequent faults of the students regarding the chemical nomenclature were detected.

Purpose

Examining the literature, it is seen that students have problems with learning the subject of chemical nomenclature with various reasons and some different methods are suggested for this subject to be learned. However, the studies being performed are mainly related with the nomenclature of ionic compounds. Besides, no study aimed at teaching the rules about the nomenclature of anions, cations, ionic and covalent compounds and the whole of oxyacides, which are included in the content of the subject, was encountered among these studies. Regarding the chemical nomenclature, different nomenclature rules are used for each type of ions and compounds. Due to this feature, it was thought that the subject would be taught more efficiently by initially disintegrating and then compounding within the frame of the application principles of the jigsaw. For these aforementioned reasons, the study aimed to compare the effect of the traditional teaching method and the jigsaw for teaching the chemical nomenclature in the general chemistry course and reveal the opinions of students, who participated in the study, regarding the process of learning. Additionally, the answers given by the experimental group students to tests that were performed before and after empiric proceedings were examined. By this means, the information deficiencies and frequent mistakes of students regarding the subject of chemical nomenclature were determined.

In line with these objectives, the problem statement of the study could be defined as; "What are the effects of the jigsaw upon the academical achievements of students in terms of the chemical

nomenclature in the general chemistry course, opinions of students regarding the process of learning and frequent mistakes and information deficiencies on this subject?". On the other hand, sub-problems of the study are as follows:

1. Is there a significant difference between the academical achievements of the experimental group students, on which the jigsaw was performed, and the control group students, on which the traditional teaching method was performed, in terms of the chemical nomenclature in the general chemistry course?
2. What are the opinions of the experimental group students, on which the jigsaw was performed, and the control group students, on which the traditional teaching method was performed, regarding the process of learning in terms of the chemical nomenclature in the general chemistry course?
3. What are the information deficiencies and frequent mistakes of the experimental group students, on which the jigsaw was performed, and the control group students, on which the traditional teaching method was performed, regarding the chemical nomenclature?

Materials and Methods

Quasi-experimental pattern with pretest – posttest control group was used in the study. Quasi-experimental method is a design, where people to be assigned to experimental and control groups are placed with a method outside of the random distribution and which involves the experimental state (Karasar, 2006). Taking some data into consideration, an experimental study could be conducted by selecting two of the available groups (classes) that relatively resemble one another the most in the study (Büyüköztürk, 2007a). The factors aimed at providing the internal and external validity of the study (Karasar, 2006) were taken into consideration during the planning and application of the process.

Research Group

Attainable sampling method was used for the determination of the working group of the study. This sampling method brings acceleration and practicability in the study; because the researcher selects an attainable condition in this method (Yıldırım & Şimşek, 2006). Two classes that received the general chemistry course in the secondary education science and mathematics fields of a university in Turkey during the academic year of 2008-2009 were selected for the study. And then these classes were randomly determined as experimental group (N=30) and control group. A special attention was paid to the similarity of life and working conditions of students in the experimental and control group, which would affect their socio-cultural status and achievements during the studies. Regarding the process of empiric proceedings, while the researcher used the jigsaw for the experimental group; he used traditional teaching methods for the control group.

Instruments

Pre-Knowledge Test (PKT) was developed in an attempt to measure the prelearnings, which form the basis of learning the subject of chemical nomenclature. Regarding the development of the test, the primary step was to examine the contents of units, in which the subject was discussed in the primary, secondary education and university program and the opinions of specialist academicians were received. As a result of the study, a literature review was performed on Atomic and Subatomic Partides, Elements, Metals-Ametals-Semimetals, Periodic Tables, Compounds, Molecular Compounds, Ions and Ionic Compounds, which were determined to form a basis for learning the subject (Beran & Brady, 1990; Burns, 1999; Erdem, Yılmaz & Morgil, 2001; Griffith & Preston 1998; Karamustafaoğlu & Ayaş, 2002). And then a table of specifications that involved acquisitions to be obtained by students regarding these subjects was formed. Multiple-choice items were written within the scope of the determined acquisitions. Opinions were received from 5 specialist academicians regarding the convenience of test items for student levels and the curriculum, quality of questions and whether the questions precisely included the related acquisitions or not. The test, which was

prepared in accordance with the opinions and suggestions of specialists, was performed on a group of 126 students who had previously received the general chemistry course as a pilot test. Regarding the items in PKT that was finalized as a result of the analyses and was consisted of 29 items, while their difficulty indexes varied between 0.32-0.83, their distinctiveness indexes varied between 0.32-0.47. Besides, while the average difficulty of items in the test was calculated as p≈0.63, the reliability of the test was calculated as r≈0,97 (KR-20).

