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The Effect of Argumentation-supported Problem Based Learning on the Achievements of Science Teacher Candidates Regarding the Subjects of Gases and Acids-Bases

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Abstract

In this study, our aim was to investigate whether the missing element in the Problem Based Learning (PBL) method could be supplied by supporting the PBL method with argumentation during a class on the topic of acidity/alkalinity and gases. In the research, a non-equivalent (pre-test and post-test) control-group design was used. The research sample was composed of 140 science teacher candidates at a state university in Turkey. The study was carried out with two experimental groups and one control group. In one of the experimental groups, problem based learning (PBL) was applied (N=44), and, in the other experimental group, argumentation-supported problem based learning (AS-PBL) was applied (N=46). In the control group, a traditional teaching approach (TTA) was carried out (N=50). The study lasted for eight weeks. Data was collected through a) the acids/bases academic achievement test and b) the gases academic achievement test and were analyzed by t-test and ANOVA (analysis of variance). The results revealed that the academic achievement of the students in the experiment group where teaching method AS-PBL was applied regarding acids/bases and gases were higher than the academic achievement of the students in the other experimental group at a significant level.

Argümantasyon Destekli Probleme Dayalı Öğretimin Fen Bilgisi Öğretmen Adaylarının Gazlar ve Asit-Bazlar Konularındaki Başarılarına Etkisi

Makale Bilgisi

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Öz

Bu çalışmada, asitlik/bazlık ve gazlar konularının öğretimi sırasında, Probleme Dayalı Öğretim (PDÖ) yöntemi argümantasyonla desteklenerek, PDÖ yönteminin eksik görülen tarafının argümantasyon yöntemiyle tamamlanıp tamamlanamayacağının incelenmesi amaçlanmıştır. Araştırmada ön test-son test eşitlenmemiş kontrol gruplu yarı deneysel desen kullanılmıştır. Araştırmanın örneklemini, Türkiye'de bir devlet üniversitesinde öğrenimini sürdüren 140 fen bilgisi öğretmen adayı oluşturmaktadır. Çalışma iki deney grubu ile yürütülmüş, bu grupların birinde probleme dayalı (N=44), diğerinde argümantasyon destekli probleme dayalı öğretim (N=46) uygulanmış, kontrol grubunda ise mevcut program (N=50) ile sekiz hafta süreyle yürütülmüştür. Veriler; a) Asitler-Bazlar Başarı Testi ve b) Gazlar Başarı Testi ile toplanmış, t-testi ve varyans analizi (ANOVA) ile analiz edilmiştir. Analiz sonuçlarına göre, argümantasyon destekli probleme dayalı öğretim yönteminin uygulandığı deney grubundaki öğrencilerin Asit/Bazlar ve Gazlar konularındaki akademik başarılarının diğer gruplardaki öğrencilerin akademik başarılarından anlamlı derecede yüksek olduğu bulunmuştur.

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Introduction

A common topic of discussion in communities is how people will develop and whether the education system will support this development. As we enter the age of information technology, an increase in the need for quality human power has accelerated these discussions. The failure of students to learn science issues, the understanding that individual behaviors are not automatic reactions given to environmental stimulators, and the increasing importance of individual differences have activated educators and directed them to search for new approaches (Greenwood, 1999). Particularly in the second half of the twentieth century, radical changes have been lived through regarding development and learning of information, and student-centered teaching approaches have gained importance (Duschl & Osborne, 2002).

Educational approaches, methods, and techniques being developed by educators are applied by teachers in various branches in their classes, and their advantages and disadvantages are determined, and findings are discussed among educators. One of the methods being most discussed among science teachers is problem-based learning. It is a method that was developed by medical educators who considered that more than one health problem can occur in one person at the same time (McDonald, 2002). Later on (after the 1970s), PBL applications were observed in areas other than health (Barrows & Myers, 1993; Boud & Feletti, 2013; Camp, 1996). After the 1980s, the PBL method was adopted by science educators and rapidly applied the teaching of all science topics (Chin & Chia, 2004; Dahlgren, Castensson & Dahlgren, 1998; Kelly & Finlayson, 2009; Marklin Reynolds & Hancock, 2010; Pepper, 2010; Peterson & Treagust, 1998). In these studies, where the effect of the PBL method on the subject learning by students was investigated generally students receiving education with the new method have been more successful than students receiving education with the traditional approach (e.g. Etherington, 2011).

Problem Based Learning (PBL)

In the classes where PBL was applied, as result of the course activities being correlated with their daily lives, students were able to transfer the skills and knowledge that they gained as into their daily lives, and they gained the skill to solve new problems that they confronted with. These elements have been considered a big advantage because, in PBL classes, students are faced with a problem for the first time, they try to understand the problem, and they question it and try to solve it (Schwartz, Webb & Mennin, 2001). They turn into independent individuals who learn for a lifetime, and they continue to learn all through their lives (Ali, Hukamdad, Akhter & Khan, 2010). It is a model that helps students to create the logical thinking and communication skills that are required today (Duch, Groh &Allen, 2001). Since it is a method in which learners form their own information in an active way, it is evaluated within context of a structured teaching approach (Ronis, 2007, p. 37). Success requires that teaching based on experiments be organized around resolution and the investigation of complex and actual life problems (Torp & Sage, 2002, p. 15).

With this method, it is expected that students will learn the fundamental concepts of a branch of science by means of solving problems, applying this information in their later professional applications, and developing their reasoning and problem-solving skills (Barrows & Tamblyn, 1980; Savery, 2006).

In the classes where PBL is applied, students have discussions among themselves to understand a problem that is given to them by their teacher generate solutions, and find alternative solutions, and try to create an accumulation of knowledge. Afterwards, they find an opportunity to compare their opinions with the ideas and perceptions of their friends in other groups and to examine everyone’s opinions (Hmelo-Silver, 2004; Hmelo-Silver and Barrows, 2008). During this time, they are encouraged by their teacher to change their opinions, if the evidence requires that. The effectiveness of PBL which has been investigated in the learning of almost every science topic, has been applied in many studies of the teaching of chemistry such as general chemistry concepts (Groh, 2001; Donnel, Connor & Seery, 2007; Ramstedt et al., 2016) and acid-based (Dobbs, 2008) and analytical chemistry (Larive, 2004; Yuzhi, 2003), and its effectiveness has been accepted.

Despite all these positive gains, there are important deficits of this method including students not having sufficient information regarding the subject in the classes where PBL is applied and them thinking only about the limited content of a subject (Banta, Black & Kline, 2000). During the PBL process, students focus only on the problems given to them which they try to solve. If other concepts related to the subject are not within the problem scenario and students are not expected to investigate them, the student can be deficient in this area. According to the results of a meta-analysis of 43 pieces of experimental studies being conducted in relation to PBL in higher education, the negative impact of PBL on students is related to the gaining of missing information (Dochy, Segers, Bossche & Gijbels, 2003). The disadvantage of PBL in terms of gaining missing information has also been revealed in other studies (Albanese & Mitchell, 1993; Vernon & Blake, 1993). For students to structure all the concepts of the subject, it is necessary for the PBL process to be organized in the proper way so as to make students feel this deficiency. Only in this case can the learner be aware of deficiencies in resolving the problem and learn by structuring the whole subject correctly in his or her mind. However, even though PBL may not be successful in increasing information, PBL is quite important in aiding people in experimenting with their teaching environments (Albanese, 2000).

Dochy, Segers, Bossche and Gijbels's (2003) remarkable finding is that students in PBL gained slightly less knowledge. Similarly, while students solve the specified problem as a group in the classes where PBL is applied, they remain uninformed regarding fundamental chemistry knowledge. It can be thought that this arises from activities such as students asserting their own ideas (making assertions) and comparing them with the opinions of their other friends and invalidating the assertions that they consider to be incorrect. A deficiency of PBL that has been criticized is the small group discussions are based on an argumentation approach. In PBL during the group discussions, students are required to create valid arguments to solve the problem in the correct way and to show the reasoning that led to their decisions. In this case, argumentation is clearly a necessary mechanism that serves as a guide for evidence-based communication among students during the problem-solving process (Jonassen, 2011; Walton, 2007).

