Application of Context-Based Educational Approaches to Correct Students' Misconceptions on Acid-Base Chemistry

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ABESTRACT: This research was to investigate the application of context-Based educational approaches to correct students' Misconceptions on Acid-Base chemistry. Research is applied in terms of purpose and is a Quasi-experimental design research. Research design was double-group with pre-test, post-test and delayed test for both test and control groups.

The statistical population of research was consisting of all female and male senior high school students of experimental sciences in West Azerbaijan province, in the academic year 2016-2017. At the time of conducting this research, the total number of these students was reported 9188 which using the Cochran formula, 264 students was selected as statistical sample of research. To data collection, we used Acid-Base Chemistry Misconception Test (ACMT), CLASS-Chemistry questionnaire and researcher-made learning questionnaire.

The data analyses of this research were performed using spss software and applying various descriptive and inferential statistics methods. The results obtained from evaluation of research hypotheses using Levin test, independent t-test, and covariance analysis test showed that context-based educational approach based on virtual laboratory and exploration had positive and meaningful effect on improving learning and motivation and changing the attitude of the students regarding Acid-Base concepts. The findings of this research also showed that the application of this educational method decreased students' Misconceptions on Acid-Base chemistry and even corrected them, compared to traditional and common methods.

Keywords: Context-based approaches, Students' misconceptions, Chemistry education, Acid-Base chemistry

Introduction

Researches have shown that students have various Misconceptions about different scientific topics (Alain, 2010). Among hordes of scientific topics, acid and base chemistry is one of the concepts related to everyday human life and form the foundation of the science of chemistry and in most curriculums, learning this topic is suggested from early elementary grades. Acids and bases are among very important and fundamental topics in teaching chemistry topics and concepts.

Acid-base reactions explain many chemical changes and simultaneously investigate three macroscopic, molecular and symbolic thinking levels. Since most of acid and base concepts are abstract, they create problems in their learning and teaching processes which result in many wrong perceptions in chemistry classes and consequently many questions arise regarding the wrong perceptions of students (Gilbert, 2006). Many factors can be considered as the source of correct Students' Misconceptions. Previous experiences of the student, common use of some terms in scientific and non-scientific languages, not paying attention to the terms used in the class, contexts and images in the textbooks, teaching method, etc. are all effective in forming misunderstandings in the students (Badrian and Safari, 2016). Identifying misconception of students is important and can be considered as a first step in avoiding misconceptions in chemistry. The identification of the students' understandings and misconceptions has been the goal of many studies carried out over the last years (Ozmen, 2004).

Different research works conducted on the nature and environment of learning have shown that most of the research conducted on this context have focused on external factors of the learning such as teaching methods, strategies, qualification of teachers, textbooks, teaching contents and class environment. However, it should be kept in mind that the learners are not separated from learning capacity and their minds cannot be considered as empty containers which should be filled by teacher (Mirzaei et al., 2016). Before entering the class, students have lots of opportunity to make their mental patterns and imaginations regarding different scientific phenomenaand the world around them. Many of their mental imaginations come from their daily experiences, observation of scientific phenomena and application of science and technology in their lives and when these topics are discussed in the class they appear as pre-imagination or pre-learning and affect teaching-learning process. False and non-scientific imaginations of the students are among important factors hindering meaningful and efficient learning and have negative effect on the stability of learning in higher levels (Gönen & Kocakaya, 2010). Authors describe these self-made concepts of students with different terms such as misthought, misunderstanding, raw imagination, common perception, false imagination or pre-imagination (Badrian, 1394).

