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ABSTRACT

This paper explores the effect of using concept maps as study tools on achievement in chemistry. Tenth grade students engaged in building concept maps as homework to investigate the correlation between their mastery of concept mapping skills and their achievement in chemistry, and gender differences in using concept mapping as a homework tool. This study provides some insight into the use of concept mapping as a homework tool and provides significant results concerning its different effects on different sex groups where females achieved higher scores than males on chemistry tests, especially on questions at the knowledge and comprehension levels. The results also show that concept mapping helped low achievers achieve higher in chemistry. Students exhibited positive attitudes toward using concept maps in chemistry. (KHR)

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The Effect of using Concept Maps as Study Tools on Achievement in Chemistry

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The Effect of using Concept Maps as Study Tools on Achievement in Chemistry

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Introduction

Since the beginning of the twentieth century, there has been a tremendous growth in the quantity of useful scientific information (Moore, 1989). Society has entered a new age. It needs responsible and scientifically literate individuals who can analyze and anticipate novel problems rather than memorize disparate facts. Society needs individuals with potential to change and adapt (American Association for the Advancement of Science [AAAS], 1989). In this context, learning science becomes a vehicle that enables learners to get better control over the meanings that shape their lives (Novak, 1998).

However, what is happening in the schools is not promising. The decline in students' performance and interest in science is becoming noticeable (Markow & Lonning, 1998). Secondary school and college students' knowledge of science is often characterized by lack of coherence. The large majority of students engage in essentially rote learning most of the time (BouJaoude & Barakat, 2000; BouJaoude & Tamim; 2000; Brandt, Elen, Hellemans, Heerman, Couwenberg, Volckaert, & Morisse, 2001; Nakhleh, 1992; Wandersee, 1990). The problems are twofold. First, the abstract and highly conceptual nature of science seems to be particularly difficult for students. Second, the techniques used in the classroom do not make the learning process sufficiently easy for students (Gabel, 1999; Schmid & Telaro, 1990). These problems are quite serious in chemistry (Gabel, 1999; Moore, 1989). Chemistry is widely perceived as a difficult subject because of its specialized language, mathematical and abstract conceptual nature, and the amount of material that needs to be learned (Gabel, 1999). The prevailing teaching techniques ignore educational theories that point out the advantages of actively involving students in the learning process. Thus, students do not feel in charge of their own learning (Francisco, Nicoll, & Trautmann, 1998).

According to Novak (1998) educators have a well-developed understanding of how people learn and enormous advances in educational theory and tools are available about the quality of the knowledge creation process. However, Novak is astonished how little of this knowledge is put into practice in academic settings. He attributes major societal problems to failures in education and sees in the coming era an exciting time for educators to challenge the new world of globalization. For him, the main concern of educators should be to help people learn how to educate themselves (Novak, 1984), and lead to a constructive change in a person's ability to cope with experience (Novak, 1998).

The most important criterion to facilitate these efforts is to place the students in an active rather than a passive role (Moore, 1989). The knowledge that empowers and increases the self-confidence of the learner is that which results from the union of individual actions, feelings, and conscious thoughts (Novak, 1998). People learn by being active, and a person is not an empty vessel to be filled with information. Information that develops by rote memorization disempowers learners and develops in them the fear of learning because it is irrelevant to their own experiences. In addition, information learned by rote in the absence of connection with previously acquired frameworks will be largely forgotten (Novak, 1998). The goal of education should be to develop educational experiences that facilitate meaningful learning, and reduce the need for rote learning.

Ausubel (1968) describes meaningful learning as the establishment of non-arbitrary relations among concepts in the learners mind. Novak (1998) sees that meaningful learning would only be achieved if the learner chooses to relate new information to ideas s/he already knows. Thus, meaningful learning will occur if the learner has relevant prior knowledge and meaningful learning material. Moreover, the learner should be willing to understand and apply the effort needed to attain meaningful understanding of the topic at hand (Novak, 1998).

Concept Mapping

As the problem of improving the teaching/learning process preoccupies educators, concept mapping holds promise in enhancing meaningful learning. Concept mapping has been used in science education in a variety of ways. It is a flexible tool that can be applied in a variety of frameworks (Stewart, Van-Kirk, & Rowell, 1979). Concept maps, for example, can play a remarkable role in curriculum development, evaluation, learning, and teaching in many disciplines (Novak, 1984).

Concept maps are useful in science curriculum planning for separating significant from trivial examples (Starr & Krajcik, 1990). They help focus the attention of curriculum designers on the teaching

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of concepts and on the distinction between curricular and instructional contents, that is between curricular content that is intended to be learned and the instructional techniques which will serve as vehicles for learning (Stewart et al., 1979). Furthermore, concept maps have been used as assessment tools. Concept maps measure dimensions different from those revealed in commonly used psychometric instruments and therefore there has been increased research interest on their validity and reliability (Markham, Mintzes, & Jones, 1994).

Concept mapping has been used as an instructional tool in a variety of contexts. Each context reflected an alternative theory of knowledge acquisition. On the one hand, the rationalist theory of learning suggests that there is an inherent structure of a discipline to be conveyed to the learner. The student concept map must then evolve in convergence to an ideal map or teacher-constructed map or an expert concept map. On the other hand, the constructivist theory of learning appreciates the implementation of concept mapping in examining the changes in content and emphasizing the uniqueness of each individual's concept map representation with respect to organization of concepts and their construction (Beyerebach & Smith, 1990). Nevertheless, both theories agree that learning will only occur if the learned concepts get organized in a certain cognitive structure.