In teaching methods, new applications have been tried in the classes with respect to radical changes, changing the emphasis from the behavioral approach to a cognitive and socially structured way of thinking, a student centered teaching process where the student is active. This requires some preliminary knowledge of the student regarding the new particulars he or she will learn including the construction of scientific information in order to correctly reflect this information. One of these pieces of knowledge is argumentation (Duschl & Osborne, 2002).

Widely used in argumentation is the Toulmin Model and according the model, components that form an argument are the data, claim, warrant, backing, qualifier, and rebuttal. (Driver et al., 2000; Jiménez-Aleixandre et al., 2000; Jiménez-Aleixandre & Pereiro-Muñoz, 2005; Osborne et al., 2004). Argumentation is a reasoning activity, the process of correlating assertions with data and thus achieving validity, strengthening assertions with reasoning and support, and invalidating the counter assertions if there are any (Erduran & Jiménez-Aleixandre, 2008). It has been shown that when argumentation applications were applied in the science class, qualities such as conceptual learning, achievement, attitude, critical thinking, self-confidence, self-expression, and communication were improved (Bağ & Çalık, 2017; Çelik & Kılıç, 2014; Gültepe & Kılıç, 2015; Hefter et al., 2014; Joung, 2003; Nussbaum and Edwards, 2011; Osborne, Erduran, Simon, and Monk, 2001; Osborne, Erduran & Simon, 2004; Sağır & Kılıç, 2012; Velez, 2008; West, 1994).

When we look at the history regarding the formation and development of cognitive concepts, we see that scientists revealed their scientific assertions by supporting them with experimental or cognitive evidences and that they make an effort for others to accept their assertions by convincing them. For example, Thomas Martin Lowry and Johannes Nicolaus Bronsted both revealed their theories related to acidity and basicity as "proton theory in relation to acid-base interactions" without knowing about the other. Although Gilbert Newton Lewis asserted his "electronic theory related to acid-base reactions" in the same year as the theory by Bronsted-Lowry was adopted, Lewis' theory was not accepted, and Lewis had to wait for nearly 15 more years to convince fellow scientists and to invalidate counter assertions (Atkins & Jones, 2009). As the students form their scientific conclusions in the science classes where argumentation approach is applied similar to the way scientists form their own scientific conclusions, they can achieve better and more meaningful learning (Driver et al., 1994; Driver et al., 2000; Osborne et al., 2004) In order for students to learn scientific information in a meaningful way, they need to understand the structure of that information and how it was formed. "Knowing" is not only being able to define what a phenomenon is but also includes understanding its importance and its correlation to the other events. In this respect, argument has a significant impact on education by incorporating these steps (Driver, 2000; Ford, 2008).

Although there are many studies in education literature about the applicability of an approach, method, or technique in a particular area being taught, the impact of these studies on the factors influencing the achievement of students (such as attitude and motivation) and bringing about a change in their accomplishment, hybrid methods such as Argumentation Supported (AS) -PBL (where more than one method are used together) are quite new and limited in number. Until now, instead of being used together, argumentation and problem based learning were made the subject of studies that compared which of them is more effective (Tüysüz et al., 2013) or investigating whether argumentation skills improved when PBL was applied. In order to give meaning to mathematical ideas, Cassel (2002) examined argumentation in a PBL environment. The research reveal that argumentation made a contribution during the process during which students attached meaning to mathematics. Cassel stated that an argumentation environment being correlated with PBL acted as a catalyzer in correlating and developing the mathematical thinking of students and in giving meaning to them. In the study where the impact of the problem-based learning method supported via computer on the argumentation skills of students were examined, the research outcomes showed that this method had a meaningful impact on the argumentation skills of students having a medium level of achievement (Belland, 2010). Belland, Glazewski, and Richardson (2011) asserted that the ability of junior high school students to produce arguments based on evidence after solving the problems in a PBL environment was insufficient, and, in order to assist in the structuring of argument based one evidence in a unit on the Human Genome Project, they examined the impact of the usage of argumentation with computer support with PBL. The findings showed that the argument assessment skills of student with low achievement level developed and that students in small groups used argumentation structures to communicate and organize. According to the findings of another study investigating the effect of argument usage of university students in philosophy education during the PBL process on the problem solving skills and motivations of students, while the conclusion was reached that the problem solving skills of group being executed by argumentation developed more fully, no difference was observed in their motivations (McGhee, 2015). Ju and Choi (2018) formed a new conceptual framework by integrating Toulmin’s argumentation model (1958) into Barrow’s (1994) HDR (Hypothetico-Deductive Reasoning) process regarding the problem based learning process in medical education. When this framework was applied, students developed their question asking skills. But for its effects to be seen in the long term, they asserted that this conceptual frame needed to be continued to be applied.

Purpose of the Research

During the problem-based learning process, argumentation should be effectively used while students support their assertions with evidence and reasoning while specifying the problem, during the process of questioning the problem, and especially during the problem solving stage which involves examining and discussing their own opinions and the opinions of their friends. Starting with the position that argumentation support should be provided to eliminate disadvantage of PBL regarding missing learning and to effectively support discussion during the application process and thus to enable meaningful conceptual learning for students. In this study, the argumentation method was integrated into the PBL method, and the aim was to determine the effectiveness of this hybrid method. For this purpose, the accomplishments of teacher candidates in a problem-based learning environment with argument support, a problem-based learning environment, and a traditional learning environment were compared.

Regarding the argumentation, while students determine the problem by considering the given problem situation during the problem based learning process, argumentation enables them to support their assertions with evidence and reasoning, questioning the problem and especially their own examination process, and to discuss their own opinions and the opinions of their friends during problem solving stage; thus, the process become more effective. The utilization of argumentation was specified in the “discussion” processes in the PBL stages as being given in the form of problem scenario, problems to be discussed, revelation of current information, determination of the information needed, discussion of the information related to the problem, discussion of the problem, and solution proposals and discussion as detailed in the PBL process (Barret & Naughton, 2015, pp. 45-47; Wood, 2003, pp. 328-330).

Research Question

When problem-based learning environments with argumentation support are compared to problem-based teaching environments and traditional teaching environments, is there a difference in their influence on the successes of science teaching candidates regarding the subjects of acids/bases and gases?

Method

Research Design

At the faculty where the study was conducted, students taking the Scientific Laboratory Applications course were registered as Class A, Class B, and Class C and, as it was impossible for us to change the class, in this research, a non-equivalent (pre-test and post-test) control group design was used (Creswell, 2002, p.193).

Control Group A, Experimental Group B, and Experimental Group C were selected without random selection. All of the groups took a pre-test and post-test. Only the experimental groups received the treatment (Creswell, 2002, p. 193).

Participants

This study was conducted with science teacher candidates in their third year at a state university in Turkey. Distribution of numbers and gender types of students participating in the study is shown in Chart 1.

All of the teacher candidates specified in all three groups had taken chemistry courses such as general, analytical, and organic chemistry; and educational science courses such as private teaching methods. There were no differences between the groups with respect to the courses they had taken in previous years.

