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Analysis of the Contribution of Argumentation-Based Science Teaching on Student Success and Retention

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Abstract

Observing the argumentation of a scientific event and understanding skill is an important component of scientific literacy. In this paper, the effect of lecturing with argumentation-oriented activities in science classes on student success and the retention of knowledge has been analyzed. The study was conducted between 2006 and 2008 academic years in an elementary school in Amasya, Turkey. The study employed a quasi-experimental research method. Argumentation based teaching method was used in experimental group. Traditional teaching method was used in control group. Two different tests were developed for data collection in the study. A subject-related success test was developed in order to determine the success of students and a preliminary knowledge test was developed to check whether the classes were equivalent and to determine their preliminary knowledge. It has been found out that there was a significant difference in favor of the experimental group in terms of student success and the retention of knowledge. When experimental groups worked on for two years were compared, no significant difference was detected between student success rates; however, the scores of second year experimental group were found to be higher. It can be said that argumentation based teaching model affects students' development of conceptual understanding and their information permanence. Argumentation can also be employed in teaching other subjects. Class activities have to be developed and argumentation norms have to be applied in science teaching so that young individuals can gain confidence in employing argumentation.

Keywords: Argumentation, science education, primary school, student success, success retention

Introduction

The purpose of science teaching is to teach the art of thinking to students, to develop the experience-based concepts in their minds and to teach them the methods for examination and analyzing the relations of cause and effect. In science, learning a subject is learning the concepts related to the subject and their interrelations. Traditional classroom environment has a structure where science topics are taught with questions whose answers are already known and student accepts the knowledge as it is. In such classrooms, science applications are restricted to the usage of scientific knowledge and no room is provided for students to research, question and develop their scientific process skills. Therefore, inevitable difficulties arise in teaching concept. Results of the researches conducted by science teachers on how students learn science concepts and how they can learn them better and which factors affect teaching have shown that it is necessary to use teaching approaches, methods and techniques that are all different from traditional teaching approach (Ebenezer & Haggerty, 1999; Wandersee, Mintzes & Novak, 1994).

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New approaches based on student-centered teaching emphasize that active participation in the process and mental effort from the individuals are required so as to generate learning. Constructivist approach, which states that learning, is generated by finding a connection between existing and newly-acquired knowledge, the effect of language and culture gains importance. Basic belief of social constructivist approach is that knowledge is structured socially; however, answer is also sought to the questions of “what is knowledge?” and “how is knowledge structured?” If knowledge consists of checked accurate beliefs, the accuracy of beliefs has to be proved with arguments and counter-arguments (Nusbaum, 2008).

According to Kuhn (1993) argumentation as a social activity is at the heart of science. Science education should be taught as promoting a way of thinking. It is a precondition that science students should actively participate in speaking and writing processes so as to explain the given scientific events, consider and make sense of the experiments (Driver et al., 1994). Applications like evaluating alternatives, weighing evidence, interpreting texts and evaluating the viability of scientific assertions can be regarded as the basic components of conducting an argumentation. In science teaching and argumentation, scientific questioning and research, assertion and belief are combined by justification, generalization of results and interpretations received from the environment. In argumentation, students deal with active logic usage (which includes defending, critizing, detailed examination, explaining and evaluating ideas) so as to test uncertainties, makes sense and achieve deeper comprehension (McAlister, 2001). Argumentation is used in examining and evaluating evidence and alternative arguments. Students are given discussion, examination and debate issues so as to ensure participation in argumentation. Written and verbal applications are also required so as to develop the students’ argumentation skills (Jeong & Davidson-Shivers, 2006).

Argumentation is defined as the coordination of an evidence or theory in order to support or disprove a conclusion, model or estimation. Teachers need to support students for understanding how scientific knowledge is constructed and validated. They have to be able to develop the skills required to discuss evidence and evaluate claims (Okada & Buckingham, 2008). According to Driver, Newton and Osborne (2000), argumentation includes evaluation of evidence, examination of alternatives, and verification of scientific assertions and assessment of counter-claims. Arguments related to the validity of knowledge claims and interpretation of evidence is in the core of science and scientific discourse. According to Billig (1987), as students deal with argumentation for defending a scientific argument and evaluating the connection between claim and evidence, argument is an important element of questioning and thinking. Discussing scientific issues in daily life (conversation) or argumentation of social problems can improve decision-making and problem-solving skills (Kuhn, 1993). Argumentation is an important component of scientific literacy. It is introduced into science class not only to improve students’ critical and scientific investigation skills and establish appropriate images of science but also to provide practical meaning for students’ development (Yan & Erduran, 2008).

Once the students have to learn a science subject formally, they possess almost all preliminary information regarding science concept and these preliminary information is not usually in accord with scientific facts. From this perspective, when science education is evaluated, learning science needs conceptual change. When literature data about argumentation is examined, these data indicates that argumentation skills of students improve their conceptual understanding and facilitate conceptual variation (Albe, 2008; Sadler, 2004). The students having advanced conceptual understanding have better argumentation level. Moreover, students having high argumentation level have better conceptual understanding and the academic studies. These two impacts are mutually interacting with each other (Nussbaum & Sinatra, 2003; Asterhan & Schwarz, 2009).