Research have shown that compared to other terms, Misconception is more commonly used as an abstract concept in scientific texts (Demircioglu et al., 2005; Mokhtar and Harizal, 2012; Weldi Manuel, 2014). Since Misconceptions help students in understanding the world around, they are hard to change and therefore they disturb learning process. The more the knowledge of teachers on the misunderstandings of their students are, the better they can prepare them to learn. Therefore, it can be said that teaching sciences includes knowing the structures of students regarding scientific explanation of scientific phenomena (Mirzaei et al., 1394). Today, structuralism is considered as the foundation of teaching sciences and the foundation of structuralism is construction of concepts in the minds of the learners; in other words structuralists believe that new knowledge is not passively transferred from teacher to student, but it is actively constructed in the mind of the learner. Sometimes the knowledge of the students originate from their misconceptions and this hinders learning knew knowledge; childhood misconceptions may hinder learning of science even in adulthood unless they are corrected (Donovan & Bransford, 2005).

Active learning is based on structuralism and plays a vital role in preventing misunderstanding (Bonder, 1996). Not many years ago, learning content was considered as the only important factor, but in recent years, in addition to content, a special attention has to be paid to the situation of learning. New theories of learning believe that cognition and learning should be situated. Therefore the context, in which cognition and learning are achieved, is of significant importance. To activate students in the process of learning chemistry, contexts should be found that are attractive and meaningful for them. In new curriculums, contexts should be chosen in a way that students can see importance and application of what they learn and therefore gain the motivation required for the expansionof their knowledge in different directions.

Educational scientists and authors have found that one of the best ways educational methods for improving chemical knowledge of the public is context based education of chemistry (Bennet & Holman, 2002); i.e. presenting contexts justifiable by chemistry. Now, according to different properties and advantages of context based education of chemistry and the great amount of attention paid to it in most countries of the world, in the recent years, context based curriculums for chemistry has been designed and expanded in many developed countries. Context based curriculum and practical programs are different for different countries. Context based discussions are related to content, stimulation of learning, a framework for expansion and application of knowledge and competencies. The meaning of context in designing context based education has been closely investigated by Gilbert (2006) and Parchmann et al. (2006).

Context based approach in the education of scientific chemical topics has its roots in the creation of contexts and relations selected from daily events. The aim of context based education is to fill the gap between daily experiences of the students and the contents of chemistry lessons. Investigations have shown that context based education causes efficiency of teaching method and better learning among the students. This method increases motivation, vision and academic progress of students in learning chemistry and helps them succeed in understanding scientific concepts (Magwilang, 2016).

In a research, Rasmand (1997) compared the performances of context based and traditional approaches in teaching chemistry. Context based approach caused motivation and attraction of students toward chemistry. Also, motivation, positive perception and success of students in chemistry were witnessed (Ulusoy and Onen, 2014).

Mahafi (2004), by introducing teaching of chemistry with social and technological approach for the completion of taxonomy of Johnstone’s thinking levels, believes that in addition to three macroscopic, molecular and symbolic levels, there has to be a fourth level as contextual level and teaching and learning chemistry should be performed in a three dimensional manner.

In contextual thinking level, students should be able to use what they learn in their daily life activities and gain a correct understanding of applications of chemical concepts in their daily lives. This thinking level is achieved when the students find themselves in situations suitable for learning and get familiar with practical contexts of their learnt concepts (Gilbert, 2006).

It seems that the application of context based approach can be effective in correcting misunderstandings of students and learning basic concepts of different sciences, especially in acid and base topics of chemistry. Therefore, in the present research we tried to address this challenging question that if the application of context based approach can have a significant compact on learning basic conceptions of chemistry specially in this regard on the correction of Students’ misconceptions?

Methodology

This research was applied in terms of objective, and semi-experimental in terms of method. Research design was double-group with pre-test, post-test and delayed test for both test and control groups. In this research the samples were selected non-randomly. Statistical population of this research involved 9188 XII grade students were studying experimental science field senior high schools in West Azerbaijan province in Iran.

Using Cochran formula, 264 of them were selected as the statistical sample of the research from 12 classes of boys and girls from 6 schools in three different regions of wealthy, semi-wealthy, and non-wealthy students in the education office of West Azerbaijan province. From these 12 classes, 6 classes were assigned as test and the remaining 6 classes were assigned as control groups.