Chart 1. Distribution of numbers and gender types of students participating in the study

Groups	Female	Male	Total
Control Group, CG	35	15	50
Experimental Group I, RG_1	29	15	44
Experimental Group II, RG_2	26	20	46
Total	80	60	140

Instruments and Procedure

With the aim of investigating research problems, the Gases Academic Achievement Test (GAAT) and the Acid-base Academic Achievement Test (ABAAT) were available. Both success tests are multiple choice test with two stages that are prepared by researcher. In order to eliminate the obstacles related to multiple choice tests, such as students revealing their critical opinions, students selecting the correct answer by chance even though there are distractors composed of incorrect concepts, and students not being able to determine their self-opinions, diagnostic tests with two stages were developed (Treagust, 1988), and they began to be used widely in physical science areas (Garnett & Treagust, 1992; Mann & Treagust, 1998; Voska & Heikkinen, 2000).

In the research, GAAT and ABAAT tests of the research were prepared in two stages according to the three main stages and steps as suggested by Treagust (1988), and the related literature was examined and based on the misconceptions of the students as a result of the pilot study.

GAAT: GAAT is composed of 16 questions. While four of these questions require the students to make drawing specifying the gas concept image structured in their minds, other questions are constituted of tests with two stages enabling the measuring of academic knowledge levels related to the subject (the application of gas laws for a closed system and a mobile system). In the first stage, the student must answer the question in multiple choice form, and, in the second stage, the student must explain the reason for his or her answer in the student's own sentences.

In order to check the appearance, structure, and concept validity of the test, a table of questions was prepared, which questions whether the gains of gases are measured in the test. The test examined by 5 experts in science education; Feedback was obtained to ensure that the appearance, structure, and concept were valid. After being edited in accordance with the formal recommendations, it was accepted as high validity. Furthermore, during the pilot administration of the test, it was administrated to 160 students, and material analysis was conducted. After the evaluation of data, following the elimination of three questions the differentiation level of which was found to be below 0.29, the average differentiation level of the remaining questions was found to be 0.47. Average difficulty level of the test was 0.40.

ABAAT: The ABAAT is composed of 19 questions. While three of these questions are open ended to determine the graphic reading and drawing skills of students and to specify their level of ability in determining necessary procedures for preparing solutions, other questions are composed of tests with two stages, enabling the measurement of academic knowledge levels related to acidity/basicity concepts (acid-base definitions, weak/strong acidity and basicity, pH and pOH, titration, dilution). In the first stage of test, the student is asked to answer by means of multiple choice; in the second stage, the student is asked to explain the reason for the answer with his or her own sentences.

To control the validity of appearance, concept, and structure of the test, a table of specifications was prepared to examine whether learning gains on the subject of acidity-basicity were measured in the test or not, and after the test was designed, in was examined by five people being experienced in science education in accordance with the proposals, and its validity was accepted to be high. Furthermore, it was administered to 160 people during the pilot test application and a material analysis was completed to test its validity. As a result of the evaluation of the data following the elimination of a question which was below 0.29 in differentiation level, the average differentiation level of the remaining questions was found to be 0.46. The average difficulty level of test was 0.34.

The reliability of the GAAT and the ABAAT was examined by calculating KR21 and two Guttman semi-reliance coefficients. While KR21 value was 0.73 and the Guttman coefficient value was 0.80 for the GAAT, the KR21 value was calculated as 0.82, and the Guttman coefficient value was 0.87 for the ABAAT, and reliance was found to be at a high level. The obtained findings showed that reliability of the tests is was high. When all the findings were considered together, it could be stated that validity and reliance of the success tests that were prepared was high.

Sample question for the GAAT and ABAAT are given Table 1.

Table 1: Sample question for the GAAT and ABAAT

GAAT/ Q7: A candle was placed in a glass lantern and the lid was closed. Since the candle can burn for 10 minutes in the bell-jar in which there is a certain amount of O_2 and $N_{2,}$ which of the below options is correct regarding the total pressure and partial gas pressure present in the jar in the fifth minute?

***P** Total*	P_{O_2}	P_{N_2}	**Explain the reason for your answer:**
a) Reduces	Reduces	Doesn't change	
b) Reduces	Reduces	Increases	
c) Doesn't change	Reduces	Doesn't change	
d) Doesn't change	Reduces	Reduces	

GAAT/ Q8: In the below figure, you can see gases that are inside two steel tubes that are room temperature with two closed steel tube, and images symbolizing molecule are given (the boiling point of both of the gases is below -250º). If you could see the molecules until the steel tube is cooled down to – 150ºC or heated up to 150ºC, what kind of a distribution would you expect them to show? Please make your drawing at the below relevant places.

Explain the reason for your answer:

-150ºC

$H_{2(g)}$ $He_{(g)}$

150 ºC

$H_{2(g)}$ $He_{(g)}$

ABAAT/ Q9: When the solutions given below in an order are added separately to a 100 mL 0,01 M KOH solution, how the initial solution OH concentration is affected? In which of the following changes occurring in OH concentration of the solution at the start been correctly given?

I. 100 mL of pure water

II. 100 mL 0,01 M KOH

III. 100 mL 0,01 M HCl

	I	II	III	**Explain the reason for your answer:**
a)	Doesn't change	Increases	Reduces	
b)	Reduces	Increases	Reduces	
c)	Increases	Increases	Doesn’t change	
d)	Increases	Doesn't change	Increases	
e)	Reduces	Doesn't change	Reduces	

Procedure

The application process of the research is explained below as the pilot application and the main application.

Pilot Application

In order to determine beforehand the negative situations that can arise during the main application process, to make necessary adjustments, and to enable researcher to get accustomed to the application, a pilot application has been conducted before initiating the main application. The pilot applications was conducted one year before the main applications with science teacher candidates being educated at the same faculty and department and the experimental groups were formed. Since the researcher was used to the work of the control group and as he had been working in the same department for a long time, a separate pilot application was not needed for the control group. 85 teacher candidates in their third year of their education participated in the pilot application. The specification of groups was made as similar as possible to the one in the actual study. The application was conducted by a researcher over 16 course hours for a period of four weeks. At the beginning of the study, pretests were administered to both groups, and information was given related to methods to be used during the application process. Since the application was begun in the experimental group, the argument-supported problem-based learning method was followed up (N=42), and problem-based learning was followed up in the control group (N=43). By making use of the pilot study, changes were made related to the activities being used in sentences that could not be understood by the students in the scenarios, and they were prepared for the main application. At the end of the study, posttests were applied to both of the groups. Several study papers related to the course that were accepted as meeting the same gains and objectives were reduced to one. Validity and reliability analyses of the prepared scale and success tests were conducted. Not understood or misunderstood by students of the questions were eliminated or were rearranged. By considering certain failures experienced and observed during pilot study, necessary corrections were made, and the questions were passed on to the main application.

Research Application

Physical science teacher candidates getting their education at the Faculty of Education where this study was conducted, as participants in two experimental groups and one control group had taken general chemistry, general physics, and general biology courses and laboratory applications of these courses; analytical and organic chemistry courses; general education sciences courses related to teacher education with respect to the Laboratory Application II course (research techniques, teaching principles and methods, etc.) and the Laboratory Applications I course.

Since the science teacher candidates were divided into three groups when they registered at the education faculty and since they get their education as three groups in parallel, researchers did not use their initiative to determine the groups in this study (success, gender, sociocultural features, etc.). Number and gender distributions of the groups is given in Schedule 1. Assignment of groups was randomly made by researchers, and they were specified as stated below:

CG: Traditional Teaching Approach (TTA)

RG_1: Problem-based Learning (PBL)

RG_2: Argumentation Supporting Problem Based Learning (AS-PBL).

In all three groups, the courses were carried out by the researcher. Study was conducted with the subjects of gases and acids/bases within the scope of the course for four hours per week for a duration of eight weeks long. In the first week, information was given to students related to the purpose and scope of the course and the applications. Notification of the method to be applied in the course within the same period was made only to the experimental groups. Pretests were administered in the first week.

Instruction in the control group CG.

The context of the Laboratory Application II course and the application periods of subjects are specified in the ECTS package. Since the researcher had given this course in previous years, he was accustomed to the applications. In accordance with the context being specified in the ECTS package related to the subjects of gases and acids/bases, researcher had gathered information from various sources, determined sub-topics, made course plans, and prepared presentations.