Mainly four factors promote the student argumentation. These are; (a) the role of teacher; (b) the use writing frames; (c) the context of socio-scientific issue, and (d) the role of students. Argumentation helps students improve understanding, participate debates actively and talk about understanding emerging scientific concepts actively in science classes. Writing and speaking about science is to enable students to undertake the conceptual understanding (Dawson & Venville, 2010).

Argumentation is the central for analysis of data and knowledge, writing persuasive explanations and directly dealing with dialogue. For this reason, argumentation is necessary in the process of social cooperation in terms of knowledge progress and problem-solving instead of competition among individuals. Argumentation involves arrangement of participation and dialogues for supporting or disproving an explanation, model or estimation result (Clark & Sampson, 2007).

Argumentations can make curious and interested individuals among, encourage them to establish the explanations that ensure deeper understanding and convince them of examining and solving their mistakes (Nussbaum & Bendixen, 2003). In argumentation, students clearly state the reasons which support their views by using their preliminary knowledge and they exert effort to justify their opinions. Others explain counter-opinions and doubts and present their alternative views. By this way, knowledge is re-built by the group, as the group interaction allows for the formation of a full understanding which is more than the mere sum of individual contributions (Driver et al., 1994). If the students agree on the benefits of argumentation, quality discussions emerge and they improve themselves as well as their peers; in addition, student interaction in personal and social fields makes sure that their common knowledge, value and beliefs develop as well. Argumentation environments can make sure that togetherness, conceptual and epistemic understanding of students can develop by this way (Duschl & Osborne, 2002). In addition, understanding the relation between the claim and the evidence in an argumentation can ensure the development of critical thinking of students. Cooperative discourse and argumentation develops the retention of knowledge and the level of conceptual comprehending by means of establishing relations between old and new knowledge (Nussbaum, 2008). Raising an alternative or conflicting argument to another argument during an argumentation results in detailed thinking and overconscious reflections cause conceptual exchange (Dole & Sinatra, 1998; Eryılmaz, 2002; Niaz et al., 2002; Nussbaum & Sinatra, 2003). In addition, research skills of students are also improved by means of argumentation (Richmond & Shriley, 1996; Druker, Chen & Kelly, 1996; Yerrick, 2000; Driver et al., 2000).

The model suggested by Toulmin, who cites the relations between elements of argumentation and their interrelations, is used for the analysis of argumentation in many areas, including science lessons (Newton, 1999; Driver et al., 2000; Erduran, Simon & Osborne, 2004). Toulmin lists the elements of argumentation as data, justification, assertion and support; however, he also defined qualitative and disproving expressions for more complex argumentations (van Eemeren, Grootendorst & Snoeck Henkemans, 1996; Driver et al., 2000; Jimenez-Aleixandre, Rodríguez & Duschl, 2000; Schweizer, 2002; Erduran et al, 2004; Paglieri, 2006; Simon, Erduran & Osborne, 2006). Below is a graphical expression of the elements of Toulmin's argumentation model in Figure 1.

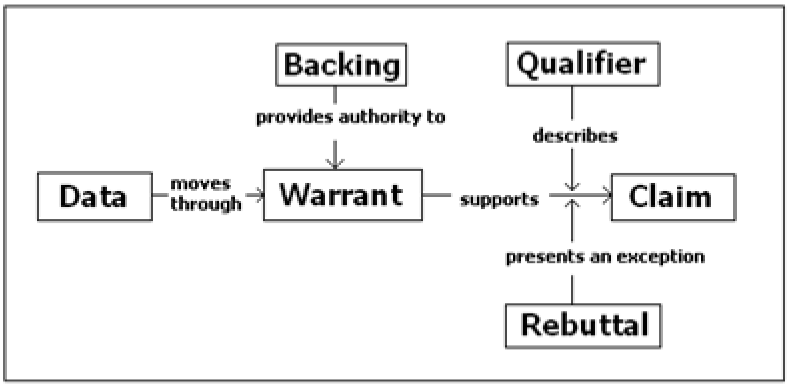

Figure 1. Toulmin argumentation pattern

Toulmin argumentation pattern's elements are data, claim, warrant, backing, qualifier and rebuttal. a) Data; phenomena which are referred to and situations used as evidence in order to support the assertion. b) Claim; is the results of established values, opinion on the value of existing situation, and assertion of viewpoint. c) Warrant, the rules and principles which explain the connection between data and assertion or results. They are the statements which are used in order to support the relation between data and assertion. d) Backing; basic assumptions which verify certain justifications, non-definite explanations in the foundation of the assumption. e) Qualifier; certain situations where assertions are taken as accurate; they provide limitations to the assertion. f) Rebuttal, specific cases where the assertion is not verified. These are the cases which contradict to the data, justification, supportive or qualitative ideas. (van Eemeren et al, 1996; Driver et al, 2000; Simon et al, 2006; Yan & Erduran, 2008) Let us explain the elements of Toulmin argumentation model with an example: there is sugar in biscuits (claim), a feeling of sweetness is created on my tongue when eating biscuits (data), nutrients which include glucose and its derivatives are sweet (warrant), food like marmalade, honey, chocolate and cake are sweet and sugar-inclusive (backing), mostly (qualitify) food prepared for dieting or diabetic patients include sweeteners instead of sugar (rebuttal).