Regarding the development of the process of Chemical Nomenclature Achievement Test (CNAT), the primary step was to perform literature reviews aimed at the subject of nomenclature of chemical compounds (Beran & Brady, 1990; Burns, 1999; Crute, 2000; Leigh, 1998; Lind, 1992; Shaw, 2003). Receiving the opinions of specialist academicians in this field, the researchers formed a table of specifications that involved acquisitions to be obtained by students regarding the subject of nomenclature, within the scope of the literature being examined. The table of specifications aimed to measure the extent of the acquisitions of students regarding the nomenclature of various anions and cations whose formulas are given, nomenclature of ionic and covalent compounds whose formulas are given, writing the chemical formulas of various anions and cations whose nomenclatures are given, and writing the formulas of ionic and covalent compounds whose nomenclatures are given. And then items that were aimed at these determined acquisitions were written. Opinions were received from 5 specialist academicians regarding the convenience of test items for student levels and the curriculum, quality of questions and whether the questions precisely included the related acquisitions or not. The test, which was prepared in accordance with the opinions and suggestions of specialists, was performed on a group of 131 students who had previously received the general chemistry course as a pilot test. Regarding the items in CNAT that was finalized as a result of the analyses and was consisted of 122 items, while their difficulty indexes varied between 0.21-0.84, their distinctiveness indexes varied between 0.31-0.71. Besides, while the average difficulty of items in the test was calculated as p≈0.48, the reliability of the test was calculated as r≈0,97 (KR-20).

Semi-structured interview technique was used in an attempt to receive the opinions of students regarding the nomenclature of chemical compounds and the teaching methods being applied. Semi-structured interviews include some determined questions. In addition to this, no certain limit is made on the answers of the individual who is interviewed (Şimşek & Yıldırım, 2006). Interview questions are formed by researchers. The questions aimed to examine the difficulties experienced by students regarding the nomenclature of chemical compounds, as well as the advantages and disadvantages of the teaching methods being used deeply within the scope of the study objectives. Opinions of 4 academicians, who are specialists in fields of chemistry education and educational sciences, were received concerning the convenience of questions that were written by researchers for these purposes. The questions were finalized in line with the opinions and suggestions that were received. Using these questions, semi-structured interviews were performed with 9 students from both the experimental and control group. The 1st question was applied on both groups in a common way; and while the experimental group was asked 4 questions, the control group was asked 3 questions. As a first step in selecting the students, post-test mean scores and standard deviations of the students in CNAT were calculated. Scores were divided into 3 levels as low, mediate and high by pulling the mean score to one standard deviation lower or one standard deviation upper over the normal distribution curve of the post-test scores of the experimental and control groups. Afterwards, 9 students with different levels were specified from each group.

Data Analysis

In the study, independent samples t-test was used for the examination of the significant difference between the pretest and posttest scores of experimental and control groups. This analysis technique focuses on the comparison of measurements (scores) of groups, which are formed in relation with a variable, that belong to a dependent variable (Büyüköztürk, 2007b).

Content analysis, which is used for qualitative studies, was performed for the analysis of semi-structured interviews that were conducted with students from experimental and control groups

(Şimşek & Yıldırım, 2006). A tape recorder was used during the interviews. The data were analysed by a researcher and a specialist. The primary step was to convert the tape recordings between researcher-student into written forms. Groupings were performed during the analysis of students' opinions, according to the similarity of statements. A code number (S1,S2..) was given to each student, whose opinions were received, during the analyses. Statements and similar elements in the obtained data were grouped, digitized and then expressed as frequency (f).

CNATs, which were performed on students in experimental and control groups, were examined in order to determine the information deficiencies and frequent mistakes of students regarding the subject of chemical nomenclature and how these changed during the process of application. A code number (S1,S2..) was given to each student during the analyses. In order to express the information deficiencies regarding the nomenclature, the frequencies of items, to which students in experimental and control groups did not give answer as a result of the fact that CNAT was performed as pretest and posttest, were determined. In order to determine the frequent mistakes regarding nomenclature, on the other hand, the frequencies of answers with similar mistakes that were given by students in experimental and control groups to the same items as a result of the fact that CNAT was performed as pretest and posttest were determined.

Procedure

Prior to the application, PKT was applied to both groups in order to evaluate their pre-knowledge levels that are essential for them to be able learn the topic of chemical nomenclature". Accordingly, knowledge deficiencies of the students were detected. A preparation course lasting for 2 hours was organized to cover the deficiencies of both groups. Topics of Atom, Elements, Metals-Non-metals-Semimetals, Periodic Table, Compounds and Ions were included in the scope of this preparation course. CNAT was applied to both groups as a pre-test after the pre-knowledge of the students were brought nearly to the same level.