After the researcher explained the subject to the students with the help of computer presentations, the teacher candidates at CG were divided into groups of five people, and they were asked to make presentations related to experiments that could be conducted in relation to the subject being explained, about how the subject could be evaluated in elementary school programs, and about the incorrect comprehension of elementary school students; and they were asked to share the information they had gathered with their friends in the class one week later. Following student presentations, the researcher transmitted his final information related to the subject to the teacher candidates and answered their questions. He then administered a posttest at the end of the unit. Flow chart of courses applied to the control group are shown in Figure 1.

Three students each were chosen based on their level of success within the group (low-medium-high), and semi-structured interviews were conducted with them about the processing of the course and student gains.

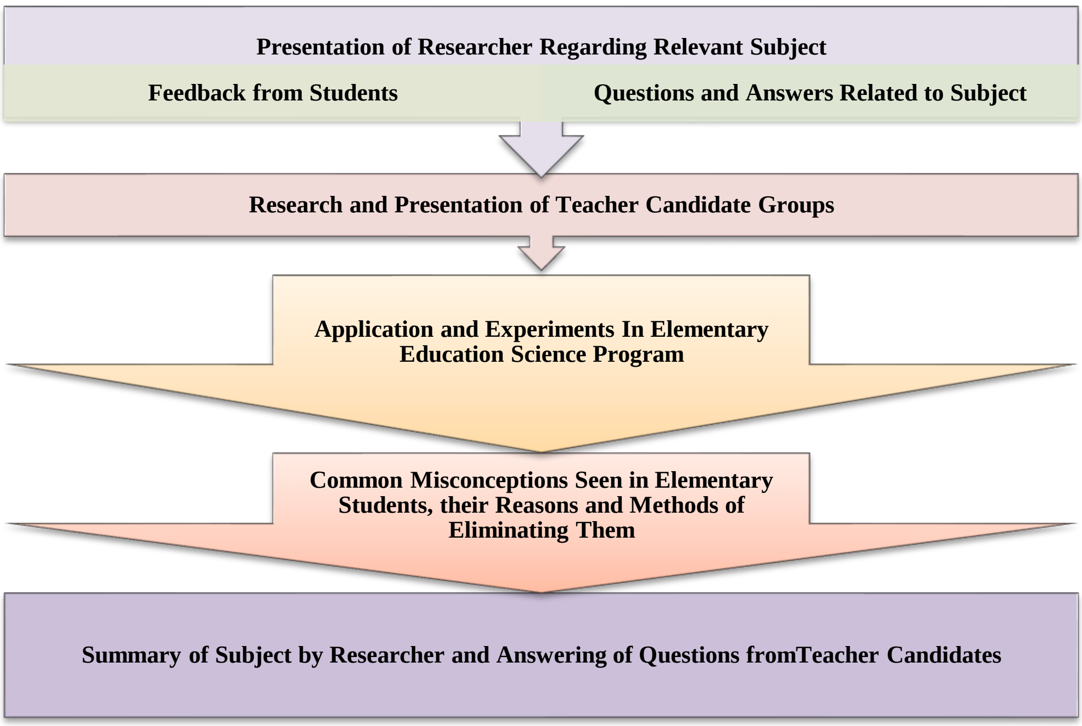


Figure 1. Course Flow Chart that was applied to control group

Instruction in the experimental group 1 RG_1

At the beginning of application, by eliminating the failures determined in the pilot applications, the final version of the problem scenarios that were prepared by the researcher was created (applicability of experiments, student perceptions, and similar particulars). The teacher candidates at RG_1 were divided into groups of four people. Pretests were applied in the first week to the RG_1 group. As per the unit program, teacher candidates first read the problem scenario, they then developed a hypothesis, and, finally, they designed experiments to test these hypotheses. Within course hours and during the following period, the groups completed their work, and, in the following week, they conducted the experiments to test their hypothesis in the laboratory.

Each group discussed among themselves, shared their hypothesis and findings with the other groups, and, finally, prepared experiment reports.

Depending on their level of success (low-medium-high), three students were determined from within the group, and semi-structured interviews were conducted with them regarding the processing of the course and student gains. A flow chart about how a problem scenario created for the relevant subject was carried out by the groups is presented in Figure 2.

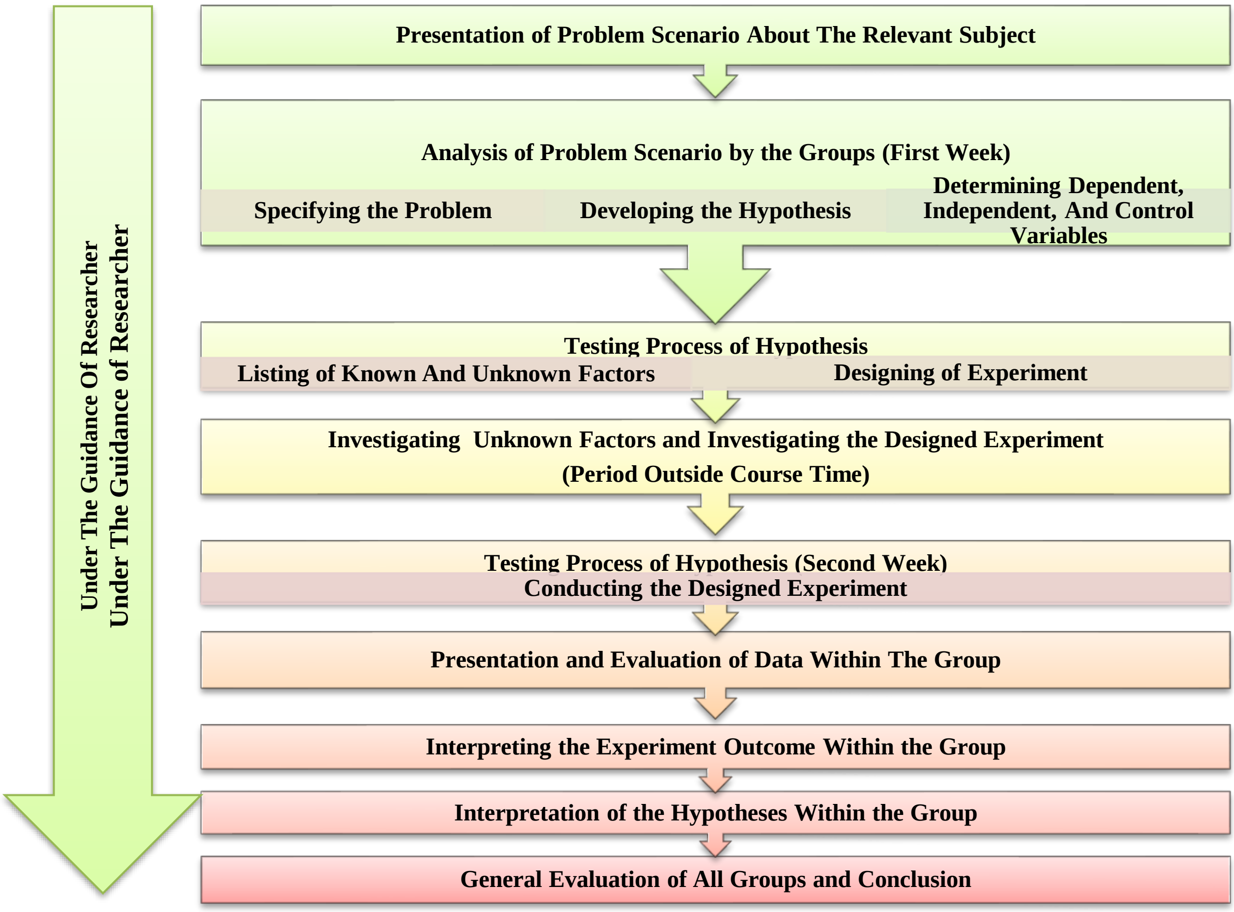


Figure 2. Course flow chart being applied to problem-based learning experiment group

Instruction in the experimental group RG_2.

