Using laboratory activities enhanced with concept cartoons to support progression in students' understanding of acid-base concepts

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Abstract

The aim of this study is to examine the effectiveness of an intervention based on a series of laboratory activities enhanced with concept cartoons. The purpose of the intervention was to enhance students' understanding of acid-base chemistry for eight grade students' from two classes in a Turkish primary school. A pretest-posttest non-equivalent groups design and one experimental group (EG; N = 19) and one comparison group (CG; N = 17) were used in the study. While the comparison group taught with laboratory activities-based instruction, the experimental group received concept cartoon enhanced laboratory activities-based instruction. *Acid-Base Achievement Test (ABAT)* consisting of 25 multiple-choice questions was administered in the form of a pretest/posttest research design. Besides, pre-interview was used for collecting data. Alternative conceptions identified in the pretest and pre-interviews were incorporated into the intervention, which thereby sought to move students toward views more in accord with scientific views for the concepts. The results of the study indicated that while there is no statistically significant difference between groups in pretest, performance of EG students is greater than the CG ones in posttest. Besides, the EG students are better in remediating their alternative conceptions related to concepts of acid-base chemistry. The findings show that laboratory activities enhanced with concept cartoons help student improve their understanding and reduce their alternative conceptions.

Keywords: Acids and bases, chemistry teaching, concept cartoon, laboratory activities

Introduction

Constructivist perspective suggests that students need to be active participants in the learning process in constructing meaning and developing understanding (Jenkins, 2000). Moving from this idea, teachers and educators try to find original and useful methods to aid in the teaching of scientific concepts. Concept mapping, animations, analogies, simulations, worksheets, concept cartoons, laboratory activities, and conceptual change texts are some of them (Çalık, Ayas & Coll, 2009; Huddle, White & Rogers, 2000; Keogh & Naylor, 1999; Özmen, 2007; Özmen, Demircioğlu & Coll, 2009). Although the literature describes a variety of interventions for researchers and teachers, in this paper we consider two of them. Whilst one of which involves student learning in the laboratory; and the other of which involves concept cartoons.

Laboratory activities make students more active in their learning. The literature suggests that students enjoy laboratory work because it is more active (Hart et al., 2000). In the laboratory, students have a chance to engage in hands-on activities, and both science and non-science majors are reported to find laboratory-based activities to be motivating and exciting (Markow & Lonning, 1998). Despite some reservations, many authors believe that laboratory work helps promote conceptual understanding (Hart et al., 2000; Özmen, Demircioğlu & Coll, 2009). Besides, practical works in laboratory gives students opportunity to gain some psychomotor skills through scientific investigations and hands-on activities and has the potential to significantly enhance learning and development of conceptual understanding (Abdullah, Mohamed & Ismail, 2009). Laboratory can offer a unique learning environment which can help students to construct their knowledge and develop logical and inquiry-type skills (Abdullah, Mohamed & Ismail, 2009). It can also promote positive attitudes, provide students with opportunity to develop skills regarding cooperation and communication, and stimulate the students and allow them to be creative, which are compatible with the constructivist teaching models (Faire & Cosgrove, 1988; Hofstein, 2004).

One of the other methods which motivating and activating students is concept cartoons which have been used in a variety of ways for educational purposes (Keogh & Naylor, 1999), such as solving problem (De Fren, 1988), enhancing motivation (Heintzmann, 1989), resolving conflict (Naylor & McMurdo, 1990), eliciting students' ideas (Guttierrez & Ogborn, 1992), and supporting progression in students' understanding (Perales-Palacios & Vilchez-Gonzalez, 2002; Stephenson & Warwick, 2002). These characteristics make concept cartoons useful in science classroom as a teaching, learning and assessment tool. Concept cartoons were firstly prepared in an attempt to develop an innovative teaching and learning strategy, which considered the constructivist views of learning in science (Keogh & Naylor, 1999; Stephenson & Warwick, 2002). The concept cartoons involve cartoon-style drawings showing everyday situation underpinned by a specific aspect of science (Keogh, Naylor & Wilson, 1998; Stephenson & Warwick, 2002). In teaching of concept cartoons, the cartoon characters suggest their alternative explanations, express diverse or alternative point of view about the science in a form of cartoon-style drawing in a worksheet or a poster. The cartoon characters bring about their ideas in a discussion format, and then students are encouraged to join the discussion with the cartoon characters (Kabapınar, 2005; Keogh, Naylor & Wilson, 1998). With this way, a concept cartoon is used for focusing group discussion, which can lead investigations to decide which idea is most acceptable (Keogh, Naylor & Wilson, 1998). Although concept cartoons are intended to elicit learners' alternative conceptions, they are used as an aid to teaching and learning approach that is applicable in a wide variety of settings. For example, according to Keogh, Naylor and Wilson (1998), concept cartoons might be used in science teaching and learning for enhancing motivation, providing a purpose for practical work, emphasizing the applications of science, enabling learners to assess their own level of understanding, and understanding in science.

Purpose of the Inquiry

The concepts of acid-base chemistry comprise the basis for this paper. This topic was chosen because of the ubiquitous nature of acid-base chemistry in everyday life, the fact that this area of chemistry involves multiple concepts, and the importance of acid-base chemistry for learning the other topics in chemistry. Additionally, acid-base chemistry is a difficult topic for students to learn (Demerouti, Kousathana & Tsaparlis, 2004; Demircioğlu, Özmen & Ayas, 2004; Özmen, Demircioğlu & Coll, 2009; Sisovic & Bojovic, 2000). In brief, the literature reports student alternative conceptions in acid-base chemistry as widespread, occurring at various grade levels and that conventional teaching strategies seem unable to rectify students' nonscientific beliefs. Thus, here we report research about an intervention intended to help students' learning acid-base chemistry more effectively.