Concept maps help the learner in making evident the key concepts or propositions to be learned and suggesting linkages between new and previous knowledge. Concept maps have been used at all educational levels and in many content areas, such as biology and to a lesser extent in physics, in an attempt to find more conceptually based methods of teaching and learning (Starr & Krajcik, 1990). However, little research has focused on the implementation of concept mapping in chemistry classrooms. Results of these research studies were not always consistent with each other resulting in the need for further studies to investigate the effect of using concept mapping in chemistry.

In summary, many students struggle to learn chemistry, but they are often unsuccessful. The reason suggested by several research studies is that many of them do not construct appropriate understanding of fundamental chemical concepts throughout their educational experiences (Nakhleh, 1992). Instead of having well structured and integrated domain-specific knowledge structures, students consider the different concepts as isolated elements of knowledge. This lack of integration may be the main reason for difficulties concerning concept formation and application of acquired knowledge (Brandt et al., 2001). Thus, concept mapping as a method to build explicit links and relations between concepts and as a study technique is expected to stimulate the construction of integrated knowledge structures by students. Therefore, students will be expected to achieve better in tests that measure high level thinking skills.

In addition, research has demonstrated that concept mapping is a skill that requires time for mastery. As a study strategy, it is most effective if it is used on an on-going basis over the course of instruction. Thus, when students build concept maps in homework assignments recurrently, they will get the chance to revise their understanding by modifying their maps leading to better understanding. Furthermore, because of personal involvement and ability to revise offered by homework assignments, concept mapping is expected to help students overcome difficulties in understanding abstract and complex science concepts by integrating them into well-structured cognitive frameworks. In this context, homework assignment will be used to lead students into mastery in building concept maps and applying concept mapping is expected to enhance meaningful learning in understanding complex chemistry concepts.

Purpose

The purpose of this study was to answer the following questions:

1. Will grade 10 students who engage in building concept mapping as homework have significantly higher grades on chemistry achievement school tests than grade 10 students who do not engage in building concept mapping as homework tool?

2. Will the use of concept mapping as homework with Grade 10 students have significantly different effects on students with different achievement levels?

3. Will the use of concept mapping as homework tool with Grade 10 students have significantly different effects on males and females?

4. Will there be a significant correlation between the students' mastery of concept mapping skill and their achievement in chemistry?

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Method

Participants

Participants in this study were sixty Grade 10 chemistry students from a co-educational private high school in Lebanon. They were divided into two sections and stratified based on achievement, which is the school policy. For the purposes of the study, the sections were randomly assigned to the experimental and control groups.

Instruments

Chemistry Achievement Tests

The dependent variable in this study is the students' chemistry achievement. Two tests were used to measure achievement. One of the tests measured students' pre-requisite knowledge in topics related to the ones covered during the study (Appendix I). The second test measured student achievement at the conclusion of the study (Appendix II.)

According to Lehman, Carter, and Kahle (1985) and Willerman and MacHarg (1991), a test must be at the comprehension level and above in order to measure meaningful learning. Consequently, most items on the achievement tests used in this study were at the comprehension level or above. The pre-test assessed students' achievement in solubility equilibrium. The post-test assessed students' achievement in acid/base titration and weak acids equilibrium. A table of specifications was used to make sure that the items on the two tests represented the content. Moreover, a detailed description of the six levels of Blooms' taxonomy (Bloom, 1969) was used to make sure that the items were at the different levels of Blooms taxonomy, with most of the items at the comprehension level or above. Two science education faculty members, a science teacher, and a chemistry education doctoral student were provided with the objectives based on which the lesson plans and tests were designed along with a detailed description and examples of Bloom's taxonomy and were asked to classify the test items and match them with objectives. Differences in classification were discussed among the faculty members, teacher, and doctoral student and the researcher in order to reach consensus.

Concept Map Scoring Rubric

The researchers developed an expert concept map (Appendix III) and a scoring rubric to monitor students when constructing concept maps (Appendix IV). The scoring rubric used in this study combined the qualitative analysis of gross structure and the quantitative analysis of links, in order to provide a valuable tool to highlight the key characteristics of concept maps. The qualitative "spoke-chain-net" classification put forward by Kinchin, Hay, and Adams (2000) is able to describe the gross changes in a concept map which is indicative of radical restructuring. In addition, the degree of valid cross-linkage, the amount of branching, and the hierarchical structure are included in the analysis because they reflect associative and superordinate-subordinate categorical relationships among concepts. As for the quantitative analysis of the concept maps, it consisted of three dimensions: the links' validity, convergence, and salience. McClure, Sonak and Suen (1999) showed that the most reliable scoring protocols are those that focus on the links in the map, the element over which pupils seem to have the most difficulty, but which reveals a good deal about their depth of understanding. In the scoring rubric, each proposition is scored from zero to three in accordance with the following scoring protocol: zero is assigned to invalid links, the links that were built based on wrong scientific information. One is assigned to the link that joins interrelated concepts but that misses the label. Two is given to the link that is scientifically correct and has a possible label indicated, but did not specify the direction. Three is given to the correctly labeled links with the directions specified by an arrow.