Studies conducted with the group to which argumentation supporting problem-based learning (AS-PBL) was applied were very similar to those of RG_1. The only differences were that information was given about argument development, Toulmin's argumentation model of Toulmin, and an argumentation orientation event was conducted for teacher candidates. Afterwards, during the activities that continued over a period of eight weeks, students reached outcomes and created reports for them by processing per the scenarios, and by having discussions with their fellow group members and the whole class at each stage (in accordance with argumentation components). The students in this group conducted argumentation activities in the form of making claims according to the Toulmin's argumentation model for the problem situations they faced, producing supporting reasons for their claims, designing experiments that would prove their reasons, and suggesting a proof or rebuttal for their claims after implementation (Figure 3). At the end of the course, data collection tools were applied as a post-test, and, following the analysis of the obtained data, discussions were conducted with a total of nine people, composed of three sets of three people each determined according to the score they got from the success tests from each level (successful, intermediate, unsuccessful) about evaluation of the processing of the course and determining the factors affecting individual development.

A flow chart about how a problem scenario created for the relevant subject was carried out by the groups when argumentation was included is presented in Figure 3.

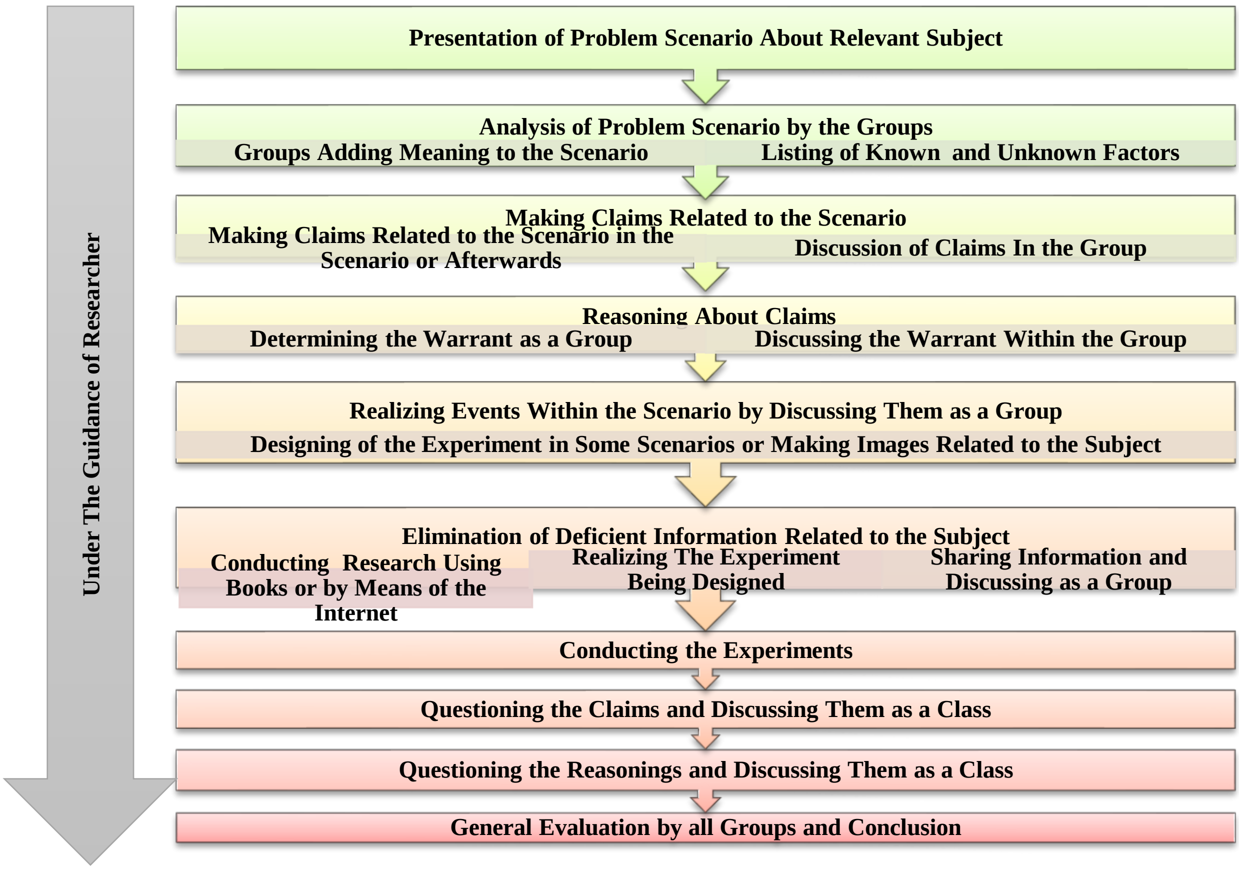


Figure 3. Course flow chart applied to argumentation supported problem-based learning experiment group

Findings

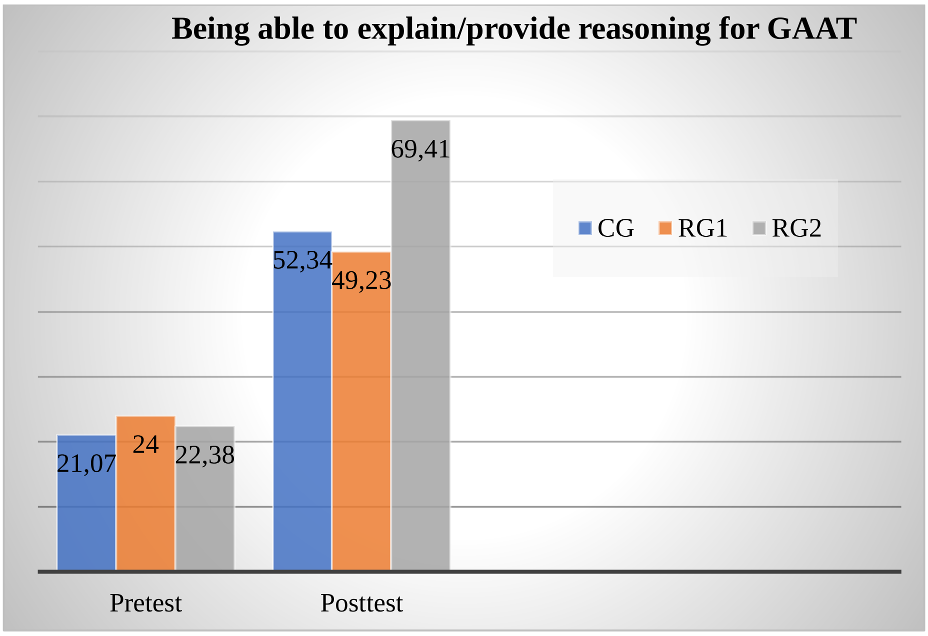
Within the contect of research, subjects of Acids-Bases and Gases in Scientific Laboratory Applications II course were taught to science teacher candidates by using three different teaching methods: the traditional teaching approach (TTA), problem-based learning (PBL), and argumentation supported problem based learning (AS-PBL). Following the training being given, the effect of teaching method being applied on the success levels of students was examined. Findings obtained in line with the purpose of the research are as follows.

Gases

Within the research context, before and after experimental processing, by using the Gases Success Test composed of 16 articles, the success levels of students related to knowledge of gases were determined. Test scoring was done so that if students chose the correct option at the first stage, and, if they explained the reason for their answer correctly, they got 1 point, and, if they chose the correct option at the first stage but made an incorrecdt explanation or left the explanation part empty, they got 0 points, and, if both of them were wrong or empty, they got 0 points. In order to be able to interpret the success scores of students more easily, scores were converted to a system of 100 points in which each question had an equal score. Descriptive statistics related to the success levels of students in terms of the subject of gases before and after experimental processing are given in Table 2. Rates of students being able to explain the questions/ reasoning are given in Figure 4.