Lectures on the chemical nomenclature were given to both groups for 2 weeks and 4 hours in a week. As a cooperative learning method, Jigsaw was used when the topic was being taught to the experimental group. Scope of the process applied in the experimental group was displayed in the Table 1.

Table 1.

Processes applied in experiment group

Period	Process
1 hour	• Explanations were made in the class regarding jigsaw. • Subtopics which were determined beforehand were allocated to the students in home groups randomly *(1), (2), (3), (4) and (5)*
1 hour	• Students who are responsible for the same subtopic formed jigsaw groups. • Students of jigsaw groups planned how they would study their topics. For example, group *(1)* Nomenclature of Cations: Students tried to answer these questions; "How are the cations classified", "How are nomenclature only one ion possible monatomic cations", "How are nomenclature more than one ion possible monatomic cations", "How are nomenclature polyatomic cations"
2 hours	• Students in jigsaw groups shared the information they collected related to subtitles and each group prepared power point presentation for all students.
2 hours	• Jigsaw groups presented their studies related to their subtitles.
Homework	• Power point presentations were handed out all students so that they could revise at home.
2 hours	• Students in jigsaw groups who became experts in their subtitles returned to their home groups. • Worksheets including all subtitles of the subject were handed out students. Each student helped his/her friends to resolve the worksheets

Necessary explanations were made regarding the method and technique that would be applied to the students in the experimental group. Of the students, 6 heterogonous groups with 5 members were formed according to the scores obtained from the CNAT applied as a pre-test. Class was arranged in such a way that best interaction between the students would be ensured. 5 subtopics specified beforehand were allocated at random to each student in the groups. These subtopics were determined as (1) Cations Nomenclature, (2) Anions Nomenclature, (3) Ionic Compounds Nomenclature, (4) Covalent Compounds Nomenclature, (5) Oxy acids and Oxy salts Nomenclature.

Students responsible for the same subtopic in home groups came together and formed Jigsaw groups [Figure 1]. Students of the Jigsaw groups became specialized in their respective fields by conducting researches on their common objectives. It was reminded to the members of the group during this process that they were responsible from learning of one another. Moreover, the author guided them to direct their researches. All Jigsaw groups presented the researches regarding their common objectives to the whole class via 20-minutes power point presentations. Points not understood completely in the presentations were concluded after being discussed all together.