Convergence measures the extent to which the possible links were actualized in the students' maps. The convergence score is computed as the number of the valid links in a map divided by the number of all possible links as derived from the expert map. Finally, salience measures the abundance of valid links. Salience is computed as the number of valid links divided by the number of all links in a student's map.

Procedure

The treatment took place during the third term of the school year. The students were pre-tested using a teacher-constructed chemistry achievement test. The study extended over six weeks. The class met five times per week for fifty minutes daily. The material covered was acid base titration and weak acids equilibrium. At the end of the treatment period, the students were post-tested. Students in the experimental group were required to answer eight open-ended reflection questions regarding their experience in constructing concept maps as homework.

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A different instructor taught each section. The researcher was in charge of the experimental group, where students were trained to use concept mapping as a study tool. A different teacher was in charge of the control group, where students covered the same chemistry content with regular exercises assigned as homework. It is important to note that the two sections involved in the study, although taught by two different teachers, had similar score averages during the first and the second semesters of the academic year during which the study was conducted. Moreover, both teachers followed a teaching pacing-chart, which contained a detailed hourly breakdown of the material to be covered, established at the beginning of the semester, to make sure that the teachers covered the same material using the same methodologies. Finally, the tests used before the start of the study consisted of high-order thinking skill questions as per school policy

The treatment period was divided into two parts. The first part consisted of training the experimental group students to use concept mapping as a study tool. One preliminary session was assigned at the beginning of the study to introduce concept mapping as a study tool, then an example of a concept map was provided followed by an application. For the remaining part of the first week students in the experimental group were accorded, towards the end of each session, some time to practice the construction of concept maps using a concept list provided by the teacher. The concept lists were related to the material taught in class, they included chemistry concepts known to students in order to help them focus on learning the process of concept mapping.

During the second week, students in the experimental group were required to construct concept maps using the concept lists identified in class. These concept maps were corrected by referring to the researcher built scoring rubric and turned back the next day to the students. The corrected maps included detailed feedback to help student ameliorate the skill of concept mapping. At the end of the second week, the second part of the treatment started and the experimental and control groups started the acid-base titration chapter, which took four more weeks to complete.

The students in the experimental group were required to submit twice per week a concept map constructed by using the concepts taught in class. The teacher did not provide the list of concepts to the students. At the end of the treatment period, both the experimental and control group students took the post-test as a periodic chemistry achievement test. Additionally, the experimental group answered eight open-ended reflection questions on the experience of constructing concept maps as homework.

Results

Pre-Test

Means and standard deviations for pre-test scores in chemistry were calculated. The mean score for the experimental group was found to be 30.66, while that of the control group was found to be 29.28 out of a maximum possible score of 45. A t-test for independent samples was carried out to test whether the experimental and the control groups differed significantly on pre-test achievement in chemistry. Non-significant differences were found with $t = 0.68$ ($p > 0.05$).

Post-Test

Because there were no significant differences on the pretest, it can be assumed that the two groups started out with equivalent means. Means and standard deviations for the scores in the chemistry achievement post-test were calculated. Table 1 presents the means and standard deviations of the posttest results for the control and experimental groups. These results include the scores on the knowledge (K-post), comprehension (C-post), and application-and-above (App-post) level questions along with the total scores on the chemistry achievement post-test (Tot-post). Note that the maximum score on the knowledge level questions is 11, the maximum score on the comprehension level questions is 7, the maximum score on the Application Level-and- above questions is 22, and the maximum score on the chemistry achievement post-test is 40.

A t test for independent samples was carried out to test whether the experimental and the control groups differed significantly on the post-test achievement in chemistry (Tot-post). No significant differences were found ($t = 1.55$, $p > 0.05$).

In addition, a t-test for independent samples was carried out to test whether the scores of the experimental and control groups differed significantly on the questions at different cognitive levels. A significant difference was found for the questions at the knowledge level (k-post) ($t = 1.97$, $p < 0.05$) on which the experimental group scored 8% higher than the control group. No significant differences were found at the comprehension level ($t = 1.75$, $p < 0.05$) and application-and-above level ($t = 1.07$, $p < 0.05$). Results are shown in Table 1.

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Table 1
Means and standard deviations of the variables used in the study for the Control and Experimental Groups

	Control			Experimental			T
	N	M	SD	N	M	SD	
K-post	30	7.53	2.08	29	8.45	1.40	1.97*
C-post	30	3.81	2.29	29	4.71	1.61	1.75
App-post	30	13.48	5.37	28 [a]	14.75	3.55	1.07
Tot-post	30	24.83	8.92	28 [a]	27.84	5.68	1.55

* $P < 0.05$
K-post = scores of knowledge level questions in the chemistry achievement post-test (the maximum score is 11).
C-post = scores on comprehension level questions in the chemistry achievement post-test (maximum score is 7).
App-post = scores of the Application-and-above level questions in the chemistry achievement post-test (maximum score is 22).
Tot-post = Total scores on the chemistry achievement post-test (the maximum score is 40).
[a] one of the scores on the Application level in the experimental group was not valid

Sex Group Interaction. Another test was conducted to see whether or not there were group-sex interactions. To investigate group-sex interactions a two-way ANOVA was conducted with sex and group as the two variables. Table 2 shows that there was a significant interaction between group and sex. To find the sources of the interaction, the means of males and females on the post-test for the control and experimental group were calculated (Table 3). Table 3 shows that while the scores of females in the control group were lower than those of the males', their scores increased more significantly then the males. The mean of the females in the experimental group was 18% higher that that of the females in the control group, while the mean of the males did not differ significantly between groups.