In Turkish Science and Technology curriculum, acid and base concepts are first mentioned in the unit of "the structure and properties of the matter" in grade 8. In this unit, students are introduced the basic concepts related to acids and bases such as definition of acid and base concepts, the properties of acids and bases, diagnosing of acids and bases, pH and pOH concepts, acids and bases encountered in daily life, damage of acids and bases, and safety while studying acids and bases. In this curriculum, teachers are asked to apply a student-centered instruction with constructivist manner and curriculum includes lots of laboratory activities and experiments. However, there is not a necessity for preparing students to laboratory activities mentally, diagnosing students' pre- and alternative conceptions, and designing laboratory activities based on these beliefs. On the other hand, there has been much discussion in science education literature about the importance of effective preparation by students for laboratory sessions (Byers, 2002; Johnstone, Sleet & Vianna, 1994; Sirhan, Johnstone & Reid, 1999). Mental preparation of the students for laboratory work is important in this process. A student entering into laboratory without some preparation is likely to spend hours of fruitless activity resulting in limited learning (Kelly & Finlayson, 2009). Teachers should activate students mentally, elicit their own ideas and raise awareness with their initial conceptions related the concepts under study before the hands-on laboratory activities. With this manner, the concept cartoons may support the teachers in the elicitation process of making the learners' ideas explicit (Stephenson & Warwick, 2002). Students who have dissatisfaction with their initial ideas will probably be more careful while doing laboratory activities and try to remove their alternative conceptions by learning scientifically acceptable ones. With this regard, we wanted to use the concept cartoons to build up discussion environment for students before confront them with laboratory activities. In such an environment, students will have the chance to discuss each other and realize their alternative and/or inadequate beliefs. In summary, we tried to combine concept cartoons with laboratory activities to make students mentally activated, to enhance students' performance while doing the activities, and to provide them an opportunity to discuss each other. This may help them to see their inadequate initial beliefs and to make the laboratory activities more conscious. Besides, although there are many studies investigating the effectiveness of laboratory activities on learning, little empirical research has been conducted on concept cartoons to examine their usefulness in science teaching. From this point of view, the purpose of this study is to find out the effectiveness of concept cartoons enhanced laboratory activities for teaching of concepts of acid-base chemistry in primary school. The specific research questions for this inquiry are:

1. Is an intervention involving the use of concept cartoons enhanced laboratory activities more effective in improving students' understanding of acid-base chemistry than the instruction based on the laboratory activities?
2. How students' alternative conceptions do change through the implementation?

Methodology

Study context

Science and technology is a compulsory subject between the grade 4 and 8 in the Turkish Educational System and implemented in a spiral manner. The general unit of "The Structure and Properties of Matter" is included in grade 8 curricula. This unit comprises five sub-units and one of them is acids and bases. In this unit, students are expected to gain eleven learning goals and these are listed in below (URL, 2012).

Learning goals related to acids and bases in the curriculum

Students;

1. *Know the acids and bases with their properties by touching, tasting and seeing.*
2. *Associate the acids to H^+ ion, and the bases to OH^- ion.*
3. *Know that species such as SO_2, Na_2CO_3 and NH_3 react with water to produce H^+ ion or OH^- ion, and write suitable equations for these reactions.*
4. *Understand that pH is an indicator of acidity and/or basicity of a solution and associate the pH scale to acidity and basicity.*
5. *Know the acids and bases commonly used in foods and cleaning materials.*
6. *Know that CO_2 found in most carbonated beverages produces H^+ ion in water, namely it pretends an acid.*
7. *Know the pH values of some acids and bases commonly used in daily life.*
8. *Know the market names of some common acids and bases as well systematic names.*
9. *Show the interaction between acids and bases, experimentally; call this interaction as "neutralization reaction"; and define the products of such reactions.*
10. *Explain why they must be careful while using acid and base solutions.*
11. *Explain the negative effects of acids and bases on matter used in daily life.*

As seen from the table, students in both groups took the same content during the implementations. In other words, the same content was taught to students in both groups with different instructional techniques in eight 40-minute lessons.

Research Design

A quasi-experimental method was used in the study because the participants of the study were already distributed to classrooms by the school management. Because school authorities did not allow the researchers to constitute new classrooms for experimental purposes, they randomly assigned the present groups as experimental and comparison groups. Among the different designs of this method, "*pretest – posttest non-equivalent groups design*" (Robson, 1998) was chosen for this inquiry and one comparison group (CG) and one experimental group (EG) were used to collect data. Each group was given both a pretest and a posttest to collect data.

The Sample

The subjects for the study consisted of 36 eighth grade students (19 boys, 17 girls) from two intact classes of a primary school in a city of Turkey. One class (N = 19; 11 boys and 8 girls) was assigned as the experimental group (EG) and the other (N = 17; 8 boys and 9 girls) was chosen as the comparison group (CG).

Instruments

Acid-Base Achievement Test (ABAT) and students' interview were used to collect data in the study.

Acid-Base Achievement Test (ABAT)

The ABAT contains 25 multiple-choice questions. Each of them includes four choices, one of these is scientifically acceptable answer and rests of them are the plausible distracters. While 14 of the questions were taken from different test books used in the schools and literature with minor revisions (Artdej, Ratanaroutai & Thongpanchang, 2009), the researchers prepared 11 of them. The reliability of the test was estimated to be 0.83 using the Kuder-Richardson 20 formula, which was considered acceptable for an instrument of this type. Table 1 summarizes the characteristics of the ABAT.