For collecting the required data, we used diagnostic test of misconception in form Acid-Base Chemistry Misconception test (ACMT) in related to students' misconceptions in acid-base chemistry topic with eighteen items, CLASS-Chem questionnaire (Colorado Learning Attitudes about Science Survey) with forty items on a 5- point likert scale and a researcher-made questionnaire with twenty items to measurer students' achievement in learning chemistry lessen.

The reliability of each questionnaires were calculated based on cornbach's alpha And the values were respectively 0.814,0.96,0.89. Also contact validity of researcher-made evaluated by two chemistry lecturers and four experienced teachers and has been approved. And the values were

Procedure

The teachers of the experimental group was introduced to the Context-based learning (CBL) and to the teaching strategy (Context-based approach) for two weeks and underwent training on the appropriate use of the CBL before implementation in order to be sure that the CBL was used as we planned. In addition, the researchers held meetings as often as necessary to correct any misuse of the CBL as well as the teaching strategy. First, in this research we considered two classes from each school, one as an experimental groups and the other as a control groups, in the second stage in the experimental groups the acid-base concepts were taught through context-based method for 8 weeks. Finally after performing all tests the obtained results have been analyzed Both experimental and control groups were observed during the implementation of the unit. In a typical instructional sequence, while the experimental teacher tried to help their students recognize and resolve the conflict between personal knowledge and scientific knowledge with the CBL, the control group teacher used a teacher-centered approach mainly involving talk and chalk sessions without practical sessions. As an example, the implementation procedure of one of the worksheets is described below:

The first stage of each worksheet was focused on the misconceptions described at the top of each worksheet (Table 1). At this stage, the students encountered the misconceptions without any indication that they were misconceptions. This was used at the start of the lesson to create a context-based method. During this process, the misconceptions were checked up in our sample. The students (pre-test) indicated that these phrases were generally true. If the students have different misconceptions, other than the ones on the worksheet they were discussed before going forward to the actual activity. These were usually done before the second stage. Then the practical activity on the worksheet was carried out to create a clear sign of the concept under investigation in the students. mind. At the end of each practical activity, small group (four or five students per group) and whole class discussions took place under the guidance of the class teacher to encourage students to think about their misconceptions and the outcome of the activity. After these discussions, the students have changed their misconceptions, as well as the misconceptions presented at the top of each worksheet, to scientifically sound concepts. In each of the activities, we generally preferred to use substances often used in daily life, such as lemon juice, red cabbage, vinegar, baking soda, coke, etc. In addition, the teacher made use of the pre-designed analogies for some concepts, such as theories of acid and base, relative strengths of acids and bases and equilibrium of weak acid and base. Also, experiments that could be harmful to the students were demonstrated by the teacher.

Table 1: Example of a worksheet used in the study

The purpose of the following activity is to remedy the following student misconceptions.

i: whether a liquid is an acid or a base can just be determined by using litmus paper.

ii: The only way to test a sample whether it is an acid or a base is to see if it eats something away, for example metal, plastic.

iii: All Fruits are Neutral.

iv: Acids burn and melt everything .

v : Indicators help with neutralization .

Carrying out the activity: In this test you will be using two known indicators and red-cabbage juice and violet carrots juice. Follow the sequence in the chart below. In each test, place about 5 cm3 of each solution in different test tubes.Then place 2-3 drops of the indicator into each of the test tubes. Carefully record the color in the test tubes.You are going to test the unknown solution after finishing the other tests .

Matters	Colour of litmus paper	Methyl orange	Colour of red cabbage	Colour of Puple(violet) carrots	Taste of matters
Tap water					
Rain water					
Soda water					
Distilled water					
Soapy water					
Lemon juice					
Coca-cola					
Milk					
Aspirin					
Shampoo					
Orange juice					
Strawberry					
Apple juice					
Plum					
Vinegar					
Tomato					
An unknown solution					

Questions: Which solutions used in the activity are acidic? Why?

Can you use red-cabbage juice and violet carrots juice to test a liquid whether it is an acid or a base?