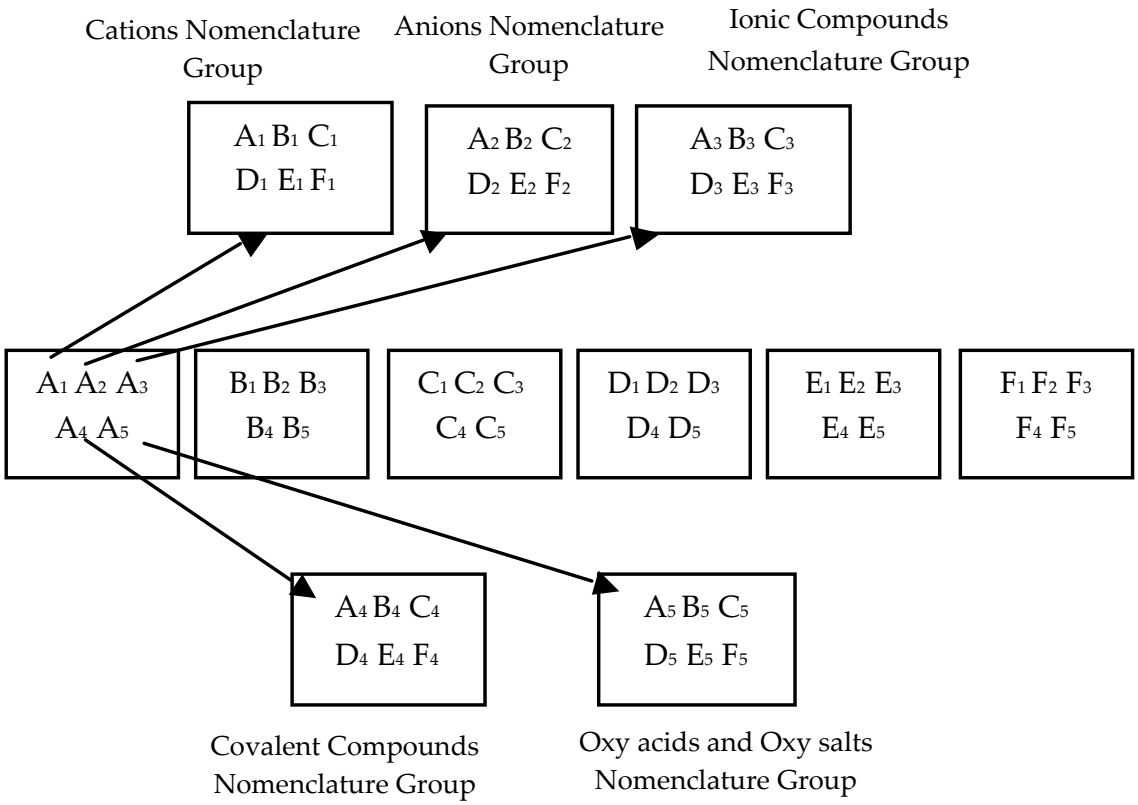

Figure 1. Forming jigsaw groups from home groups

Having been specialized in their subtopics, members of the groups returned to their actual groups. Meanwhile, worksheets including all the subtopics were distributed to the actual groups. Examples of the worksheets provided to the students are showed in the Figure 2 and Figure 3. Lind (1992)'s systematic approach served the basis of these worksheets particularly as regards to anion-cations and compound nomenclature. During the analysis of these worksheets, each student helped the group members in answering the questions related to the respective sub-topic that s/he specialized.