Table 2
Analysis of Variance for Group-Sex interactions on the chemistry Achievement Post-Test (Tot-post)

Source	SS	df	MS	F
Sex	0.33	1	0.33	0.002
Group	177.81	1	177.81	1.12
Sex X Group	158.47	1	158.47	2.84***

*** $P < 0.1$

Table 3
Mean Scores of Males and Females on the Chemistry Achievement Post-Test (Tot-post)

	Control			Experimental		
	N	M	SD	N	M	SD
Males	20	26.01	8.39	14[a]	26.21	6.06
Females	10	22.45	9.91	14	29.46	4.95

[a] one of the achievement scores in the males experimental group was invalid.
[b] Total score on the chemistry Achievement test is 40.

A two-way ANOVA was performed to check whether there were group-sex interactions for the different level questions. Table 4 shows that there was a significant interaction between group and sex at the knowledge level. To find the sources of the interaction, the means of males and females on the knowledge level post-test questions were calculated for the control and experimental groups (Table 5). Table 5 shows that while the females' scores in the control group were lower than those of the males', their scores increased more significantly then those of the males. The mean for the females in the experimental group was 19% higher than that of the females in the control group, while the mean of the males increased by 9%.

Table 4
Analysis of Variance for Group-Sex interactions on the Knowledge Level Questions (k-post) in the Chemistry Achievement Post-Test

Source	SS	df	MS	F
Sex	1.24	1	1.24	0.10
Group	17.87	1	17.87	1.42
Sex X Group	12.56	1	12.56	4.13*

*Significant at $p < 0.05$

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Table 5

Mean Scores of Males and Females on the Knowledge Level Questions in the Chemistry Achievement Post-Test

	Control			Experimental		
	N	M	SD	N	M	SD
Males	20	7.95	1.99	15	8.13	1.51
Females	10	6.70	2.11	14	8.79	1.25

Note: The total score on the Knowledge level questions is 11

Table 6 shows that there was a significant interaction between group and sex at the comprehension level. To find the sources of the interaction, the means of males and females on the comprehension level post-test scores were calculated for the control and experimental groups (Table 7). Table 7 shows that while the scores of the females in the control group were lower than those of the males; their scores increased more significantly then those of the males. The mean of the females in the experimental group was 28.4% higher than that of the females in the control group, while the mean of the males increased by 1.5%. Finally, there was no significant interaction between group and sex at the application level scores (Table 8).

Table 6

Analysis of Variance for Group-Sex interactions on the Comprehension Level Questions in the Chemistry Achievement Post-Test (C-post)

Source	SS	df	MS	F
Sex	0.44	1	0.44	0.04
Group	15.16	1	15.16	1.23
Sex X Group	12.29	1	12.29	3.20***

*** $p < 0.1$

Table 7

Mean Scores of Males and Females on the Comprehension Level Questions in the Chemistry Achievement Post-Test (C-post)

	Control			Experimental		
	N	M	SD	N	M	SD
Males	20	4.06	2.30	15	4.17	1.30
Females	10	3.30	2.31	14	5.29	1.74

Table 8

Analysis of Variance for Group-Sex interactions on the Application level and above Questions in the Chemistry Achievement Post-Test (App-post)

Source	SS	Df	MS	F
Sex	0.24	1	0.24	0.01
Group	31.77	1	31.77	1.16
Sex X Group	27.46	1	27.46	1.29

Group - Achievement Level Interactions. Students in both groups were reassigned to one of two achievement levels. Students who scored below the mean on the chemistry post-test were assigned to one achievement level (Achlevel I) and students who scored above the mean were assigned to another achievement level (Achlevel II). Consequently, a test was carried out to see whether there were group-achievement level interactions on the total scores of the chemistry achievement post-test. Results are shown in Table 9 which shows that there was a Group-Achievement level interaction. To find the sources of interaction, the means of Achlevel I and Achlevel II groups were calculated for both control and experimental groups (Table 10). Table 10 shows that the mean of the Achlevel I in the experimental group is 8% higher than that in the control group. While the mean of the Achlevel II in the control group is 5% higher than that in the experimental group. Note that the number of students that scored above the mean (Achlevel II) in the experimental group (19 out of 28) is larger than that of the students who scored above the mean (Achlevel II) in the control group (14 out of 30).