What do you have to know about an indicator before you use it? Why?

Results and Discussion

The results of the *t*-test (Table 2,3,4) also denoted that significant differences found between groups in favor of experimental group, with regard to their attitudes toward chemistry.

Table 2. Independent group t-test result for pre, post and delayed test score of ACMT test

test	Pre-test		Post-test		Delayed test	
Groups	CG	EG	CG	EG	CG	EG
N	132	132	132	132	132	132
Mean misconceptions	12.5	11.74	7.23	2.37	8.37	6.36
SD	3.28	1.3	4.33	0.806	3.19	1.34
t	1.93		12.66		6.69	
p	0.055 >0.05		0.000 <0.05		0.000 <0.05	

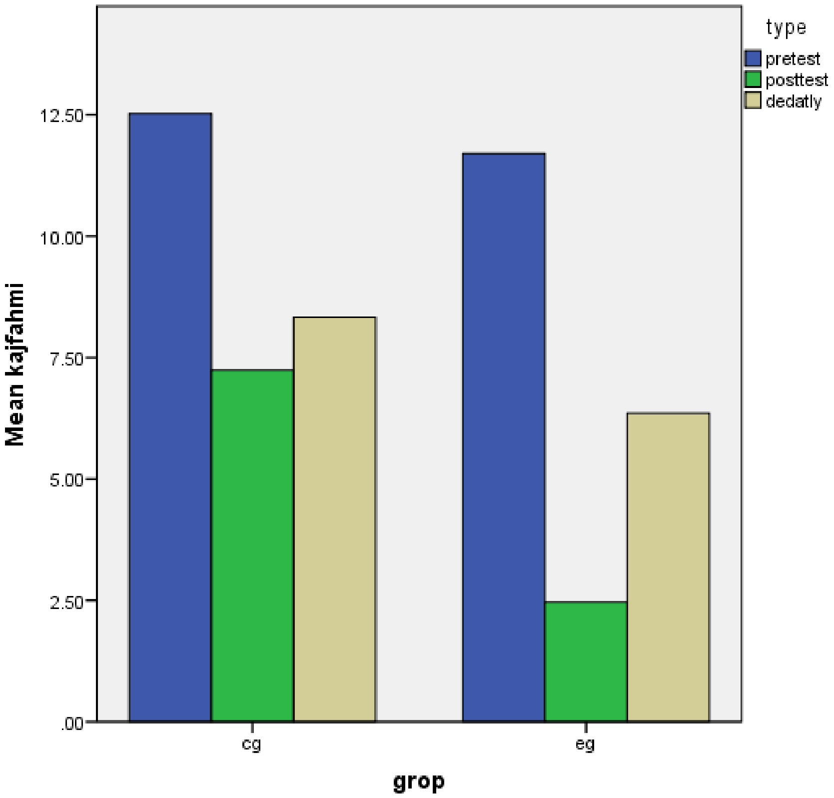

Figure 1. Independent group t-test result for pre, post and delayed test score of ACMT test

Table 3. Independent group t-test result for pre, post and delayed test score of CLASS-Chem test

test	Pre-test		Post-test		Delayed test	
Groups	CG	EG	CG	EG	CG	EG
N	132	132	132	132	132	132
Mean	225.88	228.21	266.25	281.03	212.66	248.25
SD	23.73	23.04	6.21	5.56	14.51	12.24
t	-0.8		-21.54		-20.37	
p	0.42>0.05		0.000 <0.05		0.000 <0.05	