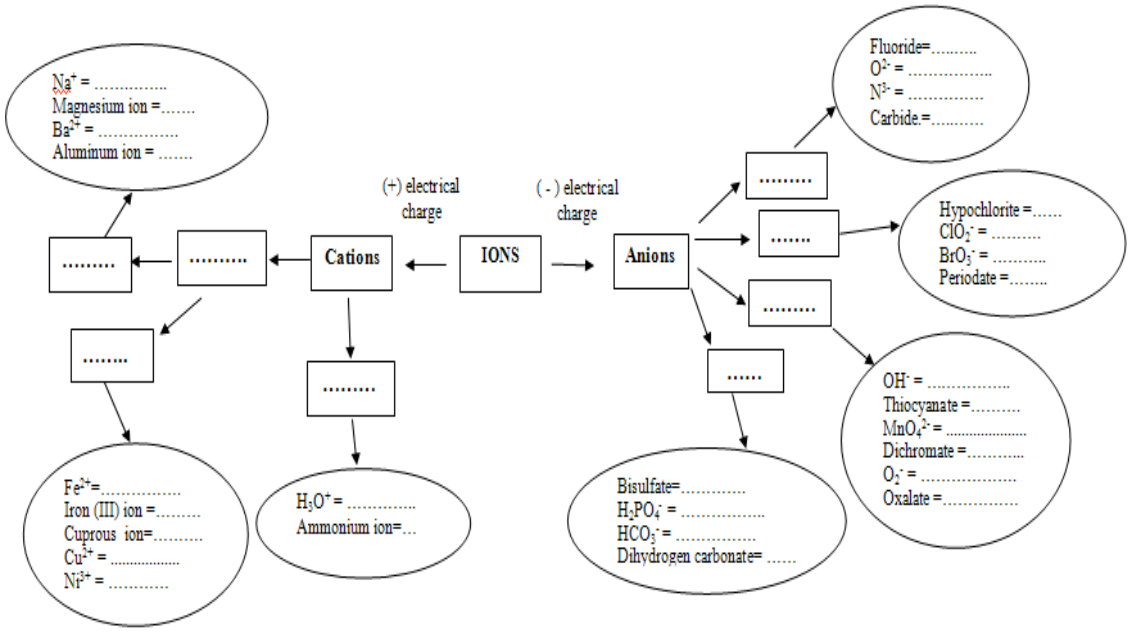

Figure 2. Example of worksheet-1

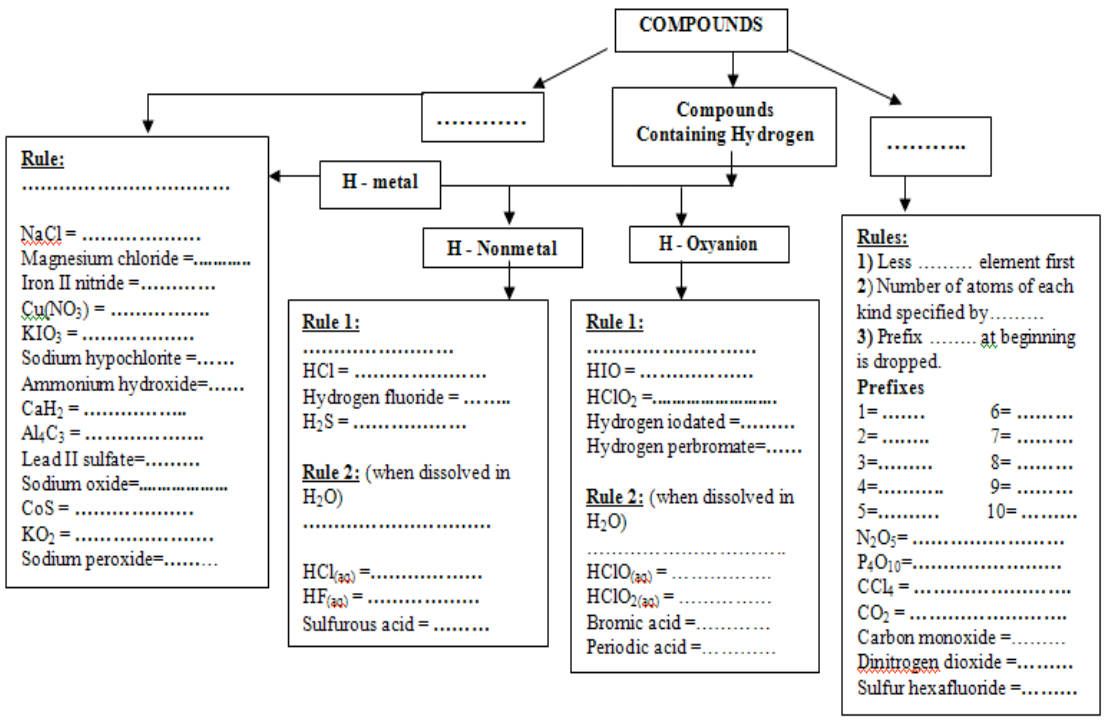

Figure 3. Example of worksheet-2

In the control group, topics of chemical nomenclature were taught by using traditional teaching method in which teacher was in centre of the learning environment. The lecturer planned the activities of the presentation related to cations nomenclature, anions nomenclature, ionic compounds nomenclature, covalent compounds nomenclature and oxy acids-oxy salts nomenclature. All of the subtopics were presented by lecturer and all the questions asked

by students related to the subtopics were answered in detail. Afterwards, worksheet-1 and worksheet-2 distributed to the students in the experimental group were projected for the control group and the students were asked to answer the questions. In the control group, each student was only responsible for self learning.

Afterwards, CNAT was applied to the groups as post-test this time and the data regarding the effects of the learning methods that were applied on the academic achievements of the students were compared statistically. Following the application of CNAT as post-test, semi-structured interviews were conducted with the students in the experimental and control groups so as to specify the opinions of the students as regards to the learning process.

Findings

Effects of jigsaw and the traditional teaching method on the academic achievements of the students

CNAT was applied before and after the empirical processes to the students of the experimental and control groups whose pre-knowledge levels were equalized. Results of the analyses conducted regarding the pre-test and post-test scores of the students in the experimental and control groups are presented along with the data in Table 2.

Table 2.

Comparative Independent Samples t-Test Analyses of Pre- and Post-Test CNAT Scores

Instrument used	Group *(N)*	Mean[a]	SD	*t*	*p*
Pre-test	Experiment *(30)*	40.2	15.9	.163	.871
Pre-test	Control *(36)*	39.7	8.7		
Post-test	Experiment *(30)*	85.4	14.3	9.2	.000*
Post-test	Control *(36)*	51.5	15.4		

*[a]Maximum score for these tests was 122 points. *p<.01*

When Table 2 was analyzed, there was no a significant difference between pre-test CNAT mean scores of both groups [$t_{(64)}$=0.163, p<.01]. However, it was found out that academic achievements of the students in the experimental group to which Jigsaw was applied were higher than those of the students in the control group to which the traditional teaching method was applied [$t_{(64)}$=9.2, p<.01]. In other words, there is a significant difference in favour of the students in the experimental group between the post-test CNAT mean scores of the students in the experimental and control groups.

Results of the semi-structured interviews regarding the learning process

From the students in the experimental and control groups, 9 students who were in the different score ranges according to their post-test scores were selected from each group. A tape recorder device was used in the interviews. Records of the dialogues between the researcher and the student were analyzed by the researcher and an expert. Questions directed to the students during the semi-structured interviews with the students and the answers of the students to these questions were grouped according to their percents [Table 3. and Table 4.]. The reason why the frequencies of students' opinions are more than 9 in total is that one student expresses more than one opinion.

Table 3.