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Table 9

Analysis of Variance for Group-Achievement Level Interactions on the Chemistry Achievement Post-Test (Tot-post)

Source	SS	Df	MS	F
Achlevel	2148.92	1	2148.92	22.79
Group	6.95	1	6.95	0.07
Achlevel X Group	94.28	1	94.28	6.21*

Achlevel = Achievement level of students on the post-test in chemistry
*P < 0.05

Table 10

Mean Scores of Achievement Level I and Achievement level II groups on the Chemistry Achievement Post-Test (Tot-post)

	Control			Experimental		
	N	M	SD	N	M	SD
Achlevel I	16	17.69	5.16	9[a]	21.06	2.63
Achlevel II	14	32.98	3.49	19	31.05	3.37

[a] one of the achievement scores in the males experimental group was invalid.
[b] Total score on the chemistry Achievement test is 40

Another two-way ANOVA was performed to check whether there were group-achievement level interactions at the knowledge, comprehension, and application-and- above level questions respectively (Tables 11,13, and 15). Table 11 presents the results of the two-way ANOVA test at the knowledge level. No significant interaction was recorded. This is consistent with the results of the t-test that showed significance between the scores of the knowledge level questions in the chemistry achievement post-test. Table 11 also shows a significant effect for the achievement levels. The means for the Achlevel I and Achlevel II groups at the knowledge level were therefore calculated (Table 12). Table 12 shows that the Achlevel II group scored 20% higher than the Achlevel I group on the knowledge level questions.

Table 11

Analysis of Variance for Group-Achievement Level Interactions on the Knowledge Level Questions in the Chemistry Achievement Post-Test (K-post).

Source	SS	df	MS	F
Achlevel	67.52	1	67.52	6712.74*
Group	2.33	1	2.33	231.46*
Achlevel X Group	1.01×10^{-2}	1	1.01×10^{-2}	0.005

Achlevel = Achievement level of students on the post-test in chemistry
*P < 0.05

Table 12

Mean Scores of the Achievement I and Achievement II Level Groups on the Knowledge Level Questions in the Chemistry Achievement Post-Test.

	Achlevel I			Achlevel II		
	N	M	SD	N	M	SD
K-post	26	6.73	1.80	33	8.97	1.10

Achlevel = Achievement level of students on the post-test in chemistry
K-post = scores of the knowledge level questions in the chemistry achievement post-test.
Note: The Total score on the Knowledge level questions is 11

Table 13 presents the results of the two-way ANOVA test at the comprehension level. Significant interaction between group and achievement levels was found. To identify the sources of interaction, the means of Achlevel I and Achlevel II at the comprehension level were calculated for both control and experimental groups (Table 14). Table 14 shows that the mean of the Achlevel I in the experimental group is 21.5% higher than that in the control group while the mean of the Achlevel II in the control group is 7% higher than that in the experimental group. Note that the number of students who scored above the mean (Achlevel II) in the experimental group (19 out of 29) is larger than that of the students who scored above the mean (Achlevel II) in the control group (14 out of 30).

Table 13

Analysis of Variance for Group-Achievement Level Interactions on the Comprehension Level Questions in the Chemistry Achievement Post-Test (C-post).

Source	SS	df	MS	F
Achlevel	113.50	1	113.50	11.20
Group	1.77	1	1.77	0.17
Achlevel X Group	10.13	1	10.13	6.01*

Achlevel = Achievement level of students on the post-test in chemistry
*P < 0.05

Table 14

Means of Achievement Levels in the Control and Experimental Groups at the Comprehension Level in the Chemistry Achievement Post-Test (C-post).

	Control			Experimental		
	N	M	SD	N	M	SD
Achlevel I	16	2.05	1.37	10	3.55	1.38
Achlevel II	14	5.82	1.17	19	5.31	1.39

Achlevel = Achievement level of students on the post-test in chemistry
Note: The Total score on the Comprehension level questions is 7

Table 15 represents the results of the two-way ANOVA test at the application-and above level. Significant interaction between group and achievement levels was recorded. To find the sources of interaction, the means of Achlevel I and Achlevel II group scores at the application -and-above level were calculated for both control and experimental groups (Table 16). Table 16 shows that the Achlevel I group mean in the experimental group is 8% larger than that of the control group while the mean of the Achlevel II in the control group is 8% higher than that in the experimental group. Note that the number of students that scored above the mean (Achlevel II) in the experimental group (19 out of 28) is larger than that of the students who scored above the mean (Achlevel II) in the control group (14 out of 30).

Table 15

Analysis of Variance for Group-Achievement Level Interactions on the Application level -and-above Questions in the Chemistry Achievement Post-Test (App-post).

Source	SS	Df	MS	F
Achlevel	755.45	1	755.45	17.20
Group	4.76×10^{-2}	1	4.76×10^{-2}	0.001
Achlevel X Group	43.92	1	43.92	7.16*

Achlevel = Achievement level of students on the post-test in chemistry
*P < 0.05

Table 16

Means of Achievement Levels in the Control and Experimental Groups at the Application and Above Level in the Chemistry Achievement Post-Test (App-post).

	Control			Experimental		
	N	M	SD	N	M	SD
Achlevel I	16	9.14	3.08	9[a]	10.89	1.83
Achlevel II	14	18.45	1.90	19	16.58	2.53

[a] one of the scores on the Application levels in the experimental group was not valid
Note: The Total score on the Application Level -and-above questions is 22

Correlation between Chemistry and Concept Mapping Subscores

The correlation between experimental group students' chemistry test scores were correlated with the corresponding concept map subscores on salience, conversion, and Total on the last concept map constructed they before the post-test was calculated. Results are shown in Table 17, which shows that the salience score did not show significant correlation with any of the question levels in the chemistry achievement test. The convergence scores, however, showed a significant correlation with the application -and-above level questions and the total scores on the achievement test, and showed non-significant correlations with the knowledge and comprehension levels. Finally, the total scores on the concept map, showed a significant correlation with the application -and-above level questions and the total scores on the achievement test, and non-significant correlations with the knowledge and comprehension levels.