Table 1. Characteristics of the acid-base achievement test (ABAT)

Areas evaluated	:	Description of acids and bases: items 1, 2 and 6 General properties of acids and bases: items 8, 22 and 25 Common properties of acids and bases: items 4, 13 and 19. Properties of acids and bases used in daily life: items 3, 10 and 23 Interacts of acids and bases used in daily life: items 5, 9, 11 and 24 Acid and base reaction: 7, 16 and 21 The meaning of pH values of acids and bases in daily life: 12, 15 and 18 Relationship between the [H^+], the [OH^-], and *pH; 14, 17 and 20*
Number of items	:	25
Response format	:	Multiple-choice
Time to complete test	:	30 to 40 minutes
Discrimination indices	:	Mean range (items) 0.46 0.30-0.39 (8) 0.40-0.49 (10) 0.50-0.59 (5) 0.60-0.69 (1) 0.70-0.79 (1)
Difficulty indices	:	Mean range 0.55 0.20-0.29 (3) 0.30-0.39 (1) 0.40-0.49 (5) 0.50-0.59 (4) 0.60-0.69 (10) 0.70-0.79 (1) 0.80-0.89 (1)
Kuder-Richardson	:	0.83

The difficulty indices ranged from 0.20 to 0.89, providing a wide range of difficulty items. The discrimination indices ranged from 0.30 to 0.79. A value of 0.30 was established as a minimum, and those greater than 0.30 were considered acceptable without the need for further revision of the test items (Peterson, Treagust & Garnett, 1989). The content validity of the test was established by a commission consisting of three chemistry educators from the university, two-experienced chemistry teachers and six science and technology teachers. The

ABAT was used in the pretest/posttest format for the study to determine students' understanding. The final version of the ABAT is given in Appendix 1.

Students' Interview

As mentioned above, the research design included two groups, one (EG) included the laboratory activities enhanced with concepts cartoons and the other (CG) was taught with laboratory activities without concept cartoons. Eight students from the EG and eight students from the CG were interviewed individually for 25-30 minutes before the implementation (pre-interview). A semi-structured approach was used in the interviews, eleven questions were asked to all students and all of which were audio taped and transcribed verbatim. Data from pre-interview were used to determine students' alternative conceptions, to design laboratory activities, to construct the phrases found in cartoons, and to develop the items of the ABAT. Therefore, findings of the semi-structured interviews were not given in *results and discussion* section.

Preparing the Concept Cartoon Enhanced Worksheets

The intervention applied in the EG includes five laboratory activities enhanced with concept cartoons. These activities were prepared in worksheet format and covered five major conceptual areas. These are; let's diagnose acidic and basic properties of matters (Worksheet A), effect of acids and bases on different matters (Worksheet B), electrical conductivity of acids and bases (Worksheet C), reactions between acids and bases (neutralization) (Worksheet D), and determination of the pH values using pH paper (Worksheet E). The researchers consistent with a constructivist-based manner in a three-step format prepared worksheets. These steps are *enter*, *activity and explanation*, and *evaluation*. In the *enter step,* concept cartoons were used to attract students' attention and to determine their pre- and/or alternative conceptions related to acids and bases. In the concept cartoons, cartoon characters phrased their alternative viewpoints about the acids and bases involved in the situation in the balloons. While one of these views was correct, the others were not scientifically acceptable. The aim of this stage is to help students realizing their alternative or/and inconsistent views. In the *activity and explanation step,* students performed the activities and recorded their data on tables in the worksheets. After that, the results were discussed with whole class and teacher made some explanations. In the *evaluation step,* students asked to respond the questions, which were related to concepts, activities and daily life applications. All of the worksheets used in the study aimed to activate students' previous knowledge, to reveal alternative conceptions and to remedy them to scientific ones. For this aim, each of the worksheets was responsible in altering one or more alternative conceptions. One of the worksheets used in the study is given in Appendix 2 (Worksheet A).

Implementation Process

In the study, the whole content of the acids and bases unit in grade 8 was taught applying different teaching approaches for the EG and CG in the same number of lessons. The groups were taught by two different teachers. The control group's teacher was male and had 10 years of science teaching while the experimental group's teacher who was female and had 8 years of science teaching experience. In both groups, teaching of the acids-bases unit took eight 40-minute lessons. The ABAT was applied to both groups before and after the implementation, as pretest and posttest. If someone examine the educational attainments related to acids and bases sub-unit (see Table 1), (s)he can see that same content were taught to students in both groups. For example, the teachers taught the same concepts, gave the same definitions, made the same experiments in both groups. The main difference between the groups was based on the concept cartoons. Teacher in the EG used the concept cartoons to activate students' pre-conceptions and to dissatisfy them with some beliefs. On the other hand, concept cartoons were not used in the CG. In addition, while the EG's teacher took into consider the students' alternative conceptions determined with pre-interviews and from the literature related to acids and bases, the CG's teacher did not make this.

Teaching Approach Used for the Comparison Group

In the CG, teacher was asked to teach the unit as he had done in the past. Instruction was made in laboratory environment. During the lessons, teacher tried to make a student-centered instruction based on the laboratory activities, discussions and oral explanations. Textbook was used as principal source and it included different activities related to acids and bases. In the process, students made some activities; teacher tried to activate students by questions and class discussion, explained the important concepts related to acids and bases such as acid and base definitions and then wrote commonly known examples on the board. In this process, students made some laboratory activities found in the textbook such as diagnosing acids and bases by using litmus paper, determining the effects of acids and bases on matters etc. themselves as group. Besides, students were asked to taste some acids and bases known from daily life such as lemon juice, vinegar, soapsuds, and toothpaste. During these tasting, students were distributed worksheets and asked them to write the taste of matters. While the students were studying these activities, the teacher walked around the classroom helping them as needed. During the activities, the students had the opportunity to ask questions. Teacher made some explanations related to properties of acidic and basic matters, diagnosing acids and bases by using litmus paper, neutralization reactions, common acids and bases used in daily life, and relation between pH and acidity. Besides, he responded the students' questions. In addition, Although Arrhenius definition was considered during the definitions, teacher also emphasized that containing H or OH in the formula is not an indicator for acidity or basicity of some species. For example, a species not having H in its formula can pretend an acid in its aqueous solution; and another species not having OH in its formula can pretend a base in its aqueous solution. CO2 and NH3 are the most suitable examples for these, respectively.