In Toulmin's model, warrants verify the path from data to result, whereas supportive are assumptions which display the accuracy of the warrants (Jimenez- Aleixandre & Pereiro-Munoz, 2002). In an argumentation, some of these elements can change depending on the area of the argumentation (medicine, law, natural science), whereas some others are area-independent. Backing, warrant and data may or may not be dependent to the area. However, claim, rebuttal and qualifiers are area-independent elements of the argumentation (van Eemeren et al, 1996).

Toulmin reported some limitations on the application and evaluation of argumentation model. The facts that suggested model takes the area of law into consideration (Mitchell, 1997; Mitchell & Riddle, 2000; Riddle, 2000), it is not always possible to determine the elements of argumentation, and data warrants and backing statements are ambiguous (Driver et al, 2000; Simon, 2008), arguments may have different meanings with different contents (Kelly & Crawford, 1997), it is not possible to examine the emotional and visual dimension of arguments, verbal messages between debaters are not taken into consideration, cultural and social-political dimensions of arguments are neglected (Paglieri, 2006), structure of the argument receives more focus than its content restricts the evaluating of the quality of the evidence (Paglieri, 2006; Simon, 2008). In addition, it is not always obligatory to regard this order as it is, either. Another point is that implementation of argumentation in a scientific context is more difficult than implementation in a socio-scientific context in Toulmin's argumentation model (Osborne, Erduran & Simon, 2004).

A good scientific argument consists of both knowledge for the area and argumentative knowledge. Knowledge in the area and personal experience are two important components for examining arguments in detail (Means & Voss, 1996). Transfer of knowledge is in the foreground in natural science classes. All conversations are in the form of teacher starting the conversation and student answering, followed by teacher evaluating. Students usually give answers formulized in a few words and short expressions. These kinds of dialogues restrict the relations which constitute and support the social life. The fact that teacher retains students from asking questions and keeps them under control hinders their comprehension (Yerrick, 2000). Teachers are not familiar with classroom argumentation applications and therefore they have difficulty in its application. Teaching of argumentation is a problem in terms of pedagogical beliefs and teachers' knowledge of content. Teacher does not direct the class to encouraging and facilitating argumentation but he\she acts as an authority who gives the right answer. In classes where teacher-based education is applied, some reasons restrict the formation of argument and connection-establishment between claim, evidence and warrant. Other problems, mentioned in literature are as the following: time-consuming nature of argumentation, heavy load and short period provided for teaching programs, willingness of students' parents for controlling what their children learn at school, their not questioning the reasons why their children's notebooks are empty, unwillingness of teachers for accepting their scientific knowledge deficiencies and different viewpoints and deficiencies in argumentation skills (Newton, 1999; Clark et al., 2003).

Studies in argumentation are mostly qualitative in nature. Most of researches concerning argumentation are related with socio-scientific issues, improving students' argumentation skills and quality of written argument (Kortland, 1996; Patroni, Potari & Spiliotopoulou, 1999; Driver et al, 2000; Zohar & Nemet, 2002; Sadler & Zeidler, 2005; Venville & Dawson, 2010; Sampson & Clark, 2011). Literature suffers from the shortage of studies which examine the impact of this method on student success and retention of knowledge. In this research we were interested in the contribution of argumentation to students' conceptual understanding of science. In this research, argumentation approach has been applied to science classes in experimental terms and its impact on the success of 8^{th} grade students as well as the retention of such success has been observed. Below are the problems for which this study sought answers:

- Is there any significant difference between the academic success levels of students who receive argumentation-based teaching and traditional methods of teaching?
- Is there any significant difference between the academic successes levels of students who meet argumentation model for the first time and who are familiar with the model?
- Has argumentation model any impact on the retention of knowledge?

Methodology

Research Model

Compulsory education in Turkey is 8 years and students receive natural science courses between 4^{th} and 8^{th} grades. Main topics which form the content of this study are given at 7^{th} and 8^{th} grades. In this study, where we employed experimental pattern, two groups were chosen in the application school from 7^{th} and 8^{th} grades, one of which was experimental group and the other was control group. This study was non-equal control group "quasi-experimental model". In quasi-experimental pattern studies, both groups are applied preliminary and post tests, but here the method is applied only on the experimental group (Creswell, 2003). In experimental groups, lessons are delivered with argumentation based method, whereas control group receives lessons with traditional (teacher-centered) method which is accepted as the method employed in the school previously.

Working group of the research

This study was conducted in a government-run elementary school in Amasya, Turkey. The experimental and control groups were in the same school. This research was a longitudinal study. In the first year of this two-year study, argumentation-based science teaching was conducted at 7th and 8th grades. During the second year, study continued with 8th grade students who became familiar with the method and studied with 7th grade in previous year. Both first and second year studied classes were 8th grade. By this way both the impact of method on success of students and the way by which familiarity with the method affects success of students were examined. In addition, success test was reapplied two months after the teaching delivered in the second year and retention of knowledge was studied. The distribution of research group was seen in Table 1.

Table 1. Distribution of research group

Application	Experimental Group		Control Group	
	n	%	n	%
1. year	27	53	24	47
2. year	20	52.6	18	47.4

When Table 1 was analyzed it was seen that number of students both in experimental and control group were decreased in second application. As students who didn't answer both pre and post test weren't evaluated and also some students left the school because of personal reasons.