Table 17
Correlation between Concept Map No.4 Subscores and the Post Achievement Test Scores

	K-post	C-post	App-post	Tot-post
		Students (n=28)		
CMSal	0.19	0.12	0.18	0.18
CMConv	0.39	0.31	0.61**	0.55**
CMTot	0.41	0.32	0.61**	0.55**

**Correlation is significant at the 0.01 level (2-tailed).
C-post= scores on the comprehension level questions in the chemistry achievement post-test.
K-post = scores of the knowledge level questions in the chemistry achievement post-test.
App-post = scores of the Application -and-above level questions in the chemistry achievement post-test.
Tot-post = Total scores on the chemistry achievement post-test.
CMSal= salience score on the last concept map
CMConv=convergence score on the last concept map
CMTot= Total score on the last concept map

A high CMSal score means that the student concept map includes a high number of correct propositions. A high CMConv score means that the student concept map is close to the expert concept map. A high CMTot score means that the student included in his or her concept map a larger number of directional correct propositions.

Results of the Reflections Questionnaire

The student in the experimental group answered eight open-ended reflection questions on their experience in constructing concept maps as homework at the end of the treatment period. Results of analysis of the students' responses to the questions are summarized below.

When the students in the experimental group were asked about the difficulties they faced at the beginning of concept map construction, 66% said they faced few problems. The problems were mainly in arranging the concept in hierarchies, especially when there were a large number of concepts. They also faced problems in stating the right label and determining the right direction for the links between concepts. However 76% said that after practice, at the end of the treatment period, they did not have any more problems in building concept maps. As for the other 24%, who were still facing problems, they had difficulties in forming correct links and cross-links and were not able to include all concepts in a clear presentation.

All the students agreed that concept mapping was a good technique for studying. Their reasons could be summarized as following: Student suggested that concept mapping helped them organize information leading to better understanding and the ability to answer questions easily, assisted them in summarizing the learned material which made revision for exams much easier, helped them retain the learned concepts for a longer time, and was instrumental in aiding them to identify their mistakes.

As for the students' reply when they were asked about using concept mapping in other subjects than chemistry, 97% said that concept mapping was a good technique for studying academic subjects. Thirty one percent of them said they would use concept mapping in studying only for chemistry because chemistry is a subject that has many concepts and their definitions need to be linked and memorized. Moreover, 35% said that concept mapping could be used in all subjects, not only in chemistry, because all material should be organized to make studying easier. The rest of the students (31%) said that they would use concept mapping in some subjects only because concept mapping works best for subjects that contain a lot of definitions and interrelated concepts such as biology and chemistry while courses like math and physics require mainly calculations and numerical applications.

When the students were asked to give their general comments on the experience of using concept mapping for studying, and to suggest any improvement on the use of this technique, all of them agreed

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that the use of concept mapping in studying is beneficial. It helps to organize the new information learned, saves them for longer time in the mind, and simplifies tasks.

Twenty eight percent of the students had no suggestions to improve the application of concept mapping; they found it beneficial as it is designed in the study. However, 58% suggested improvements. On the one hand, as concept mapping is a new skill to be learned, they found that learners would need more guidance at the beginning. They suggested that concept mapping would be done in class as group work and corrected also in class then, maybe at a later time, it could be done individually. Students also suggested that the concept mapping correction rubric, given as feedback, would be more efficient if discussed individually in more details. On the other hand, as concept mapping can be sometimes cumbersome, they suggested building concept maps less frequently and using computers to make the presentation clearer.

Discussion

Using concept mapping as a homework tool was expected to result in better achievement in chemistry. These expectations were based on the assumptions that this tool organizes information, fosters metacognition, and engages students in building their knowledge structures.

Results showed that the mean score of the chemistry achievement pre-test of the experimental group was slightly higher than that of the control group at the pre-test level. But at the post-test level, the experimental mean score on the chemistry achievement test exceeded that of the control group. So, there was a change, although it was not significant.

Other analysis dealt with the differential effect of using concept maps as homework tools on the achievement level of the students. It is worth noting that based on the school policy, students were divided into two heterogeneous groups based on achievement. Achievement level interactions were not detected at the knowledge level. However, significant interactions were obtained at the comprehension and application-and-above levels. In addition, a significant interaction was found when the total scores were considered. The means of achievement level group I (students who scored below the mean) in the experimental group were higher than those in the control group for the comprehension level questions, the application-and-above level questions, and for the total scores. These results showed that the concept map technique, used as a homework tool, helped the students who scored below the test scores mean (achievement level group I) to achieve better on high cognitive level questions.

What deserves attention is that the means of achievement level group II in the experimental group, at the comprehension and application -and-above level questions and at the total scores, were slightly lower than those in the control group. The differences between the experimental and control group means, for the achievement level group II, were not significant for the comprehension level and total scores. But, the achievement level group II students in the control group scored significantly higher, at the application-and-above level questions, than those in the experimental group with. Stensvold & Wilson (1990, 1992) got these same results in their two studies with grade 9 and high school students. Among students with high abilities, those who constructed concept maps scored lower on the comprehension test than those who did not construct maps. However, among students with lower abilities, those who constructed concept maps scored higher than those who did not. Stensvold & Wilson (1990, 1992) suggested that concept maps might have limited the perception of high ability students because they might have had there own successful strategies which were not applied when they used concept maps.