Results of the semi-structured interviews of the students in the experimental group

Questions directed to the students and opinions of the students	f
1) What are the reasons of difficulties that are experienced regarding the chemical nomenclature?	
Existence of different nomenclature rules for the ion and compound species makes learning difficult	8
The fact that the topic is totally based on memorization makes learning difficult	4
It is not difficult to learn them with sufficient practicing	3
I find it difficult as I do not know the periodic characteristics of the elements	2
The fact that the names of the elements are derived from Latin makes learning difficult	1
2) What can you say about the advantages and disadvantages of the use of jigsaw on learning the topic?	
It increased our achievements	8
Firstly dividing the topic into subtopics and then combining them facilitated learning	8
It promoted cooperation among friends	6
It encouraged us to conduct researches	5
It enabled me to feel as a teacher	5
It strengthened our friendship relationships	4
When somebody does not fulfil his/her responsibility, success can not be acquired	2
That communication within the group is weak reduces the rate of success	1
Much more time is needed to apply this technique	1
3) Would your success rate be different if traditional teaching method had been applied?	
I do not think that we could be successful to this extent	8
I get distracted after a while as the teacher is lecturing	6
I become more successful by conducting researches	4
Being responsible for all the rules included in the topic would reduce my willingness to learn	2
I do not find it necessary to prepare for the course when the teacher lectures the topic	2
I forget what the teacher lectures in a short time if don't repeat them	2
I think that I will catch the same success when I listen the lecture carefully	1
4) Has the use of jigsaw leaded to a change in your attitudes regarding the scientific researches?	
I learned how to conduct a scientific research	8
I learned how to access to information in the libraries and internet	8
I learned how to make a selection among the information I have found	5
I acquired experiences as regards to preparation of presentation	5
It didn't cause any change in my attitudes regarding scientific researches	1

Table 4.

Results of the semi-structured interviews of the students in the control group

Questions directed to the students and opinions of the students	f
1) What are the reasons of difficulties that are experienced regarding the chemical nomenclature?	
The fact that the topic is totally based on memorization makes learning difficult	7
Existence of different nomenclature rules for the ion and compound species makes learning difficult	6
The fact that the names of the elements are derived from Latin makes learning difficult It is not difficult to learn them with sufficient practicing	6 2
2) What can you say about the advantages and disadvantages of the use of the traditional teaching method on learning this topic?	
I get distracted after a while as the teacher is lecturing	7
I don't think that traditional teaching method will be effective	5
I forget what the teacher lectures in a short time if I don't repeat them	4
I don't prepare for the course when the teacher lectures the topic	3
3) Would your success rate be different if any other learning method had been applied instead of traditional teaching method?	
I become more successful if I become active during the course	7
I attend to the courses as prepared if I undertake responsibility	5
I become more successful by making researches	4

Analysis of the answers given by the students in the both groups to CNAT

Answers of the students to the questions of CNAT which was applied to the students of the both groups before and after the empiric processes were analyzed. By means of the analysis of the answers given to the pre-test, information deficiencies and frequent faults of the students as regards to the topic of chemical nomenclature were detected. Through analysis of the answers given to the post-test after jigsaw and traditional method was applied, it was determined to what extent the deficiencies and faults were covered. Frequencies of the information deficiencies and frequent faults of the students as measured by CNAT were presented in Table 5 and Table 6.

Table 5.

Information deficiencies of the students of the both groups in CNAT

Information Deficiencies of the Students in the Chemical Nomenclature Achievement Test	Control		Experimental		Questions not answered
	Pre Test	Post Test	Pre Test	Post Test	
	f*	f*	f**	f**	
Inability to name the specific named anions	27	20	25	5	SCN^-: ---------- MnO_4^-: ----------
Inability to write the formulas of specific named anions	28	21	25	9	Dichromate: ---------- Acetate: ----------
Inability to name the oxy acids	25	19	24	7	$HClO_4$:---------- HIO_2: ----------
Inability to write the formulas of the oxy acids	22	19	19	4	Chloric acid:---------- Hypoiodous acid:-----
Inability to name the oxy salts	24	18	25	8	$Ca(ClO_4)_2$: ---------- $NaIO_2$: ----------
Inability to name the ionic compounds including hydrate	27	20	21	11	$Ba(OH)_2 . 8 H_2O$: ------ $CoCl_2 . 6 H_2O$: ---------

* *Frequencies calculated for 36 students in control group*

** *Frequencies calculated for 30 students in experimental group*

When Table 5 was analyzed, it was observed that the rate of the students who did not answer the questions regarding the nomenclature of the specific named anions and oxygen acids and writing their formulas was high when CNAT was applied as a pre-test. Moreover, questions concerning the nomenclature of the oxy salts and compounds including hydrate were not answered by the students. This shows us that the students had deficiencies in these topics. However, when the answers given to CNAT applied as post-test at the end of the processes, it was observed that students in experimental group decreased the rate to leave the abovementioned questions unanswered.

Table 6.