Data collection tools

Two different tests were developed for data collection in the study. A subject-related success test was developed in order to determine the success of students and a preliminary knowledge test was developed to check whether the classes were equivalent and to determine their preliminary knowledge. Science and technology course books of 7th and 8th grades and questions prepared by government to high-school entrance exams and concept fallacies in the literature were employed when preparing test questions for the students. In these tests, beside conceptual and mathematical questions, graphical-picture questions were also used which handle the three-dimensional structure of chemistry. Questions were examined by science teachers and two chemistry-teaching academic staff and required adjustments were made and final shape was given.

Preliminary knowledge test (PT) consisted of 21 multiple-choice questions and an open-ended question with 4 clauses. Lowest score that could be received from this test was 1 and the highest was 25. Reliability of the test was found as cronbach α=0.79.

As the success test (ST), one right-wrong question with 35 clauses, 8 multiple-choice questions and 6 fill-in-the-gaps questions were prepared. Lowest score that could be received from this test was 1 and the highest was 68. Reliability of the test was found as cronbach α=0.90. Before the application, preliminary knowledge and success tests were employed and success test was reapplied as the posttest. In the first year of the research, two months before the applications ended, two students over the class average, two students close to the class average and three students below the class average were chosen according to posttest scores and a semi structured interview was conducted. In the second year of the research, two months after the posttest application, success test was reapplied and retention was checked.

Application

Acids, bases and salts were studied in the research. The success test was applied as pre and post test (same test). Preliminary knowledge test and success test were applied to experimental and control groups in the week when lessons began in the academic year. Timing of applications is given in Table 2 briefly.

Table 2. Research applications timeline schedule

Timing	**Experimental Group**	**Control Group**
1st and 2nd lessons	Preliminary test and Pre- test (success test) applications	Preliminary test and Pre- test (success test) applications
3rd lesson	Determination of study groups and explanation of Toulmin argumentation pattern	Traditional method Teacher- centered teaching (Teacher delivered lecture, made demonstration experiments and students were taken notes precisely in their notebooks.)
4th lesson – 21st lesson (2nd week- 7th week)	Argumentation Activities Predict-observe-explain Expressions table Discussion with competitive theories Class drama Discussion with models Discussion with cartoons Discussion with evidence cards	
22nd lesson (8th week)	Post-test (success test) application	Post-test (success test) application
8 week later after post-test application	First year: Interviews Second year: Persistence test (success test)	Firs year: Interviews Second year: Persistence test (success test)

In experimental groups, Toulmin argumentation model was presented and an activity was made with students for teaching argumentation elements in the third lesson. At the beginning of the research, heterogeneous groups consisting of three students were formed on according to the previous year's science grades of students in the experiment group. One speaker was determined in each group which would change in each subject. Misconceptions related to acids and bases in the literature were examined so as to prepare materials suitable for argumentation method. The classroom drama, expressions table, predict-observe-explain, discussion with stories and discussion with caricatures activities were made in experimental groups. The process with which such concepts were developed throughout chemistry history was examined and these were employed in classroom-drama activities. The developmental process of these concepts was examined throughout chemistry history and the students were in drama activities during the process. Students were assigned the tasks of narrating the works conducted by Boyle, Lemery, Lavosier, Liebig and Arrhenius on acids and bases in historical order. Questions were asked after the explanation of each scientist's theory on acids and bases and the student were required to support or reject opinions on these explanations using the elements of Toulmin argumentation method. The other activity was expression table, a table for expressions including the misconceptions on acids and bases was distributed and students were asked to read all the responses carefully, select one of their preferences and explain the reasons for their opinions. Later, groups compared their answers within themselves and determined a single answer, which was explained by the speaker in class discussion. Group speakers defended their assertions based on data and using warrants, backings and rebuttal; different opinions in the class were also raised and argumentation continued. In competitive theories of which argumentation started with caricatures, students were asked to pick a theory given in the activity page and one of the explanations, which was followed by group and class discussion. In teaching some not-so-easy-to-comprehend topics like ionization of acids and bases and strong/weak acid-base concept, computer animations were employed and predict-observe-explain activity was conducted. In this activity, students were distributed working papers related to an electrolysis mechanism designed as a demonstration experiment. Students were asked to write down their estimations related to the brightness of the lamp when sodium hydroxide, acetic acid, hydrochloric acid and ammonia solutions with dilution equal to the experiment container in testing mechanism were placed separately; then, they were asked to explain the consistency of their observations with their estimations and to provide explanation for their opinion. Students were made sure to pay attention to the usage of Toulmin argumentation elements in their explanations and argumentations.

In control groups, courses were delivered with traditional method which was previously used in the classroom. Teacher-centered education was performed in control group. Teacher (researcher) delivered the lecture, provided examples, conducted demonstration experiment and made sure that short notes were taken in the notebooks. In the week following the end of the course, success test was conducted as a posttest on both experimental and control groups. Eight weeks later, interviews were held with students chosen among first-year application classes. The posttest average of both two classes was calculated and two students having over average, average and below average among the other students were chosen. Semi-structured interview was performed after 8 weeks from the end of application. In the application of second year, success test was reapplied so as to measure the retention of knowledge.