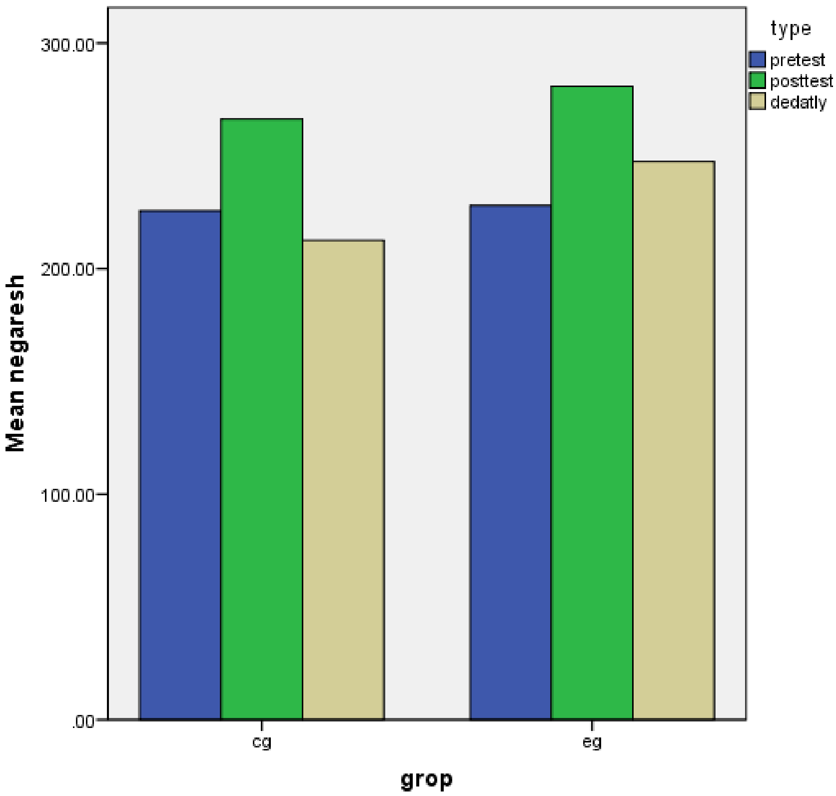

Figure 2. Independent group t-test result for pre, post and delayed test score of CLASS-Chem test

Table 4. Independent group t-test result for pre, post and delayed test score of chemistry learning test

test	Pre-test		Post-test		Delayed test	
Groups	CG	EG	CG	EG	CG	EG
N	132	132	132	132	132	132
Mean	3.86	3.9	12.95	15.06	13.31	14.32
SD	1.05	1.06	3.46	2.08	2.03	1.75
t	-0.351		-6.005		-4.32	
p	0.73>0.05		0.000 <0.05		0.000 <0.05	

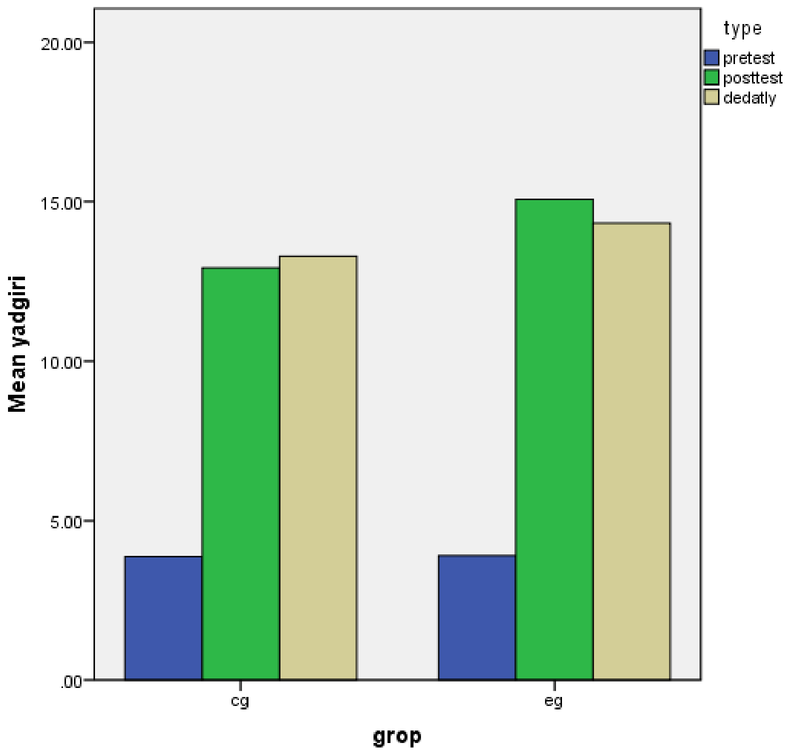

Figure 3. Independent group t-test result for pre, post and delayed test score of chemistry learning test