Table 2: Descriptive statistics about the success level regarding the subject of gases

Group	GAAT (Pretest)						GAAT (Posttest)					
	Min.	Max.	*Mean*	S.D.	Skew ness	Kurto sis	Min.	Max.	Mean	S.D.	Skew ness	Kurto sis
TTA	0,00	69,23	*21,07*	*13,51*	0,98	2,33	15,38	84,62	*52,34*	*16,10*	0,01	-0,42
PBL	0,00	46,15	*24,00*	*13,96*	-0,36	-0,88	15,38	92,31	*49,23*	*16,81*	0,48	0,49
AS-PBL	0,00	76,92	*22,38*	*14,25*	1,59	4,22	23,08	100,00	*69,41*	*17,28*	-0,17	-0,15



CG: TTA, RG1: PBL and RG2: AS-PBL

Figure 4. Average figures related to teacher candidates being able to explain/provide reasoning for GAAT items

In the groups for which different teaching methods were used, it was seen that the achievement levels of students in the groups related to gases were similar before the experimental process and that there were differences between the groups following the experimental process. In order to examine the meaningfulness of the difference between the achievement levels of the students in terms of their knowledge of gases depending on teaching method, first, the fulfilment of the normality and homogeneity of assumptions about variances was examined. The results of the Shapiro-Wilks and Levene tests conducted for this purpose verified that homogeneity was achieved and that normal distribution was revealed. Results of the one-way ANOVA conducted to examine the meaningfulness of the difference between achievement levels of students regarding gases as per teaching method due to the fulfillment of required assumptions are shown in Table 3.

When the results of the one-way ANOVA were examined, the difference between the post-test scores and pre-test scores of students were found to be meaningful for all three teaching methods. Accordingly, it can be stated that all three teaching methods were effective in improving the accomplishment of students related to knowledge of gases. In order to understand the effect of the experimental process better, the magnitude of the Cohen's d impact were calculated for the differences between the groups. The magnitude values of the Cohen's d impact between groups were 0.09 (small effect), 0.45 (small effect), and 0.50 (medium effect) respectively for TTA/PBL, AS-PBL/TTA, and AS-PBL/PBL (Cohen, 1988). According to these results, AS-PBL was more effective with respect to the other two methods.

Table 3: ANOVA results of achievement level related to knowledge of gases as per teaching method

Measurement	Statistics	Sum of Squares	df	Mean Squares	F	p	Difference	Cohen's d
GAAT (Pre-test)	Between groups	207.09	2	103.54	0.535	0.59	-	
	Within group	26496.21	137	193.40				
	Total	26703.30	139					
GAAT (Post-test)	Between groups	10764.88	2	5382.44	19.225	0.00	**TTA/PBL**	0.09
	Within group	38356.00	137	279.97			**AS-PBL/ PBL**	.45
	Total	49120.88	139				**ASPBL/ PBL**	0.50

* Positive values show that there was an increase in measured features following experimental process

The results of the dependent sample t-test being conducted to examine the meaningfulness of the difference between post-test scores and pre-test scores on the students' gases achievement test regarding the teaching method being applied within scope of research is given in Table 4.

Table 4: Results of dependent sample t-test for achievement level regarding gases

Group	Post-test/pre-test difference*			Dependent sample t-test		
	Mean	**S.D.**	**Cohen's d**	**t**	**df**	**Sig**
TTA	31.27	17.35	0.72	12.23	49	0.00
PBL	25.23	19.72	0.63	9.05	43	0.00
AS-PBL	47.03	17.73	0.82	17.60	45	0.00

* Positive values show that there was an increase in measured features following the experimental process

**p<.01*

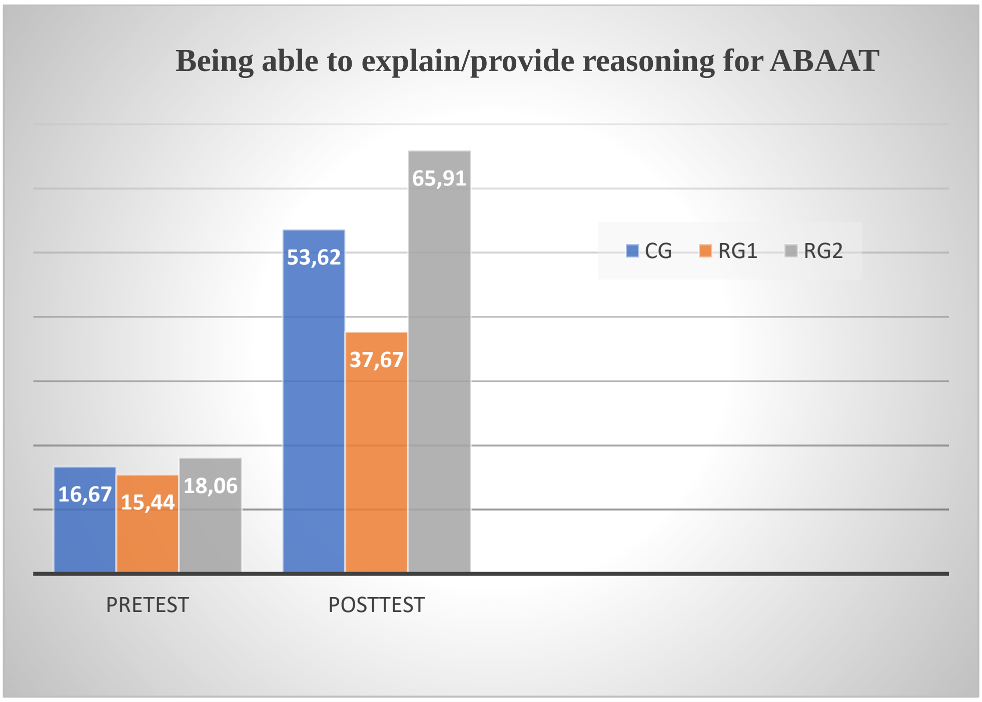
When results of dependent sample t-test were examined, the difference between the post-test scores and the pre-test scores of students for all three teaching methods was found to be meaningful. Accordingly, it can be stated that all of the three teaching methods were effective in improving the accomplishment of the students related to their knowledge of gases (p<.01 or .05). When impact magnitudes were examined, while the most effective method for students in improving their accomplishment level was AS-PBL (0.82-big); it was followed by TTA (0.72-medium) and PBL (0.63-medium) teaching methods. According to these results, it can be said that the AS-PBL method is more effective than the other two methods.

Acids/bases

Within the research context, by using an achievement test for the students before and after the experimental process on the subject of acids/bases subject composed of 19 articles, the students' achievement levels in terms of their knowledge of the acids/bases subject were determined. The test scoring was so that if students chose the correct option at the first stage and if they explained the reason for the answer correctly, they got 1 point, and if they chose the correct option but made an incorrect explanation or left the explanation section empty, they got 0 points, and if both of them were wrong or empty, they got 0 points. In order to interpret the achievement scores of the students more easily, scores were converted into a system of 100 where each question would have an equal score. Descriptive statistics related to the achievement levels of students regarding the subject of acids/bases before and after the experimental process are given in Table 5. The rates of students explaining the questions are given in Figure 5.