Analysis of Data

Research findings were analyzed with SPSS. Independent samples t-test was applied for a comparison of pretest scores. For evaluating first and second research questions, covariance analysis was applied to posttest score. Third research question was evaluated by repetitive measures analysis to retention tests. For data group, the assumptions required for t-test and covariance analysis were controlled. Preliminary checks were conducted to ensure that there was no violation of the assumptions of normality, linearity, homogeneity of variances, homogeneity of regression slopes and reliable measurement of the covariate. Results were evaluated at p=0.05 statistical level.

Findings

Effect of argumentation on student success

At the beginning of the research, preliminary knowledge and success test were applied to all groups. Tests for the first year were shown as PT_1 and ST_1, whereas tests for the second year were shown as PT_2 and ST_2. PT scores were compared in 1st and 2nd applications so as to determine the pre-application equivalence of experimental and control groups, results of which can be seen in Table 3.

In Table 3, it is seen that there was a significant difference between preliminary knowledge levels of experimental and control groups [$t_{(40.206)}=2.290$ $p<0.05$], whereas no such significant difference was detected for the second application [$t_{(36)}= -0.270$; $p>0.05$]. According to constructivist approach, previous experiences and knowledge accumulation of an individual affect their learning process. For this reason, the effectiveness of the method to be applied in non-equivalent groups is a controversial issue. PT scores were taken as covariant so as to keep under control the differences between students.

Table 3. t-test results for independent samples of PT scores

Test	Group	n	Mean	sd	t	df	p
PT_1	Experimental	27	9.66	4.13	2.290	40.206	0.027
	Control	24	7.58	2.16			
PT_2	Experimental	20	7.50	3.08	-0.270	36	0.789
	Control	18	7.58	4.47			

In applications belonging to both years, it was found out that there was no significant difference between success test and preliminary test scores of experimental and control groups. Average scores for the application in the first year were 20.15 for the experimental group and 20.20 for the control group (t_{49}= -0.032; p>0.05), whereas the averages for the second year were found as 18.05 for the experimental group and 15.11 for the control group (t_{36}= 1.09; p>0.05).

In the posttests conducted after research applications were completed, a significant difference was found between pretest results of experimental and control groups (p<0.05). In the first year applications, it was found out that pre and post test ST_1 results raised from 20.15 to 36.70 in experimental group (t_{26}=-8.403; p=0.000) and from 20.21 to 29.58 in control group (t_{23}=-5.606; p=0.000). As regards the ST_2 results of second year, scores raised from 18.05 to 39.40 in experimental group (t_{19}=-7.57; p=0.000) and from 15.11 to 30.28 in control group (t_{17}= -4.24; p=0.000).

Descriptive statistical results of the covariance analysis conducted for a comparison of posttest scores within the same year between research groups is provided in Table 4.a.

Table 4.a. Descriptive statistical results of ST scores

Application	Group	n	Unadjusted Mean	sd	Adjusted Mean
ST_1	Experimental	27	36.70	7.92	35.97
	Control	24	29.58	6.44	30.41
ST_2	Experimental	20	39.40	10.78	39.67
	Control	18	30.28	9.54	29.97

The unadjusted mean is the score of the calculated mean from research data, adjusted mean is calculated according to covariates (PT_1 and PT_2 for Table 4.a). In Table 4.a, it can be seen that ST_1 and ST_2 scores calculated by taking into account the preliminary knowledge test scores are higher in experimental groups (35.97 and 39.67) than that is of control groups (30.41 and 29.97).

In Table 4.b, it can be seen that student success shows a significant difference between the experimental group to which argumentation-based teaching method was applied and control group to which traditional teaching method was applied (F_{1-48}=7.537; p<0.05; and F_{1-35}=14.013; p<0.05).

Table 4.b. ANCOVA results for ST scores

Application	Source of variance	Sum of Squares	df	Mean Square	F	p	η^2
1. year	Covariates						
	PT_1	307.84	1	307.84	6.488	0.014	0.119
	Group	357.65	1	357.65	7.537	0.008	0.136
	Error	2277.61	48	47.45			
	Total	3229.647	50				
2. year	Covariates						
	PT_2	1538.864	1	1538.864	24.266	0.000	0.409
	Group	888.634	1	888.634	14.013	0.001	0.286
	Error	2219.548	35	63.416			
	Total	4546.763	37				

Eta squared (η^2) is an effect size statistic and represents the proportion of variance of the dependent variable that is explained by the independent variable. When the eta squared is higher than 0.14, it is interpreted as a large effect (Cohen, 1988). The argumentation based method explains some 14% of the variance of the success of the groups for first-year application (η^2=0.136) and 29% of the variance for the second year (η^2=0.286). Argumentation based teaching method has large effect on students' achievement.

Effect of familiarity to argumentation method on student success

Comparison of posttest scores for all groups of both years is provided in Table 5.a and Table 5.b.