In summary, students in the CG took part in the learning process actively and made some activities in this process. However, they did not use the concept cartoons and did not discuss the pre- or alternative conceptions before the instruction. Moreover, teacher did not mention students' possible alternative conceptions during her instruction.

Teaching Approach Used for the Experimental Group

Before the implementation process, teacher and authors discussed the purposes of the laboratory activities, the role of concept cartoons and teaching approach for the EG. Implementations were done in laboratory environment. Each of the worksheets were distributed to students and asked them to examine the enter section, individually. After that, students were expected to write down their observations in the blank areas below the concept cartoons. After they finished writing, the students were told about common alternative conceptions that were determined from pre interviews and literature. The ideas were discussed with the students. This discussion aimed to develop potentially cognitive conflict in the students when they subsequently conducted the laboratory activities. The main aim here was to help students to see that they needed to consider competing explanations for their observations. After the discussion was finished and students' explanations related to concept cartoons found in the enter section of the worksheets were taken in written, teacher grouped the students for activities in the second step. These groups were designed to be similar, and heterogeneous in terms of students' performance as based on the pre-interviews. Students carried out the activities in groups of four to six students, and teacher walked around the tables and asked some questions related to activities to help and canalize them. After the students had finished the activities, the results were presented and discussed with the whole class and teacher emphasized important points of the topic in order to make students' minds clearer. During discussions, alternative conceptions held by the students before the activities were re-evaluated and this gave the students an opportunity to compare their previous and new knowledge. Such an approach aimed to correct students' alternative conceptions and to present scientific information behind the activities. In last step, conceptual questions related to activities and daily life situations for acids and bases were asked to students to elaborate and transfer their knowledge.

Data Analysis

In the analysis of the ABAT, firstly, the total score of each student in both groups were calculated. For this aim, each correct answer for the 25 multiple-choice items was given 4 point, and if a student responded to all questions correctly, a maximum of 100 points was possible. The pretest scores of the groups were compared by using independent t-test to determine whether a statistically significant mean difference existed between two groups. Because there was no significant difference between pretest results, the posttest scores were also compared by using independent t-test to see the effects of intervention on students' understanding of acids and bases.

Result and Discussion

The descriptive measures of the tests for the EG and the CG are given in Table 2. As seen from the Table 2, students' mean scores of pretest were similar for the EG ($M=23.37$; $SD=12.38$) and the CG ($M=25.18$; $SD=9.67$). Independent *t*-test results towards pretest scores also indicated that there was no statistically significant difference between groups ($t=0.484$, $df=34$, $p=0.631$). This reflects similar backgrounds of the both group students in respect to acid-base chemistry achievement before the intervention.

Table 2. The comparison of the pretest and posttest results of the groups in the ABAT

	Groups	N	Mean	SD	*t*	*p*
Pretest	Experiment	19	23.37	12.38	0.484	0.631
	Comparison	17	25.18	9.67		
Posttest	Experiment	19	66.11	17.66	2.896	0.007
	Comparison	17	48.94	17.86		

Because there were no statistically significant differences between the pretest results, the posttest results were compared via independent t-test and a statistically significant difference was found between the posttest scores of the EG (M=66.11; SD=17.66) and CG (M=48.94; SD=17.86) with respect to the chemistry achievement (t= 2.896, df=34, p=0.007). This means that there was a significant mean difference between the students in the EG and CG with respect to understanding of acids and bases.

Students' pre-interviews conducted before the study and literature review give us some information about the students' views and alternative conceptions related to acids and bases. Based on these data, we developed worksheets to remedy students' ideas and to improve their understanding about the concepts. Table 3 shows percentages of students' alternative conceptions before and after the intervention.

From implementation of the ABAT in pretest, twelve alternative conceptions were identified. While the percentages of students' alternative conceptions in pretest ranged from 11% to 63% in the EG, that of the students in the CG ranged from 6% to 65% (Table 3). The students in each group held almost the same alternative conceptions in pretest at about the same percentages. The alternative conceptions obtained from the study support previous studies, which suggested that students at a variety of levels hold similar alternative conceptions (Bradley & Mosimege, 1998; Demircioğlu, Ayas & Demircioğlu, 2005; Nakhleh & Krajcik, 1994). In the EG, during the intervention, worksheets enhanced with concept cartoons were used to remedy students' alternative conceptions identified in the pretest and pre-interview. Examination of the posttest results suggested that the EG students had fewer alternative conceptions after instruction. For example, the students in EG had completely corrected the following two alternative conceptions in the posttest: (i) *Acidic substances taste bitter and peppery*; (ii) *Bases are composed of acids* (Table 3). However, in the CG group, all of these alternative conceptions were retained.