Frequent faults of the students of the both groups in CNAT

Faults of the Students in the Chemical Nomenclature Achievement Test	Control Group		Experimental Group		Sample Mistakes
	Pre-test f*	Post-test f*	Pre-test f**	Post-test f**	
To name monatomic anions and cations like elements	21	18	18	2	O^{2-}: Oxygen Ca^{2+}: Calcium
To misspell the charges of the named ions	15	12	13	2	Lithium ion: Li^{2+} Carbide: C^{2-}
To name monatomic, multiple valance cations without specifying the stock number	20	17	21	3	Cr^{3+}: Chromium Ni^{2+}: Nickel
Misnomenclature of the oxy-anions	22	15	23	5	SO_3^{2-}: Sulfate ion ClO_2^-: Chlorate ion
To misspell the formulas of the oxy-anions	14	10	13	3	Phosphite ion: PO_4^{3-} Bromate ion: BrO_4^-
To misspell the suffixes of the anions in the nomenclature of the ionic compounds	7	5	7	1	Fe_3N_2: Iron (II) nitrogen CaH_2: Calcium hydrogen
Nomenclature of the ionic compounds like covalent compounds	7	4	6	-	$Cr(OH)_3$: Chromium trihydroxide K_2CO_3: Dipotassium cabonate
Not to specify the stock number of the cations during the nomenclature of the ionic compounds of the monatomic, multiple valance cations	19	17	18	6	$PbCO_3$: Lead carbonate $Fe(OH)_3$: Iron hydroxide
To misspell the suffix of the 2nd element in the nomenclature of the covalent compounds	5	4	5	1	PBr_3: Phosporus tribrom CCl_4: Carbon tetraclor
Nomenclature of the acid solutions like ionic compounds	9	8	10	4	$HF_{(aq)}$: Hydrogen fluoride $HNO_{3(aq)}$: Hydrogen nitrate
To misspell the formulas of the ionic compounds including hydrate	6	4	5	1	Calcium sulfate dehydrate: $CaSO_4(H_2O)_2$ Copper (II) sulfate pentahydrate:$CuSO_4(OH)_5$

* *Frequencies calculated for 36 students in control group*

** *Frequencies calculated for 30 students in experimental group*

When Table 6 was analyzed, frequent faults of the students in both groups regarding the topic of chemical nomenclature as well as the rates of these faults in the pre-test and post-test could clearly be seen. It was observed that the rate of the faults of the students in experimental group in CNAT applied as post-test was lower than that of CNAT applied as pre-test.

Disscusion

It was determined that the academical achievement scores of experimental group students, on which the jigsaw performed, were significantly different from the academical achievement scores of control group students, on which the traditional teaching method was performed, in terms of the chemical nomenclature. This difference statistically shows that academical achievements of

experimental group students' increase compared to that of control group students.

Regarding the instruction of chemical nomenclature, Hanson (2002) and Shaw (2003) developed computer-based materials; Caps (2008), Chimeno (2000), Chimeno et. al., (2006), Crute (2000), Sevcik, Hicks & Schultz (2008) and Wirtz, Kaufmann, & Hawley (2006), on the other hand, designed various games and activities in order to make the subject more entertaining and exciting. However, it is seen that the extent of these studies being examined is very limited and that they rather focus on the nomenclature of ionic compounds. The data that were obtained as a result of the study show that the jigsaw is an effective method to be used in teaching the subjects of the nomenclature of ion, ionic compound and covalent compounds.

The results that were obtained in this study show a parallelism with various studies, which researched the effect of cooperative learning methods in science education upon the academical achievements of students or their relevant information and skills (Berger & Hazne, 2005; Doymuş, 2008a, 2008b; Doymuş & Şimşek, 2007; Eilks, 2005; Lai & Wu, 2006; Lazarowitz et. al., 1994; Lucas, 2008; Tarhan & Şeşen, 2008; Tezer & Altıparmak, 2008). As a result of these studies, it was determined that jigsaw increases the academical achievement of students and contributes to the removal of conceptual mistakes and information deficiencies. The reason of this achievement of groups that apply the jigsaw was arrayed by Doymuş, (2008a) as follows: students help one another and act within the scope of a common goal, they think about one another positively and act in a more successful way together, and the technique enables the formation of positive relations between students with different skills, as well as the formation of communication, dialogue, belonging to a group and effort for a common goal for them.

Semi-structured interviews were performed in order to determine the opinions of experimental group students, on which the jigsaw was performed, and control group students, on which the traditional teaching method was performed, regarding the process of learning concerning the subject of chemical nomenclature in the general chemistry course. It was concluded that the reasons disabling the subject to be learned might include the fact that among the answers given to the question "What are the reasons of difficulties that are experienced regarding the chemical nomenclature?" that are jointly directed to students in experimental and control groups, there are different nomenclature rules for each type of ions and compounds and these rules are intermingled, this is a highly memorization-based subject and the names of elements are derived from the Latin language. Examining the literature, the number of studies that include the opinions of students regarding the nomenclature of chemical compounds is very limited. In parallel with the results that were attained in a study that was conducted by Lind, (1992), the subject of nomenclature was defined as unsystematic, unimportant and memorization-based by students.