Table 5.a. Descriptive statistical results of ST scores of all groups in the research

Group	n	Unadjusted Mean	sd	Adjusted Mean
Experimental 1	27	36.70	7.92	34.97
Control 1	24	29.58	6.44	30.39
Experimental 2	20	39.40	10.78	40.31
Control 2	18	30.28	9.54	30.78

Table 5.b. ANCOVA results of ST scores of all groups in the research

Source of variance	Sum of Squares	df	Mean Square	F	p	η^2	Source of difference
Covariates							
PT	1593.973	1	1593.973	28.189	0.000	0.251	E_2-C_2
Group	1319.583	3	439.861	7.779	0.000	0.217	E_2-C_1
Error	4749.901	84	56.546				
Total	7841,282	88					

Significant difference has been found out when ST results of all groups are compared ($F_{3\text{-}84}$= 7.779; p=0.000; η^2=0.217). The method explains 21.7% of the variance between the groups. Preliminary test taken as covariant explains 25% of the variance between the groups' success. Argumentation based teaching method and preliminary test scores explain together

47% of the total variation. It was found out that the difference stems from the experimental group of second application ($\overline{X}_{E2}$=40.31) and control group of the same year ($\overline{X}_{C2}$=30.78; E_2-C_2) as well as the control group of the first year ($\overline{X}_{C1}$=30.39; E_2-C_1). Adjusted mean for the first application in experimental groups was found as 34.97 and for the second application as 40.31. Although the success improved significantly in the second application, the difference between the experimental groups has been found as statistically insignificant (in p=0.05 significance level). The study was conducted at the beginning of both academic years and students conducted no method-related study other than the first chapter of natural science course. Nevertheless, the difference between the averages of the experimental groups shows that the success of the group in which second application was conducted improved remarkably.

Effect of argumentation method on the retention of knowledge

In the first year when the research was conducted, eight weeks after posttest scores were determined, seven students were chosen from each group according to the classroom averages and interviews were held. Three questions were asked to the students: "what do you think about acidity-basicity? What is pH? Which one is the most acidic and basic among pH=3, 5, 7, 9 and 13 solutions? How do detergent, vinegar and salt affect turnsole paper?" Students' answers to these questions are presented below. (E_g: experimental group girls, E_b: experimental group boys, C_g: control group girls, C_b: control group boys)

> ***E_{g1}***: *Materials which can release H^+ are acidic and materials which can release OH^- are basic. Among those which can release to aqueous solution, pH 0-7 are acidic, pH 7 is neutral, and pH 7-14 are basic. Strong acids' pH is 6 and strong basics' pH is 14. Weak bases' pH is 8 and weak acids' pH is 1. Soap is basic, salt is neutral, vinegar is acidic, detergent is basic. Salt consists of a mixture of acidic and basic, thus, it is neutral. Basic soap turned turnsole paper from red to blue, and acids turned it from blue to red.* Which is the most acidic among 3, 5, 7, 9 and 13? *pH 5 is the most acidic, 13 is the most basic.* What kind of interaction occurs between acid and base? *A reaction occurs between them and composes salt and water.*

> ***E_{b2}***: *Base is the one which is rich in terms of OH^- ions; the one which is rich in terms of H^+ ions is called acidic. The ones which are rich in …aqueous solutions measured pH acidicity.* Which is the most acidic among 1, 3, 6, 9, 13 and 14? *The most acidic are 1, the most basic are 14, and salt is composed of a combination of acid and base…vinegar can show acidic and soap can show basic features. Lemon is acidic.* How do you know that it is acidic? *Acid turns turnsole to red, and bases turn it into blue. Salt is a combination of acid and base.*

> ***E_{g3}***: *…acid turns turnsole paper to red and base turns it to blue, the one which releases H^+ ion to aqueous solution is acidic and the one which releases OH^- is basic. The materials which receive a value between 0 and 7 at the left of pH scale, which conduct electric current in aqueous solution, and which create H_2 gas in reaction with Al are called acidic. pH is the expression of acidity. When acid and base gives reaction, salt is formed.* Can you write down this reaction? *$NaOH + HCl \rightarrow NaCl + H_2O$. The strongest acidic is 3, the strongest basic is 13. Detergent is base to blue, vinegar is acidic to red, salt is neutral therefore it does not have any impact.*

First student of the argumentation-based teaching group understood the acidicity-basicity and pH concept, but he/she has a misconception as regards the strength of acid-base. No problem was detected in the other student as regards the issue of strength and concepts. Third student recalled the concepts of acidic, basic, pH as well as the features and reactions of acids. Two of the other four students who were interviewed had no difficulty in recalling their knowledge as regards the subject, with the exception of strength.

> ***C_{b1}:*** *... acidic caustic material, basic are the solids that water cannot change. pH I can not recall. Most acidic is 13 as it is the highest…most basic is 3 as it is the lowest…Do acids react with bases? They do. HCl + NaOH → reacts (could not write down the name of the reaction). Detergent turn's turnsole paper to blue and salt turns it into red. Vinegar also includes acid; it also turns it into red. Salt is caustic, therefore it turns it into blue.*

> ***C_{g2}:*** *acidic is what releases H^+ ion to the material…cola includes acids. I don't remember bases. ...acids turn turnsole into blue and bases turn it into red. Detergent includes bases, it makes red, and vinegar includes acids, thus, it makes blue. Salt includes acid.* (Researcher asked acid and base reaction) *Acids and bases do not react.* HCl + NaOH → *must be acid. Most acidic solution is pH 3 and most basic solution is 13. 3, 5 are acidic and 7, 9, 13 are basic.* Based on what? *(No answer)*