Table 5: Descriptive statistics for achievement level related to acids/bases subject

Group	ABAAT (Pretest)						ABAAT (Posttest)					
	Min.	**Max.**	***Mean***	**S.D.**	**Skewness**	**Kurtosis**	**Min.**	**Max.**	***Mean***	**S.D.**	**Skewness**	**Kurtosis**
TTA	0.00	38.89	*16.67*	*10.08*	0.28	-0.38	22.22	83.33	*53.62*	*14.40*	0.28	-0.17
PBL	0,00	38.89	*15.44*	*8.86*	0.31	-0.03	5.56	77.78	*37.67*	*16.28*	0.46	-0.26
AS-PBL	0,00	44.44	*18.06*	*10.59*	0.41	0.42	22.22	94.44	*65.91*	*18.19*	-0.39	-0.47



CG:TTA, RG1:PBL and RG2:AS-PBL

Figure 5. Average figures of teacher candidate being able to explain/provide reasoning for ABAAT items

In the groups for which different teaching methods were used, it was seen that the achievement levels of students in the groups related to acids/bases were similar before the experimental process and that there were differences among the groups following the experimental process. With the aim of examining the meaningfulness of the difference between the achievement levels of students regarding knowledge of bases/gases depending on the teaching method, first, the fulfilment of assumptions about the normality and homogeneity of the variances was examined. The results of the Shapiro-Wilks and Levene tests conducted for this purpose verified that homogeneity was achieved and that normal distribution was revealed. The results of the one-way ANOVA test conducted to examine the meaningfulness of difference between the achievement levels of the students regarding acids/bases per teaching method due to the fulfillment of required assumptions are shown in Table 6.

When results of the one-way ANOVA test were examined, the difference between post-test scores and pre-test scores of the students for all three teaching methods was found to be meaningful. Accordingly, the magnitude values of the impact of Cohen’s d among the groups was 0.46 (small effect), 0.35 (small effect), and 0.63 (medium effect) for the TTA/PBL, AS-PBL/TTA, and AS-PBL/PBL differences, respectively (Cohen, 1988). According to these results, the AS-PBL method was more effective with respect to the other two methods.

Table 6: ANOVA results for acids/bases achievement level per teaching method

Measurement	Statistics	Sum of squares	df	Mean squares	F	Sig.	Difference	Cohen’s d
ABAAT	Between groups	159.57	2	79.78	0.826	0.44	-	
(Pre-test)	Within groups	13235.49	137	96.61				
	Total	13395.06	139					
ABAAT	Between groups	18899.36	2	9449.68	35.421	0,00	TTA/PBL	0.46
(Posttest)	Within groups	36549.28	137	266.78			AS-PBL /PBL	0.35
	Total	55448.63	139				**AS-PBL /PBL**	0.63

$p<.05$

The results of the dependent sample t-test conducted to examine the meaningfulness of the difference between the post-test and pre-test scores of acids/bases achievement test of students in terms of the teaching methods being applied within the context of research are given in Table 7.

Table 7: Results of dependent sample t-test for acids/bases achievement level

Group	Difference of post-test/pre-test *			Dependent sample t-test		
	Mean	**S.D.**	**Cohen’s d**	**t**	**df**	**Sig.**
TTA	36.96	16.28	0.82	15.40	49	0.00
PBL	22.22	15.75	0.65	9.98	43	0.00
AS-PBL	47.85	20.13	0.85	15,77	45	0.00

* Positive values show that there has been an increase in measured features following the experimental process.

When results of dependent sample t-test were examined, the difference between the post-test scores and pre-test scores of students was found to be meaningful for all three teaching methods being applied. Accordingly, it can be stated that all three teaching methods were effective in improving the accomplishment of students regarding the subject of acids/bases. When the magnitudes of the impact were examined, the most effective method in improving student accomplishment was the AS-PBL (0.85-big), followed by the TTA (0.82-big) and the PBL (0.65-medium) teaching methods.

Following the process, semi-structured discussions were held with teacher candidates. The opinions of teacher candidates about their accomplishment related to the subjects of gases and acids-bases are exemplified below.

Among students in the control group (CG):

CG_{S2} commented that “ the *research I did with my friends as a group and presentations in the class were quite good. The course was joyful, but still I cannot manage chemistry well.”* emphasizing that he thought well of the course was thought well but that he could not manage chemistry;

CG_{S5} commented that “*As always, I listened to my course, I worked, and I got good grades*,” and he stated that the course progressed as always, and that he could be successful when he worked.

CG_{S9} commented that *"the teaching of subjects at the courses was quite successful, and I learned much better. In particular, our investigation of incorrect conceptions and experimental samples improved our successes,"* and he considered the course to be positive in the direction of improving the level of success.

Among students in experiment group 1 (RG_1):

RG_{1S1} said, '*PBL was a method new to me, and my groupmates and I had difficulty in finding experiments related to certain subjects. For this reason, we may not have learned those subjects completely*," explaining that the difficulties experienced were due to the fact that the method was newly implemented.

RG_{1S5}: Has said: '*During the courses my group friends did everything and not much was left for me. I am used to the courses told by the teacher and for this reason I could not eliminate my deficiencies relating with certain subjects.' and* he believes that he will be more successful if he continues his course with TTA.

RG_{1S8}: Has stated**:** '*Courses were entertaining with PBL and I liked it very much to search for certain things with my friends and to find answers to the problems. For this reason, I think that I have been successful.'* and he finds himself successful with this method.

Among students in experiment group 2 (RG_2);

RG_{2S2}: Has said: '*This course processing had a style I was not accustomed to and I think I had some difficulty for this reason*.' and he shows the method he is not used to as the reason of his failure.

RG_{2S6}: Has said**:** '*With the help of argumentation I understood what I thought and why. It helped me to correct it if I have learned a subject wrongly and our discussions with my friends were very effective. For this reason, my success improved.'* and he links the increase in his success to argumentation.

RG_{2S8}: Has said: '*PBL is a beautiful method. Problem given was in fact related with the questions in my mind and they were the things I could not understand. In this way by investigating I could answer them, and I understood the subject. Besides argumentation activities I had enabled me to strengthen the issues.*' and he has used the method to solve his own problems and he has stated that he could enhance them by means of argumentation.

When the student's opinions are examined, reasoning of outcomes coming out of quantitative analysis can be seen.

Discussion and Conclusion

Even though many teaching methods and techniques have been developed and applied in the past, generally students could not achieve success levels expected from them in science education and especially in learning chemistry (Dochy, Segers, Bossche & Gijbels, 2003; Nakhleh, 1992; Tatar, 2007; Tosun vd., 2015; Serin, 2009). Today, in order for students, whose interests, perceptions, environments and school opportunities change, to be successful in science classes it is necessary to change/update the implemented programs and the teaching approaches being used.

In this study, the impact of the PBL and AS-PBL methods on student achievement levels with respect to traditional teaching approaches was investigated and, furthermore, whether the part of the PBL method defined as "missing learning" in terms of being a general examination subject of educators could be completed with argumentation support or not was investigated.

It was discovered that the accomplishment of science teacher candidates related to the subjects of gases and acids/bases on which the study was carried out had improved at a meaningful level at the end of the study with respect to pre-tests. Since teacher candidates also were taught about these subjects with nearly the same content during their high school education. their success as members of three groups composed of students of the same level (control, PBL and AS-PBL groups) also increased in each of the three groups in post-tests, but when the magnitude of the impact of Cohen's d was examined, the most effective method in increasing success was AS-PBL, followed by TTA and PBL. This situation is in line with the literature studies concluding that PBL does not make a significant difference in success (Serin, 2009; Selçuk, 2010; Şahin, 2009; Taşoğlu & Bakaç, 2010).