Further analysis investigated the interaction between sex and the effect of using concept mapping as a homework tool. There were no significant interactions between sex and the intervention at the application-and-above level. However, the concept mapping technique, used as a homework tool, favored girls over boys in the total scores in the chemistry achievement test and when knowledge and comprehension level questions were considered. It is worth nothing that previous research has not investigated interaction between using concept maps and gender.

The significant interactions between using concept maps and gender can be interpreted in light of the cognitive style theory that categorizes males and females into different learning styles. According to Wapner (1986), males are field-independent learners while females are field-dependent learners. Field independent individuals, such as males, use active reasoning patterns that include cognitive structuring skills. While field dependent individuals, such as females, take things the way they are and are passive in a learning context. The concept mapping technique, used as a homework tool, placed the students in a novel experience where structure was absent, and involved them in an active process of identifying links

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between concepts. This would lead to the conclusion that the concept mapping technique, used as a homework tool, should favor males over females, but this is not the case in this study.

At a first glance, the results of this study might seem to contradict the conclusions derived from cognitive style theory. However, a closer look at the results may provide some clarification. On the one hand, studies have shown that concept map construction is difficult (Lehman et al., 1985) and that students need excessive training to master the concept mapping technique (Beyerebach & Smith, 1990; Brandt et al., 2001). Thus, it is possible the learning style of females would enable them, more so than males, to master the new technique of building the concept map. The field-dependent learners (females) must have been more conforming to teachers' demands and more consistent in their work than the field-independent learners (males) in following the instructions to master the technique of building the concept map. Consequently, because mastery is crucial for concept mapping to be beneficial (Beyerebach & Smith, 1990; Brandt et al., 2001), students who may have followed the steps consistently benefited more from using concept maps as homework tools.

The correlation between the chemistry total post-test scores and the concept map subscores, (Salience, Conversion, and Total) of the last concept maps constructed by students before taking the post-test were computed. Results showed that the convergence and total scores showed significant correlations with students' achievement in chemistry. A high convergence concept map score means that the students' concept maps were close to the expert concept map. A high total concept map score means that the students included in their concept maps a larger number of correct directional propositions. These results indicate that students who mastered concept-mapping skills performed better on high cognitive level questions. These results are in agreement with Ausubel's (1968) description of meaningful learning as the establishment of non-arbitrary relations among concepts in the learners' minds. Thus, it can be concluded that concept mapping involved the students in actively relating new information to prior knowledge resulting in meaningful learning.

Other findings emerged when analyzing data from the students' reflections. Analysis of the students' answers showed that 66% faced problems when they started constructing concept maps. However 76% said that after practice they did not have any more problems. The students' reflections support further the recommendations to extend the duration of treatment when implementing concept mapping in order to get significant results (Brandt et al., 2001). These reflections also support the claim highlighted in previous research that the concept mapping technique needs excessive practice for mastery (Beyerebach & Smith, 1990; Brandt et al., 2001).

Other questions in the reflection questionnaire elicited students' attitudes toward concept mapping as a homework tool. Students, in general, showed a very positive attitude toward using the concept map as homework. They agreed that concept mapping was a good technique for studying and found it very beneficial. These students suggested that concept maps helped them summarize and organize new information, retain information longer, and simplify their learning tasks. Furthermore, concept mapping, used as homework, helped the students review for exams and discover and correct their own mistakes. Thus, it could be concluded that concept mapping helped students develop and use metacognitive skills, which resulted in better achievement.

Students' opinion varied when asked about using concept mapping in subjects other than chemistry. Some of students' thought that concept mapping could be used in all subjects, not only in chemistry, because organizing content is essential for success in all subject areas because studying becomes easier. Others believed that concept mapping should be used in some subjects only because it works best for subjects that contain a lot of definitions and interrelated concepts such as biology and chemistry, while courses like math and physics require mainly calculations and numerical applications.

Concerning the burdens associated with the concept maps, 58% of the students suggested improvements in the way concept maps are used in classrooms. Most interesting was the students' suggestion to use computers to make the presentation of concept maps clearer and the task of constructing them simpler. In fact, using computers in constructing concept maps is a current trend in science education that has the potential to improve the quality of concept mapping and consequently achievement in different subject areas.

Conclusion

This study provided some insights into the use of the concept mapping as a homework tool. It provided significant results concerning its differential effect on different sex groups where females achieved higher scores than males in the chemistry test, especially for questions at the knowledge and comprehension levels. Moreover, the results showed that concept mapping, used as homework, helped

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low achievers achieve higher in chemistry. Finally, students exhibited positive attitudes toward using concept mapping in chemistry and other subjects.

Recommendations

Recommendations for Teaching

The results of the study showed that students enjoyed using concept mapping. It showed that it had a differential effect on achievement in chemistry at higher cognitive level questions for females. Consequently, the concept mapping technique may be assigned as homework to engage students in constructing and altering their own knowledge structures, with the understanding that there is a need to help males become more engaged in using the technique because of its possible benefits. In addition, concept maps proved to be successful tools in helping low achievers improve their grades. Nevertheless, concept mapping may become effective for high achievers too if they were encouraged to periodically check their maps during the learning process.