> ***C_{b3}:*** *acid is caustic, it conducts electrical current. It turns turnsole into red. Bases turn it into blue. Detergent includes bases, it makes blue; vinegar makes blue, it has bases. Lemon is also acidic as it has a sour taste.* Vinegar is also sour, why did you call it base? *Then it is also acidic. Common salt is acidic.* Are there any determinants of acidicity other than turnsole paper? *Phenolphthalein.* What is pH? Which one is the most acidic among 3, 5, 7, 9, 13? *No answer, teacher.*

> ***C_{g4}:*** *Acids are sour, they turn turnsole paper into red, and their aqueous solutions conduct electricity. Bases turn it into blue, they have a sour taste and they turn phenolphthalein into pink. Bases release hydroxide ion OH^- and acids release H^+.* What is pH? *Reaction of acids and bases…they create salt. There is acid in detergent, it turns into red vinegar also has acid, and it also turns into red, salt has bases therefore it turns into blue.*

Students chosen in the group, where traditional teaching method was applied hardly or wrongly recalled the features of acids and bases, and none of them answered the question completely. Using phenolphthalein in order to determine pH is an answer given only in control group. One of the other three interviewee students told that he/she could not recall anything; another told that solution formed as a result of the reaction of acids and bases and the third one recalled the features of acids and bases inversely.

The question "what does strong and weak acid-base mean? Which one is weak base; pH 11 or pH 9?" was answered by students as follows:

> ***E_{g1}****: Strong acids' pH is 1 and strong bases' pH is 14. Weak acids' pH is 6 and weak bases' pH is 8. In the pH scale line of 3, 5, 9, 13, strong base is the most remote from 7. The one most remote to neutral is strong acid. pH1 is strong acid…acidicity is releasing H^+ in acidic aqueous solution. As pH 1 can release easily, H^+ is strong; as pH 5 cannot release easily in the environment, it is weak acid; 5 is close to neutral for which reason it is weak. pH 8 is weak base and pH 11 is strong base.*

> ***E_{g3}****: Strength or weakness depends on the amount of H^+ and OH^- released during reaction. If it can release entire ion it is strong, if not it is weak. ... the more distant to pH seven, the less neutral it is. Therefore pH 3 is the strongest. The more neutral it is, the stronger it is*

> E_{b4} *...strong acid conducts electrical current well, and it conducts H^+ ion. The higher the amount of H+, the more it can conduct electricity; hence, it is stronger. Is pH 11 acid or base? It is strong base.*

C_{b1}: ... strength or weakness is related to the atomic number…I forgot my teacher. pH 9 is strong…no, weak acid…pH 7 is base.

C_{g2}: strong is which conducts electrical current in aqueous solution faster, weak is the opposite. How does it conduct? In strong, there are more ions. In strong acid there are more H+ ions, and in strong base there are more hydroxide ions. Which one is the strongest acidic; 3, 5, 7, 9, 10 or 13? *Acid 7, the strongest base is 13, I think as there is more hydroxide in bases.* pH 9- pH 11 which is the weak base? pH *9, as it has less hydroxide.*

C_{b4}: strong acid gives damage with its causticity, weak acid is found in the things we eat. For example the acid in bleacher is caustic, the acid in lemon is normal. 1,3,5,7,9,10; which one is the strongest acid? *pH 9 is the strongest acid, pH 1 is the weakest acid, 7 is medium acid.*

Other students of the experimental group evaluated the strength of acidity and basicity according to its distance from pH 7, and the level of conducting electrical current and release of H^+ ion. Two students in control group answered "I do not know" whereas they gave answers like the one: which is more caustic or more effective is stronger.

In the research conducted during the second year, two months after the applications for determining retention of knowledge were completed, success test was repeated and regarded as retention. ANCOVA results for comparing the retention tests in experimental and control groups are provided in Table 6.

Table 6.a. Descriptive statistical results for pertinence test

Group	n	Unadjusted Mean	sd	Adjusted Mean
Experimental	20	35.50	10.72	35.74
Control	18	25.88	10.07	25.62

Table 6.b. ANCOVA results for pertinence test

Source of variance	Sum of Squares	df	Mean Square	F	p	η^2
Covariants						
PT	1217.024	1	1217.024	33.684	0.000	0.311
Group	968.350	1	968.350	15.825	0.000	0.265
Error	2691.754	35	76.907	12.591	0.001	
Total	4783.895	37				

In Table 6.a, it can be seen that retention of knowledge is higher in the group in which argumentation-based teaching was applied. When preliminary knowledge test scores were taken as a covariance, it was found out that there was a significant difference between adjusted averages of groups, which were $\overline{X}_E$=35.74 and $\overline{X}_C$=25.62 (F_{1-35}= 12.591; p<0.000) η^2=0.265 shows high effect size. Argumentation based teaching method which was applied experimental group in this research has a large effect on students' knowledge retention and it explains 27% of variance of the group successes for retention test. And preliminary test taken as covariant explains 31% of the variance. The experimental application and covariant explain together 46% of the variance between the groups retention scores.