Since the success tests used in the study were diagnostic tests with two stages, they could show whether teacher candidates answering the questions have understood the subject per scientific model or not. The situation in which teacher candidates who could not structure this explanation part correctly could not get full scores is evidence of students receiving missing information related to the subject. We can see that teacher candidates in all groups answered the part, “Explain the reason for your answers” related to gases in pre-tests with approximate values (Figure 4). In the post-tests, biggest success was achieved by the argumentation supported PBL group who gave correct answers at average rate of 69%. It could be that the reason for this difference was that, during the argumentation process, students learned with which reasoning process an assertion could be explained. (Driver et al., 1994; Driver et al., 2000; Osborne et al., 2004). In other words, during the class activities, the AS-PBL group learned how an assertion could be reasoned about and defended. Thus, in the exam, these students could provide justification and explain the reasons for their answers. These results are in line with the conclusion that the argumentation of Cassel (2002) and Belland (2010) increases success by supporting PBL.

In this same test, the lowest success was achieved by students in the PBL group. This means that teacher candidates continuing their education with PBL could not provide reasoning for the test articles. This is a situation worthy of discussion, and there are two probable reasons for this situation. First, students in PBL group did not have the information required to explain/justify their answer effectively. The second reason is that pre-service science teachers do not know how to be warrant. When these two probable reasons are evaluated by considering the research findings, the situation in which the post-test success rate of success reflected by the low test scores of PBL group supports the idea that these students were not able to improve their area knowledge during the PBL applications. This situation shows the disadvantage of missing information acquisition of PBL and is in line with the literature (Dochy, et.al. 2003). In a similar way, one of the students in the PBL group (RG_1S_1) stated that they focused heavily on the PBL process during the interviews, and, for this reason, the area of field information remained missing.

Even though these two findings support the conclusion that that the area of field information of the PBL group students remained missing, the second probable reason has still not been invalidated. In this research, the TTA and PBL group students did not receive training on how to conduct an argumentation during the period of activities, or they did not participate in an event. This situation is a difference that must be considered while invalidating the second probable reason. The students learned that, in order for the AB-PBL group to defend their assertions in an effective way during the argumentation process, the area information was important, and, thus, they attached importance to learning the chemistry subject in the relevant experiments. They also learned how reasoning should be conducted. However, since the PBL and TTA group students did not defend any assertions, they had not learned how reasoning should conducted. As in the section where reasons for their answers were asked for in the gases and acids/bases tests from these two groups, the PBL group was more unsuccessful in both tests This situation supports the idea that this failure originated from “missing field information” and not from “not knowing how to reason.”

These results of the research supports the assertion that information missing from the courses carried out with PBL bears significant importance for the literature.

It can be seen in Figure 5 that the situation is similar for the acids/bases subject, and, since the argumentation supported problem based learning method improves the skills of students in making assertions and to making presentations by justifying their assertions through questioning the reasons, it can minimize the missing gains related to the attainment of information. While students in the second experimental group were interviewed, they stated that by means of the S_6 argumentation, they could fill in the “explain the reason for your answer” section easily, and that they could learn the topics better; they also stated that with S8, they were able for them enhance what they had learned with argumentation and that they could understand much better. The teacher candidates were generally convinced that argumentation was part of the process. In this case, the opinion that presence of argumentation in the problem based learning process played the role of a guide for evidence based communication and that it was a required mechanism for permanent learning is in conformity with the outcomes of the study (Jonassen, 2011; Walton, 2007).

AS-PBL was effective in improving the success of students in both of the subjects and in their being able to use the information they gained. PBL had less effect with respect to TTA. It overlapped with the outcome obtained by Tüysüz et al (2013) that argumentation supported teaching improved achievement more with respect to PBL and laboratory supported teaching (we can consider it a traditional method) and that PBL improved student achievement least. Furthermore, studies stating that the argumentation supported PBL method was more effective in developing question asking and answering skills with respect to problem based learning (Ju & Choi, 2018), and it is more effective in developing problem solving skills (McGhee, 2015) which also supports the outcome of this research. During the interviews conducted with the students, the group which was most satisfied with respect to understanding the subject was AS-PBL. The PBL students stated that they worked to solve the problems, but they could not do so and understood the subject less. Because these teacher candidates were not accustomed courses being conducted in this way, they were not able to structure the information correctly; the achievement of the TTA group shows that the education system they were accustomed to was in this way.

By adopting a student-centered teaching approach with the radical change of following a behavioral approach, numerous teaching approaches, methods, and techniques were developed. The Effects of the approaches, methods, and techniques generally developed by education scientists are investigated by field educators. It is expected that the impact of a method in education to vary according to the ages, sociocultural environments, and learning environments of students in the classes and according to such factors as courses, units, and subjects. According to these factors, some methods may have advantages and some may have disadvantages. Can a more positive outcome be obtained by eliminating the disadvantage of a method by an advantage of another method in relation to the teaching of a subject?

In this study conducted by starting from above mentioned idea, with respect to all parameters being investigated, an outcome was reached that argumentation supported problem based learning applications and activities caused more efficient results to be obtained with respect to all parameters being examined.

While studies in which argumentation and problem based learning are hybridized in the literature are quite rare, they do occur in the areas of medical education (Ju & Choi, 2018) and philosophy education (McGee, 2015). In this respect, this study proposed a new method that will contribute to this area and which asserts that it is necessary that, in chemistry education, problem based learning should be applied by being hybridized with argumentation. This proposal should shed light on new studies.

Suggestions

These days when we are trying to adapt to a world that is constantly developing and changing, we can keep up as long as we are science literate individuals who learn for a life time and who continuously improve themselves .Thus, our task as teachers is to provide contemporary education to our students in conformity with today's conditions. Instead of education where information is received directly in a passive way based on memorization, we should aim to educate individuals who think about the information they have learned, who question, and who have problem solving skills. For this reason, it is necessary to convince teachers that argumentation is an important component of science education. This research results have shown that argumentation supports PBL quite successfully. Based on this result, the necessity of including argumentation in PBL environments is an important suggestion of this research.

AS-PBL activities in this study applied in science laboratory can be organized and applied in the same conditions outside the laboratory, in different laboratory courses and on different topics and a database can be created. Furthermore, it can also be applied in different education levels.

During the formal education period at our schools throughout the country, our students should be made accustomed to methods such as PBL, argumentation, and cooperative learning which are widely used throughout the world in a programmed way.

Since effective usage of PBL and argumentation methods can also be affected by the social and cultural environment, this study can also be attempted in regions with varying social and cultural differences.

By establishing different teaching methods, techniques, and hybrid methods, the effectiveness of such methods such as argumentation and PBL can be compared.

In studies with longer periods (such as two or three periods), how AS-PBL affects variables such as attitude, self-sufficiency, desire for debate, and critical thinking can be investigated and supported in a qualitative way. The proposal by Ju and Choi (2018) that the outcomes with applications for long term periods should be looked at are also presented in this study.

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Statement of Publication Ethics

In this study, scientific, ethical and citation rules were ensured all responsibility belongs to the Corresponding Author. The research has no unethical problems.

Conflict of Interest

This study does not have any conflict of interest.

Researchers' Contribution Rate

Researchers' Contribution Rate

Authors	Literature review	Method	Data Collection	Data Analysis	Results	Conclusion
Gülseda Eyceyurt Türk	☒	☒	☒	☒	☒	☒
Ziya Kılıç	☒	☒	☒	☒	☒	☒

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Appendix 1

Bartın University Journal of Faculty of Education
The Ethical Issues Declaration Form For Authors

Article Title	The Effect of Argumentation-supported Problem Based Learning on the Achievements of Science Teacher Candidates Regarding the Subjects of Gases and Acids-Bases
Discipline	Chemistry Education
Type of Article	Research article
Year of Data Collection	2014

As the author of the article, I declare in this form that scientific and ethical rules are followed in this article and that the article does not require the permission of ethical committee for the reason that the data of the study were collected in 2014. In addition to, the article has been produced from first author's "The Effect of Argumentation-Supported Problem Based Learning Applications on the Success of Scientist Candidates on Acid / Bases and Gases" titled doctoral dissertation.

05/06/2020

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