Investigation of research first hypothesis :

In table 5, presented covariance analysis results for determining chemistry learning average differences in control and experimental groups. Statistics F amount for randomized variable(pre-test) is equal with 5.73 and also it is significant statistically (P<0.05) also we conclude that , post-test scores were effected by pre-test scores. For group or intervention test (Field-centered approach) must be removed pre-test effect as a randomized variable which it is named diffraction. According to table 5 , F amount has significant effect in field-centered approach in exploiting and artificial laboratory and it is equal with 4.27(P<0.05) So we conclude that field-centered approach cause to changes in groups. Research first hypothesis was presented based on learning with field-centered approach against traditional learning method and enhancing of students learning was confirmed in basic and acidic concepts.

- Table 5. Covariance analysis for investigation chemistry learning difference in control and experiment group:

Changes resources	Total of squares	Freedom degree	Squares average	F	Significance
Pre-test	228.34	4	57.08	5.73	0.000
Group	228.34	1	228.34	4.27	0.009
Error	45.75	4.59	9.966		

Investigation of research second hypothesis:

In table 6 , presented covariance analysis results for determining viewpoints average differences against chemistry learning in control and experimental groups. Statistics F amount for randomized variable(pre-test) is equal with 3.57 and also it is significant statistically. (P<0.05) Also we conclude that , post-test scores were effected by pre-test scores. For group or intervention test (Field-centered approach) must be removed pre-test effect as a randomized variable which it is named diffraction. According to table 6 , F amount has significant effect in field-centered approach is equal with 246.79 (P<0.05) So we conclude that field-centered approach cause to changes in groups. Therefore , research second hypothesis was presented based on learning with field-centered approach against traditional learning method and enhancing of students learning and viewpoints were confirmed in basic and acidic concepts.

- Table 6. Covariance analysis for investigation viewpoint differences of chemistry learning in control and experiment group:

Changes resources	Total of squares	Freedom degree	Squares average	F	Significance
Pre-test	2916.71	82	35.57	3.57	0.029
Group	8876.789	1	8876.789	246.79	0.000
Error	2508.301	69.74	35.97		

Investigation of research third hypothesis:

In table 7 , presented covariance analysis results for determining misunderstanding average differences in basic and acidic concepts in control and experimental groups. Statistics F amount for randomized variable(pre-test) is equal with 4.04 and also it is significant statistically. ($P<0.05$) Also we conclude that , post-test scores were effected by pre-test scores. For group or intervention test (Field-centered approach in exploiting and artificial laboratory) must be removed pre-test effect as a randomized variable which it is named diffraction. According to table 7 , F amount has significant effect in field-centered approach is equal with 46.45 ($P<0.05$) So we conclude that field-centered approach cause to changes in groups. Therefore , research third hypothesis was presented based on learning with field-centered approach against traditional learning method and enhancing of students learning and motivation, viewpoints changing and also reducing students misunderstanding were confirmed in basic and acidic concepts.

- Table 7. Covariance analysis for investigation misconceptions differences in control and experiment group:

Changes resources	Total of squares	Freedom degree	Squares average	F	Significance
Pre-test	884.66	12	73.72	4.04	0.002
Group	709.641	1	709.641	46.452	0.000
Error	273.641	17.912	15.28		

students' misconceptions and The percentages of the students' misconceptions in both groups on the pre-test and post-test and the delayed test are given in Table 8 and Table 9.As can be seen from Table 9, the students in both groups held almost the same misconceptions on the pre-tests. The misconceptions obtained from the subject of this study support previous findings in the literature (Ross et al., 1991; Hand et al., 1991; Nakhleh et al., 1994; Ayas et al., 2002; Demircioğlu, 2003.). Prior to the instruction, the percentages of the misconceptions held by the students in the control group ranged from 28 % to 78 %, and those of the students in the experimental group ranged from 30 % to 72 %, as shown in Table 9. This shows that the subjects have a great number of misconceptions related to the concepts under investigation. Before the treatment, the most common misconception among students in both groups was that " Hydrolysis is to being separated of a matter into its ions by water " (Table 8).
result showed that when chemistry concepts were related to everyday life during teaching, their retention in the learner.s mind was greater. This finding was similar to that of Ross and Munby (1991). They found that the students retain everyday concepts more than are scientific concepts. After the instruction, the most common misconception was that " *required students to predict the pH of a solution of 10^{-8} M HCI. The majority of the students reasoned that the pH of the solution would be 8. The students' written responses about this question showed that they simply used the equation of pH = -Log [H^+] tofind out the pH of the solution, as indicated in the following excerpt from one of the writtenresponses:*
"HCI → H+ + CI- pH=-Log [H+] => pH=-Log [10^{-8}] and so, pH= 8"
with 42% of the control group and 30% of the experimental group holding it. The misconception indicated that most of the students, especially in the control group, failed to realize the central role of water in neutralization reactions. The concentration of H_3O^+ and OH^- ions in the neutral aqueous solution is about 10^{-7} mol/l. Therefore, neutral doesn.t mean that the two are not present in the medium. In the literature, Schmidt.s (1991, 1995)

suggestion for the reason of this misconception was that students misunderstood the concepts of neutralization and neutrality.

Table 8. Students' misconceptions identified through students' written responses.

	Students' misconceptions
1	Equilibrium system in acidic or basic solution is not affected by the temperature :
1a	pH of pure water is always equal to 7
1b	Neutral solution is equivalent with pH = 7 (Halstead, 2009)
1c	K_w water equals to 1.0 x 10^{-14}
2	In calculation of pH using the formula pH = -log[H3O+], [H3O+] is just from the solute (A solution of 10^{-8} M HCI has a pH of 8)
3	Neutralization of acid and base always gives a neutral product
4	In a neutralization reaction, when one of the reactants (acid or base) is weak, the neutralization does not completely take place
5	All salts are neutral
6	Hydrolysis is to being separated of a matter into its ions by water
7	A strong acid is always a concentrated acid
8	At the end of all neutralization reactions ,there are neither H^+ nor OH^- ions in the resulting solutions
9	As the number of hydrogen atoms increases in the formula of an acid, its acidity becomes stronger
10	Species having formulas with hydrogen are acids and those having formulas with hydroxyl are bases :
10a	PH_3 is an acidic compound
10b	NaH is an acidic compound
10c	$B(OH)_3$ is an basic compound
11	Acids burn and melt everything
12	The only way to test a sample whether it is an acid or a base is to see if it eats something away
13	All Fruits are Neutral
14	Bronsted-Lowry theory can explain all acid-base reaction

Table 9. The percentages of students. misconceptions determined in the pre-test, post-test and Delayed test in the experimental and control groups

Student Misconceptions	Control Group N=132						Experimental Group N=132					
	Pre-test		Post-test		Delayed test		Pre-test		Post-test		Delayed test	
	f	%	f	%	f	%	f	%	f	%	f	%
1a	83	63	32	24	40	30	81	61	24	18	28	21
1b	70	53	34	26	44	33	75	57	18	14	25	19
1c	84	64	40	30	50	38	87	66	29	22	36	27
2	94	71	48	36	55	42	91	69	32	24	40	30
3	54	41	21	16	29	22	51	39	15	11	21	16
4	67	51	26	20	36	27	70	53	20	15	26	20
5	81	61	33	25	40	30	78	59	22	17	32	24
6	103	78	37	28	45	34	95	72	26	20	37	28
7	88	67	34	26	42	32	83	63	21	16	34	26
8	53	40	16	12	21	16	58	44	11	8	18	14
9	74	56	29	22	36	27	79	60	18	14	26	20
10a	55	42	13	10	18	14	61	46	8	6	13	10
10b	50	38	10	8	11	8	45	34	5	4	11	8
10c	91	69	42	32	54	41	88	67	25	19	29	22
11	71	54	24	18	13	10	74	56	13	10	8	6
12	54	41	20	15	29	22	51	39	7	5	11	8
13	37	28	16	12	24	18	40	30	11	8	18	14
14	91	69	40	30	49	37	88	67	24	18	32	24