Examining the opinions of students in the experimental group regarding the jigsaw, it is emphasized that dividing the subject primarily into separate topics and then combining them is a factor that enables learning. In addition to this, it is seen that the jigsaw increases the achievement, enables cooperation among group friends, changes negative attitudes towards the scientific research and contributes to students concerning how to make researches and use resources such as internet, library. The primary negative opinions of students were about allocating time for studies, communicating with their group friends, performing preliminary preparation for studies and taking responsibility. These results that were attained show similarities with the results of the studies that were performed by Doymuş & Şimşek (2007), Bilgin & Karaduman (2005), Eilks (2005), Gillies (2006) and Hazne & Berger, (2007). These studies revealed that cooperative learning methods increase the achievement and self-confidence of students, enable a positive dependence between them, remove the rote learning and develop their skills regarding the processes of scientific research.

Students in the experimental group stated that they would not have got the same achievement if traditional teaching method had been used for the instruction of the chemical nomenclature. The fact that since students are generally inactive in the traditional teaching method, they lose

attention after a certain time was showed as a reason for this condition. It is seen that the opinions of control group students regarding the traditional teaching method are similar with that of experimental group students, as well. Control group students stated that the traditional teaching method is not a useful teaching method; students lose attention when the course is taught with a straight narration by the teacher and they forget what they have learned unless the teacher repeats the subjects. These results that were attained support the results of a number of studies, which compare the traditional teaching method and cooperative learning method. (Avşar & Alkış, 2007; Bilgin & Karaduman, 2005; Eilks, 2005; Özdilek et al., 2010; Tezer & Altıparmak, 2008; Vesile, 1999; Young, Hadgraft & Young, 1997).

Examining the literature, no study was encountered in relation with the information deficiencies and frequent mistakes of students regarding the nomenclature of chemical compounds. Thus, this study examined the answers of students given to the questions in CNAT, which was performed as pretest and posttest in an attempt to determine the information deficiencies and frequent mistakes of experimental group students, on which the jigsaw was performed, and control group students, on which the traditional teaching method was performed, in terms of the chemical nomenclature.

It was observed that students gave answers to questions aimed at the nomenclature of compounds that contain proper-noun anions, oxyacides, oxysalts and hydrates at a very low rate in CNAT, which is applied before empiric proceedings (Table 5). These results show that students have information deficiencies on these subjects. Frequent faults of the students in the pre-test applied before the empiric processes can be listed as such; (1) to name the monatomic anions and cations like elements, (2) to misspell the charges of the named ions, (3) to name the monatomic, multiple valance cations without specifying the stock number, (4) misnomenclature of the oxy-anions, (5) misspell the suffixes of the anions during the nomenclature of the ionic compounds, (6) to name the ionic compounds like covalent compounds, (7) not to specify the stock number of the cations during the nomenclature of the ionic compounds of the monatomic, multiple valance cations, (8) to misspell the suffix of the 2nd element in the nomenclature of the covalent compounds, (9) to name the acid solutions like ionic compounds, (10) misspell the formulas of the ionic compounds including hydrate (Table 6).

While the rate of students to give correct answers to questions in CNAT that is applied after empiric proceedings is very high especially for the experimental group, it was observed that the aforementioned mistakes that are made in the pretest are also considerably lower in the experimental group compared to the control group (Table 5 and Table 6). This condition shows that the jigsaw is an effective method for students to learn the subject of the chemical nomenclature.

Conclusion and Suggestions

As a consequence, it could be asserted that regarding the chemical nomenclature, the course activities that are planned according to the jigsaw are effective upon increasing the academical achievement levels of students, enable cooperation among group friends, change negative attitudes towards the scientific research and contribute to students concerning how to make researches and use resources such as internet, library. Besides, it was concluded that the jigsaw is effective upon the decrease of frequent mistakes that are made by students in relation with the chemical nomenclature and removal of their information deficiencies. The following suggestions could be made in line with the results that were attained in the study:

- Jigsaw could be used for the purpose of increasing the academical achievement of students and removing their information deficiencies regarding the chemical nomenclature in the general chemistry course.
- The effect of the jigsaw upon students' academical achievements, attitudes, skills of scientific process and removal of conceptual mistakes could be researched in other studies, as well.

- The effect of the jigsaw upon academical achievements of students could be researched in relation with the subject of the chemical nomenclature within the scope of secondary school science and technology course and high school chemistry course.
- A review could be performed on broader samples in order to reveal the difficulties experienced by students in terms of the chemical nomenclature in detail.

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