Table 3. Percentages of students' alternative conceptions before and after the intervention

Alternative conceptions (AC)	Experimental Group		Control Group	
	Pretest (%)	Posttest (%)	Pretest (%)	Posttest (%)
1. In the formulas, species containing H are acids and species containing OH are bases	63	21	47	24
2. Acidic substances taste bitter and peppery	26	0	24	12
3. While acids are poisonous, bases are not	58	32	65	47
4. Acids burn and melt everything	63	11	59	29
5. Bases are composed of acids	37	0	35	6
6. The only way to test a sample whether it is an acid or a base is to see if it melts something	42	5	53	12
If we add Na metal into acidic solution, it; -				
7. melts	32	16	47	29
8. burns	26	16	29	15
9. disappears	26	21	18	12
10. While aqueous solutions of ~~the~~ acids conduct electricity, bases are not	32	5	35	12
11. Electrical conductivity of all acids and bases are the same	26	11	29	6
12. We can determine the strength of an acid or base by using litmus paper	11	21	6	35

Two of the alternative conceptions held by the most students before the implementation were "*while the acids are poisonous, bases not*" and "*acids burn and melt everything*". These have also been common in related literature (Demircioğlu, Ayas & Demircioğlu, 2005; Özmen, Demircioğlu & Coll, 2009).

While the former was held by 58% of the EG students and 65% of the CG students in pretest, these ratios were 32% and 47% in posttest. The latter showed a decrease from 63% to 11% from pretest to posttest for the EG students and from 59% to 29% for the CG students. In the present study, worksheet A was used to overcome these alternative conceptions in EG. As seen in Appendix A, it consisted of a concept cartoon aiming to activate students' preconceptions, and practical activities that gave students the opportunity to actually experience the effects of different indicators on some acids and bases found in laboratory and examples of acidic and basic substances used in daily life; and to taste some weak acidic and basic substances. From the practical activities, the students were able to see that some weak acidic and basic substances could be tasted. As a result, they could see that acids did not burn and melt everything and that not all acids were poisonous. After students completed the practical activities, they were asked to discuss the results of the activities and to compare with their pre-conceptions. Based on this, most of the EG students dispelled their alternative conceptions. That the practical activities are effective in remedying alternative conceptions related to acids and bases is also reported by Özmen, Demircioğlu and Coll (2009). They used practical laboratory activities in teaching of acids and bases and found that such activities increased students' understanding. Of course, the CG students also dispelled their alternative conceptions to a certain extent. But Nevertheless, teacher in the CG did not use worksheets including concept cartoons and alternative conceptions. For this reason, the EG students became more successful than the CG ones in remedying alternative conceptions.

One of the alternative conceptions was that "*in the formulas, species containing H are acids and species containing OH are bases*" (see Table 3, AC-1). This was held by 63% of the EG students in pretest and 21% in posttest, while these ratios were 47% in pretest and 24% in posttest for the CG students. This is also a common alternative conception in the literature (Acar Sesen & Tarhan, 2011; Demircioğlu, 2009; Demircioğlu, Ayas & Demircioğlu, 2005). In all levels, students believe that if a matter contains H, it is an acid; if a matter contains OH, it is a base. We think that there may be a few reasons for such erroneous ideas. One of them may be poor explanations and examples given by teachers while describing the theories of acids and bases in their courses. Another one may be microscopic nature of these concepts. In this study, it was used species containing OH in their formula such as CH3COOH, containing H such as NH3, H2O, CH4 and containing neither H nor

OH such as CO2, MgO in the worksheet A and E in order to remedying the AC-1. After discussing the acidic and basic properties of these species, the teacher emphasized that aqueous solutions of some species are not basic although they contain OH group (for example, CH3COOH). Besides, aqueous solutions of some species are basic although they contain H (for example NH3); some species are not acidic although they contain H (for example, H2O and CH4); and aqueous solutions of some species are acidic although they do not contain H (for example CO2). These examples show students that having H in the formula is not a unique criterion for determining acidic and basic properties of the solutions of these species. Students have already seen this truth during the activities. Teachers often think that some concepts are very simple and students learn them easily when they are explained in detail. We know from the literature that traditional approaches, especially verbal explanations, are not effective for remedying students' alternative conceptions because of their resistant nature to change (BouJaoude, 1991).

Another alternative conception was that "*the only way to test a sample whether it is an acid or a base is to see if it melts something*" (see Table 3, AC – 6) and this is most common in the literature (Özmen, Demircioğlu & Coll, 2009). This was held by 42% of the EG students in pretest and 5% in posttest; and for the CG students, these ratios were 53% in pretest and 12% in posttest. In the study, the worksheet A and B struggled with AC-6 in EG. For this aim, in worksheet A, students tried to test acidic and basic properties of some matters by using litmus paper, pH paper, red cabbage, phenol phatelyn, tasting, and slippery feel. Also, in worksheet B, students had opportunity to see the effect of different acids and bases on various matters. For example, in one of the activities, a piece of meat was put into hydrochloric acid, nitric acids, ammonia and sodium hydroxide solutions, separately. After waiting for a while, students observed the change on the surface of the meat. In another activity found in worksheet B, students dropped lemon juice, vinegar, and soapsuds onto their hands and observed that these acids and bases did not affect their hands. These two activities showed students that while some of the acids and bases affected the matters, some others did not. This observation says us that whether a sample melt matters or not is not only way to classify it as acidic or basic. Based on these activities, most of the students in EG dispelled their alternative conception (see Table 3, AC – 6).

Another alternative conception was that "*we can determine the strength of an acid or base by using litmus paper*" (AC – 12).This is different from others. As follows, AC – 12was held by 11% of the EG students and 6% of the CG students in pretest, and these ratios were 21% and 35% in posttest, respectively. The results show that there is an increase in ratios of the AC – 12in both groups from pretest to posttest. These increases in the ratios are amazing for us. Because, worksheet E is exactly about the determination of the strength of acids and bases via pH paper and students made some activities by using pH paper. And also, AC – 12 was already located in the concept cartoon section of the worksheet E and discussed in the groups. In the study, students in the EG also used litmus paper to determine acidic and basic properties of matters in worksheet A and B. For this reason, a number of students in this group may think that they could use litmus paper instead of pH paper to determine the strength of acids and/or bases. On the other hand, the CG's students also had AC – 12 and its ratio increased from pretest to posttest. Similarly, the CG's teacher informed her students that litmus paper was used to test acidic and basic properties of matters and then made some simple testing activities. Although she talked about the pH paper, students did not make practical activities by using it. Therefore, this might have caused such a view that we could determine the strength of an acid or base by using litmus paper.