Conclusions and Implications

Chemistry is central to designing new medicines, developing new sources of energy and analysing contaminants in our food chain. An understanding of chemistry is required to address major issues facing humanity, such as global warming and clean water supply. It truly is the central science.

When we look at our curricula at school, little of this richness is apparent. The subject is taught in discrete chunks of facts, often disconnected. Chemistry syllabuses have been described as being like a ladder, with rungs representing information. We seem to insist that students must climb each rung of the ladder before getting to the top, before they can see the point of it all. It's no surprise then that numerous research studies have found that students have difficulty relating concepts and think chemistry is disconnected from everyday life. In addition, there is a logical flaw with our content dominated approach. The French philosopher of science Henri Poincaré once wrote that 'science is built up with facts, as a house is with stones. But a collection of facts is no more a science than a heap of stones is a house.' What elevates science from being a collection of facts is the knowledge of how to apply these facts to new situations.

Context-based learning (CBL) is an approach that turns these ladders on their side, so they become supports for a platform representing a context. Students are presented the everyday relevance, or context, up front. The teaching of chemistry necessary to understanding the context emanate from this, reaching into appropriate topics, as required. Considered this way, the CBL approach has several benefits. It shifts away from overloading curricula with content, with a focus on rote memorisation of isolated facts. There is an emphasis on how we know information instead of what we know. Armed with knowledge of these facts as a result of completing the context, as well as a knowledge of how the context problem was addressed, students can develop the ability to transfer what they know to unfamiliar scenarios – the 'how to' aspect of scientific enquiry, currently missing from our curricula..(Gilbert, 2006)

The results indicate that training with the Application of context-based educational approaches to correct Students' Misconceptions on Acid-Base Chemistry was more successful in remedying students' misconceptions on acids and bases than conventional instruction. This result supported the notion that it is not easy to eliminate misconceptions just by employing traditional instructional methods. The students participation in the practical activities has caused not only greater understanding but also greater interest in the study of chemistry. So, while teaching acids and bases, teachers should organize activities that encourage students to use their prior knowledge and experience, and also provide them with opportunities to apply the newly acquired concepts in a variety of situations. That is, instructional strategy should focus on: first, what is known or unknown about the concepts of acids and bases, and then the new knowledge should be constructed upon existing knowledge. We have concluded that the Students' misconceptions of the concepts of the acids and bases generally originated from their experiences in everyday life. So, when preparing a teaching program and student-activities on the concepts, it is very important to include everyday substances in the activities. Additionally, the students in both groups had more difficulty in understanding the neutralization (titration process) and related concepts than the others in the unit, because of the complex structure of the neutralization concept. In the teaching of this concept, in addition to simple titration activities that we used in this study,using different technologies, especially microcomputer-based activities could be suggested as better teaching tools (Nakhleh et al., 1993).

Another important conclusion was that the students in the experimental group attained more positive attitudes toward chemistry than did those in the control group. This result indicated that the Context-based approaches achieved success in moving the students' attitudes in the desired direction.

Teachers should be aware of students’ prior knowledge and misconceptions on acids and bases, because they are strong predictors of student achievement. In short, when suitable strategies are used in the teaching of the unit ’acids and bases‘, they are more likely to cause a significantly better removal of misconceptions and acquisition of scientifically sound concepts. In addition, chemistry teachers should be encouraged to prepare teaching materials related to the other chemistry topics in the light of the models of Context-based approach.

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