Intra-group pre-post and retention test scores were compared, too. In experimental group, success scores of students showed a significant difference in favor of posttest between pre and post tests ($\overline{X}$ =18.05), in favor of posttest between posttest and retention test ($\overline{X}$ =39.40) and in favor of retention test between retention test and pre test ($\overline{X}$ =35.50) (F_{2-38}= 47.971; p=0.000). In control group, on the other hand, significant difference was detected in favor of posttest between pre and post tests ($\overline{X}$ =18.05), in favor of posttest between posttest ($\overline{X}$ = 30.28) and pretest ($\overline{X}$ =15.11) and in favor of retention test between retention test and pretest ($\overline{X}$ =15.11) (F_{2-34}= 13.089; p=0.000).

Conclusion and Discussion

In the research, the impact of application of argumentation method in teaching the subject of acids and bases on success and retention in natural science classes has been examined; in addition, the impact of familiarity with the method on success has been analyzed.

As a result of a post-learning evaluation of the data obtained, it has been observed that success increased in argumentation-based groups when compared with traditional-teaching-based groups and this result was the first research questions' answer. In first-year applications, pretest mean for the experimental group was 20.15; this score increased to 36.70 for posttest mean. Second-year means were 18.05 at the pretest whereas the score for posttest changed to 39.40. In the control group, pretest for the first year became 20.20 and posttest became 29.58; for the second year, they turned out to be 15.11 and 30.28, respectively. The change in the level of success of the groups is given in figure 2. From this figure, it can be seen that averages in the experimental groups of both years is higher. Although there is no statistically significant difference between them, the average of second-year experimental group was found to be higher. This result was second research questions' answer. It is believed that the reason for the lack of the significant difference is the fact that students did not respond to the applied test in a careful and interested manner.

In terms of retention of knowledge, it has been found out that argumentation method is more effective, it was the third research questions' answer.

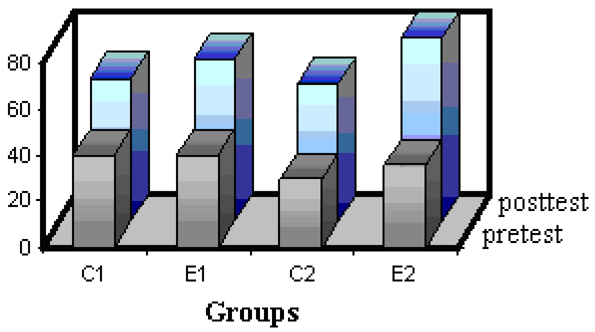

Figure 2. Success test average scores of research groups

After the first year applications, the interviews performed with students support the results of posttest and retention test. The group of students who were taught via argumentation gave truer answers in acid-base concepts, the properties of acid-base and strong-weak acid-base topics. This case can be interpreted as information permanence attained in lessons. High rate of effect size in ANCOVA results belonging to the post and retention tests (second year posttest η^2=0.286 and retention test η^2=0.265) indicates the effect of method (argumentation) on students' achievement clearly.

Most of the researches in literate have been dealt with conceptual and social dimension of argumentation, defining and improving of discussion level (Richmond & Shriley, 1996;

Druker et al, 1996; Sadler, 2004). Cross et al. (2008) studied to determine relationship between the quality of argumentation and scientific understanding and they found meaningful difference between pre-test and post-test scores in biology lesson. Zohar and Nemet (2002) reflected that before instruction only 16.2% of the students were successful related to biological knowledge in constructing arguments in genetics; after instruction 90% of the students were successful in related subject. Moreover, their study stated biological knowledge test score had meaningful difference between experimental and comparison groups in favor of experimental group which argumentation method applied.

The historical context was help to students' discussion. During the class theatre activity, the students are presented the historical development of the acid-base concepts and thus, a discussion environment is established for students. During the historical development of the acid-base concepts, realizing and establishing the interrelations of the data, assertion, justification, support and rebuttal makes it easy that the students attend the discussions and they understand the cognitive percept simply. It is observed that when the information that the scientist acquire while they are forming their models is presented to the students, the students form the similar models that is of the scientists.

It can be said that argumentation which is the independent variable of the study affects students' development of conceptual understanding and theirs' information permanence. The participation of students on discussion help students understands the structure and language of scientific debate during classroom argumentation. The active participation of students and their communication about understanding emerging scientific on debates also help them learn science. Because writing and speaking about science provided them to explain their concepts and to give decisions thus they performed conceptual understanding correspondent to scientific facts. As Duit and Treagust (1998) stated that students' learning and conceptual understanding were rich in social construction knowledge.

Findings have to be discussed and students have to conduct conversations parallel to the applications in a scientific society so that scientific phenomena can be accurately understood. The environment in natural science classes has to be diverted away from a knowledge-transfer process conducted under the leadership of teacher to the one, where the students can express their opinions freely and contrary views can be presented. Attention must be paid to the application of argumentation method in education and natural science classes. Argumentation can also be employed in teaching other subjects. Class activities have to be developed and argumentation norms have to be applied in science teaching so that young individuals can gain confidence in employing argumentation. Teachers and candidate teachers can be given information on preparation of argumentation activities and management of classroom argumentation, because the argumentation skills are valuable beyond science education.

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