Conclusion

This paper tried to determine the effectiveness of laboratory activities supported by concept cartoons on students' understanding of acid-base concepts, and in remedying alternative conceptions for these topics. The results show that the intervention enhanced students' understanding for acid-base chemistry, and hands-on nature of the practical works and concept cartoons were particularly helpful for the students. Although students in both groups improved their performance, the EG performed better, overall. The positive effect of laboratory activities on students' chemistry achievement is well known and phrased in the related literature (e.g. Hart et al. 2000; Lazarowitz & Tamir, 1994; Özmen, Demircioğlu & Coll, 2009). In similar, the positive effect of concept cartoons on students' achievement is also reported by several researchers (Kabapınar, 2005; Perales-Palacios & Vilchez-Gonzalez, 2002; Stephenson & Warwick 2002). However, we also know that each teaching method has some limitations if it is used single. For example, Nakhleh, Polles and Malina (2002) report that laboratory work often lacks purpose or well-defined learning objectives. Similarly, Fisher (1997) reported that the visitors who saw a humorous cartoon had less retention of the instructional material and scored lower on the test. As authors, we believe that a combination of these two methods might have enhanced the effect of each other. The results show that combining the pedagogies of laboratory-based activities and concept cartoon may be a useful strategy for teaching acid-base concepts. On the other hand, some of the alternative conceptions are still encountered after the implementation. This indicates that concept cartoon enhanced laboratory activities also has failed to overcome some students' alternative conceptions towards scientific ones. For this reason, laboratory activities enhanced with concept cartoons also needs to be integrated with some other contemporary teaching methods to be more effective in enhancing students' learning of acid-base chemistry concepts. Namely, researchers may also improve our approach by integrating new teaching methods into this cooperation.

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APPENDIXES

Appendix 1. The final version of the ABAT ((*): Asterisk indicates correct answer)

1. Which one of the following statements about acids is correct?

a. Acids have bubbles

b. All species producing an acidic solution with water contain H atom in the formulas

c. Some weak acids can be tasted (*)

d. Acids melt and destroy everything

2. Which one of the following statements does define the concept of ACID the most correctly?

a. If a species contains H in its formula and can give it to water, it is an acid

b. If a species increases the amount of H^+ ion when it dissolves in water, it is an acid (*)

c. If a species increases the amount of OH^- ion when it dissolves in water, it is an acid

d. If a species melts and destroys everything, it is an acid

3. Which one of the following statements about the properties of some species used in daily life is wrong?

a. Orange juice are sour in taste

b. Window cleaners are soapy to touch

c. Solution of the sugar is basic (*)

d. The unripe apple is acidic

4. Which one of the following statements related to acids, bases and salts is incorrect?

a. Acids are sour in taste, bases are bitter in taste

b. Substance which are neither acidic nor basic are called neutral

c. Acids turn blue litmus red and bases turn red litmus blue

d. All of the salt solutions are neutral (*)

5. What kinds of beakers should be used to store acidic solutions such as lemon juice and vinegar?

a. Beakers made of iron

b. Beakers made of glass (*)

c. Beakers made of zinc

d. Beakers made of aluminum

6. Which one of the following statements does define the concept of BASE the most correctly?

a. If a species contains OH in its formula and can give it to water, it is a base

b. Bases are the matters that are composed of acids

c. If a species increases the amount of OH^- ion when it dissolves in water, it is a base (*)

d. Species that can be used as household chemicals are bases

7. Which one of the following reactions is a neutralization reaction?

a. $KOH + HCI \rightarrow NaCI + H_2O$ (*)

b. $Ca + 2HCI \rightarrow CaCI_2 + H_2$

c. $CO + ½ O_2 \rightarrow CO_2$

d. $NaOH \rightarrow Na^+ + OH^-$

8. Which one of the following statements related to acids and bases is correct?

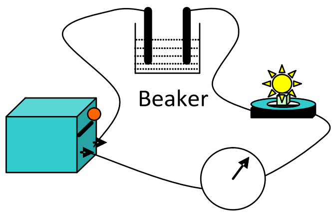
a. While acids are poisonous and harmful, bases are harmless

b. Acids burn and melt everything

c. Aqueous solutions of bases conduct electricity (*)

d. If we mix an acid with a base, a neutral solution occurs every time

9. Suppose that each of the following solutions is separately put into the beaker in adjacent figure. Which one will not light the bulb?



a. Lemon juice b. Soap solution

c. Solution of table salt d. Alcoholic water (*)

10. I. Solution K do not conduct electricity

II. Solution L turns red litmus blue

III. Solution M produces bubbles when it contacts a piece of metal

If you consider the given information, which of the below solutions can be K, L and M solutions?

	K	L	M
a.	Sugar solution	Lemon juice	Vinegar
b.	Salt solution	Soap solution	Vinegar
c.	Distilled water	Vinegar	Soap solution
d.	Distilled water	Soap solution	Lemon juice (*)

11. Which one of the following species should be used for rubbing the skin to decrease the effect of the sting of a honeybee?

a. Lemon juice   b. Vinegar   c. Soap solution (*)   d. Unripe apple juice

12. pH values of some solutions are given in adjacent table. If you consider the given information, which of the below solutions can be X, Y and Z solutions?

	X	**Y**	**Z**
pH	4	7	11

	X	**Y**	**Z**
a.	Salt solution	Vinegar	Lemon juice
b.	Lemon juice	Salt solution	Ammonia (*)
c.	Soap solution	Salt solution	Ammonia
d.	Vinegar	Ammonia	Lemon juice

13. Which one of the following statements is the most correct regarding acids?

a. All acids are poisonous
b. All strong acids cannot dissociate in water
c. An aqueous solution of acid can highly conduct electricity (*)
d. A strong acid can react with metal to produce more bubbles than a weak acid

14. In an aqueous solution, it is determined that the amount of H^+ ions is less than the amount of OH^- ions. Which one(s) of the following statements is/are correct for this solution?

I. It is basic   II. It is acidic
III. It conducts electricity   IV. It turns blue litmus red

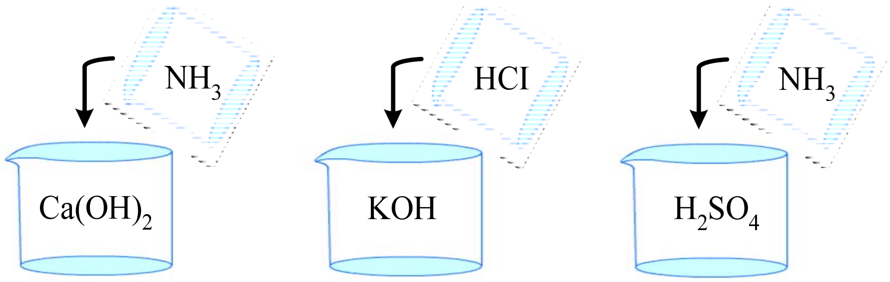
a. I and III (*)   b. II and IV   c. I, III and IV   d. II, III and IV

15. Which one(s) of the following statements about the pH values of acidic or basic matters used in daily life is/are wrong?

	Matter	pH value
I.	Vinegar	3
II.	Bread	9
III.	Apple	4
IV.	Milk	12

a. II and IV (*)   b. II and IIII   c. I, II and III   d. II, III and IV

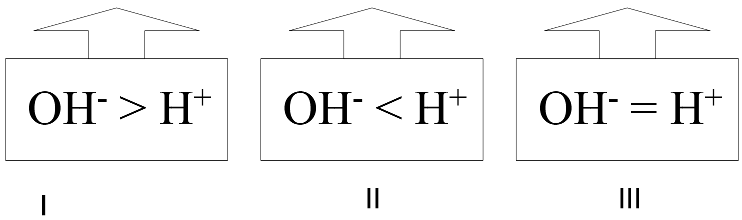
16.



Which one of the beakers has reaction when the species are mixed as seen in figure?

a. Only I　　b. Only II　　c. Both I and II　　d. Both II and III (*)

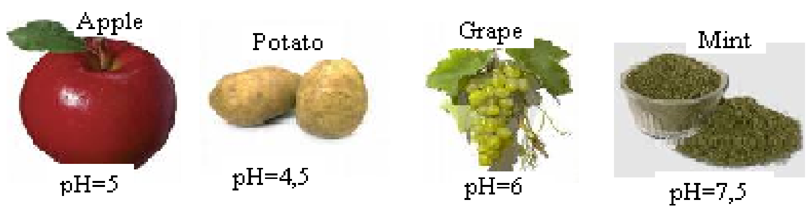
17.



Which one of the below views is incorrect related to solutions found in above beakers?

a. The solution found in beaker I is acidic (*)
b. pH value of the solution found in beaker III is equal to 7
c. Acidity of the solution found in beaker II is the greatest
d. The reaction between solution I and solution III forms salt and water

18.



Which one of the following statements about the plants given pH values is wrong?

a. The potato is the most acidic one
b. The grape is more acidic than the apple (*)
c. The mint shows basic property
d. The apple is more acidic than the mint

19. Which one of the following statements is the most correct regarding bases?

a. Base is highly soluble in water

b. All bases are corrosive

c. Compounds that do not contain OH can also be basic (*)

d. Aqueous solutions of bases cannot conduct electricity

20. Which one of the following statements is absolutely correct for a solution if the pH value of it is less than 7?

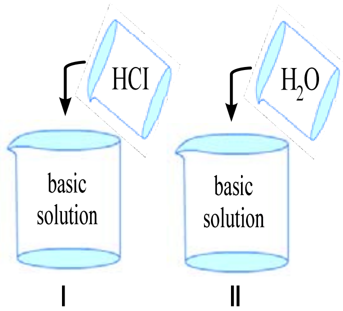
a. It is a salt solution

b. It is a basic solution

c. It is an acidic solution (*)

d. It is a neutral solution

21. There are some aqueous solutions of a base in two separate beakers. If we add some aqueous solution of HCl into the beaker I and some water into the beaker II like adjacent figure, what can be said about the basicity of the solutions in beaker I and II?



a. Basicity decreases in both beakers (*)

b. Basicity increases in beaker I, decreases in beaker II

c. Basicity decreases in beaker I, increases in beaker II

d. Basicity decreases in beaker I, does not change in beaker II

22. Which one of the following statements is incorrect for acidic solutions?

a. Acidic solutions conduct electricity

b. Acidic solutions turn blue litmus red

c. Acidic solutions are soapy to touch (*)

d. Acidic solutions react with basic solutions to give salt and water

23. We know that acids turn blue litmus red and bases turn red litmus blue. If a piece of **blue litmus** is plunged into the following solutions separately, what can be said the color of the litmus paper?

	Soap solution	**Vinegar**	**Lemon juice**	**Soda water**
a.	Red	Blue	Blue	Blue
b.	Blue	Blue	Blue	Red
c.	Red	Red	Blue	Blue
d.	Red	Blue	Blue	Red (*)

24. Plants do not grow well when the soil is either too acidic or too basic. What do you suggest the farmer to do if the soil is too acidic?

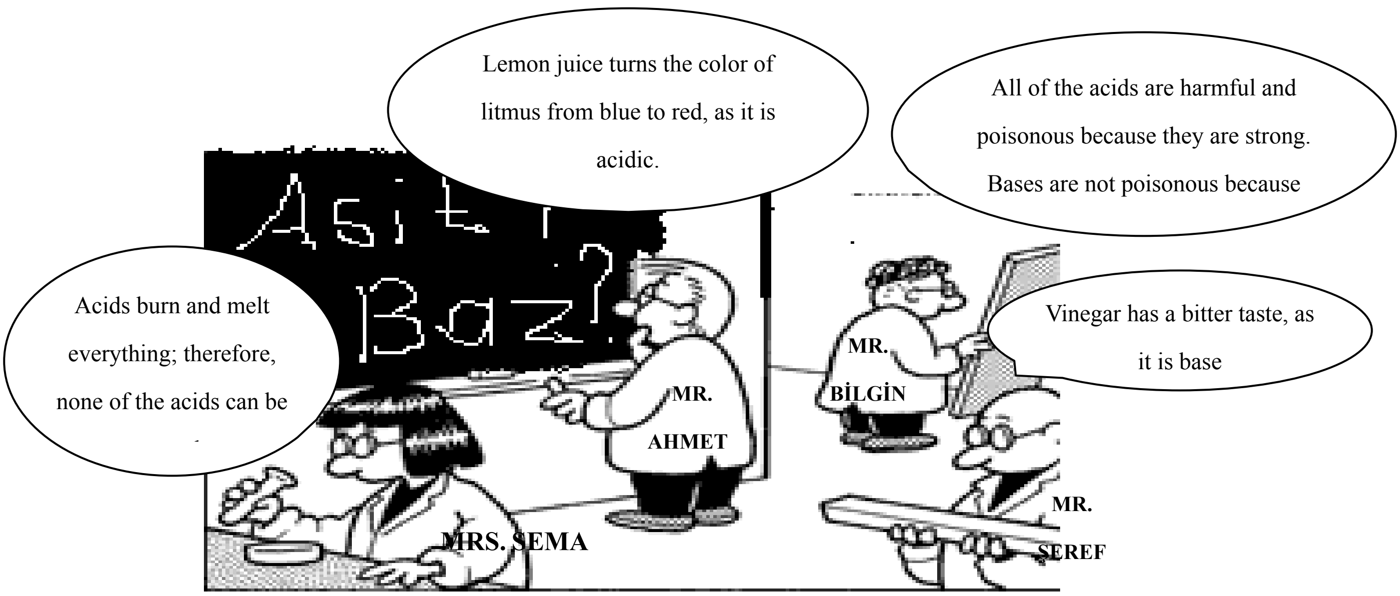
a. He should add salt to soil
b. He should add slaked lime to soil (*)
c. He should add water to soil
d. He should fallow the soil

25.
I. It reacts with some metals to give bubbles
II. Aqueous solution of it conducts electricity
III. It turns red litmus blue

Which one(s) of the above statements is/ are correct for basic solutions?

a. Only I   b. Only II   c. Both I and III   d. Both II and III (*)

Appendix 2 (Worksheet A): Let's Diagnose Acidic and Basic Properties of Matters



A group of researchers investigates acids and bases and they share collected data with each other. In your view which of the data is correct? Please explain why you think like this.

………………………………………………………………………………………………
………………………………………………………………………………………………
………………………………………………………………………………………

Please check your ideas by making activities in below

Please be careful while using acids and bases. Open the faucet and pour the acid on water while pouring the waste acid into the sink. Wash all over the skin with plenty of water if acid contacts with skin.

Required Equipment and Substances:

14 test tube, hydrochloric acid, sodium hydroxide, water, red and blue litmus, dropping pipette, phenol phatelyn, soapsuds, lemon juice, vinegar, toothpaste, bleach, red cabbage

Procedure:

❀ Please put both red and blue litmus into the liquids found in the test tubes, separately. Watch the color change of litmus and fill on the below table.

Substances	Litmus		Phenol phatelyn	Taste (*)	Red cabbage	Slippery feel
	Blue	Red				
Hydrochloric acid*						
Sodium hydroxide*						
Bleach*						
Lemon juice						
Vinegar						
Toothpaste						
Soap solution						

ATTENTION: Do not taste the substances with asterisk, absolutely

- ❖ Add a few drop phenol phatelyn into the solutions found in the test tubes. Watch the color change of litmus and fill in the table.
- ❖ Taste the lemon, vinegar, soapsuds and diluted toothpaste and fill in the table.
- ❖ Test the slippery feel of the substances by touching except hydrochloric acid and sodium hydroxide and fill in the table.

Respond the questions based on your observation:

1. How acids and bases do affect the litmus paper?

   ...…………………………….……………………………………………………

2. How the colors of phenol phatelyn are in acid and base?

   …………...…………………………………………………………………

   …...

3. How the colors of red cabbage solution are in acid and base?

- Mince and crush the red cabbage and heat a few minutes by adding some water. Filter the solution and cool. Repeat the same procedure made by litmus and phenol phatelyn for red cabbage solution.

Is there any difference between your ideas before and after these activities? Which of the researchers is straight with us? Write your opinions in detail. ………………………………………………………………………………………………
……………………………………………………………………………

If the following substances spoke, what would they say about their acidity or basicity?

Write some acidic and basic substances, which we use in daily life for, eat and drink.

ACID	1-	2-	3-
BASE	1-	2-	3-