Further recommendations for teaching could be derived from the students' reflections. The students recommended longer training sessions when using concept maps and direct feedback to give learners the opportunity to master the technique. Another recommendation is to use this technique in other subject areas. Finally, when possible, use computers to minimize the complication in constructing and presenting clear concept maps[1].

Recommendations for Further Research

More research needs to be done on the use of concept map as homework. New studies should be done to test further the effect of concept mapping as homework with a larger number of students, in different types of schools, and for different age groups. Another factor maybe important, which is the length of the treatment. A longer study may show more significant results since students will get more opportunities to practice concept mapping. Finally, research needs to be conducted to investigate the possible benefits of using computers to construct and present concept maps.

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[1] See http://www.semanticresearch.com/

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Appendix I

Chemistry Pre-Test

Part A

I. Choose the letter of the statement that best completes the sentence or answers the question:

1. Fill in the blanks:
A deliquescent solid is a solid which can ______ _____from the air to form a solution.
   a. absorb water vapor
   b. absorb gases
   c. absorb liquid
   d. absorb carbon dioxide
   e. none of the above
2. Which of the following chemicals is a hygroscopic liquid?
   a. Hydrochloric acid
   b. Water
   c. Oil
   d. Nitric Acid
   e. Sulfuric acid
3. Gases A, B, C, D and E are all diatomic. The heat change, in KJ/mole, that takes place when each of them dissolves in water is given. On the basis of the energy consideration *only*, which gas do you expect to have the lowest solubility at room temperature?
   a. _H = +100
   b. _H = - 100
   c. _H = -10
   d. _H = + 20
   e. _H = - 30
4. Which of the following does **not** conduct electricity when dissolved in water?
   a. HNO_3
   b. NaCl
   c. NH_3
   d. HCl
   e. N_2
5. Fluorine in **not** expected to form an ionic solid when it reacts with which of the following?
   a. Magnesium
   b. Sulfur
   c. Barium
   d. Calcium
   e. Iron
6. Which equation represents what happens when H_2SO_4 dissolves in water?
   a. H_2SO_4 _› $H_2^{+}{}_{(aq)} + SO^{-4}{}_{(aq)}$
   b. H_2SO_4 _› $2\ H^{+}{}_{(aq)} + 4\ SO^{-2}{}_{(aq)}$
   c. H_2SO_4 _› $H_2^{+}{}_{(aq)} + SO_4{}^{-2}{}_{(aq)}$
   d. H_2SO_4 _› $2\ H^{+}{}_{(aq)} + SO_4{}^{-2}{}_{(aq)}$
   e. H_2SO_4 _› $2\ H^{-}{}_{(aq)} + SO_4{}^{+2}{}_{(aq)}$
7. Complete the following sentence. A saturated solution is a solution
   a. in which the minimum amount of solute has been dissolved in a given quantity of solvent in contact with un-dissolved solute
   b. in which the maximum amount of solute has been dissolved in a given quantity of solvent in contact with un-dissolved solute
   c. in which the maximum amount of solute has been dissolved in a given quantity of solvent in contact with dissolved solute
   d. in which the minimum amount of solute has been dissolved in a given quantity of solvent in contact with dissolved solute
   e. which contains exactly 1 mole of solute per mole of solvent

8. Complete the following sentence. Molar solubility is defined as the
    a. concentration of a saturated solution of the solid
    b. maximum number of moles of solid that dissolves in 100g solvent
    c. maximum mass of solid that can dissolve in 1 dm^3 solvent
    d. concentration of any solution of the solid
    e. maximum mass of solid, in grams, that dissolves in 100g solvent

9. Which of the following four chemicals is soluble in water?
    a. $ZnSO_4$
    b. $Pb(OH)_2$
    c. $CuCO_3$
    d. Fe_2O_3
    e. All of the above are insoluble

10. A few drops of $Na_2SO_{4(aq)}$ were added to a test tube containing little of $BaCl_{2(aq)}$. What equation represents the reaction that is expected to take place in the tube?
    a. $Ba^{+2}_{(aq)} + 2SO_4{}^{-}{}_{(aq)} \rightarrow Ba(SO_4)_{2\,(s)}$
    b. $Ba^{+2}_{(aq)} + SO_4{}^{-2}{}_{(aq)} \rightarrow BaSO_{4\,(s)}$
    c. $Na^{+}_{(aq)} + Cl^{-}{}_{(aq)} \rightarrow NaCl_{(aq)}$
    d. $Ba^{+2}_{(aq)} + SO_4{}^{-2}{}_{(aq)} \rightarrow Ba(SO_4)_{2\,(s)}$
    e. $Na^{+}_{(aq)} + Cl^{-}{}_{(aq)} \rightarrow NaCl_{(s)}$

11. A few drops of $AgNO_{3(aq)}$ were added to each of 3 test tubes containing:
Tube1: $KCl_{(aq)}$ Tube2: $KBr_{(aq)}$ Tube3: $KI_{(aq)}$
What is expected to form in each tube?
    1. A white precipitate in tube 1
    2. A creamy precipitate in tube 2
    3. A purple precipitate in tube 3
        a. 2 only
        b. 1 only
        c. 1 and 2 only
        d. 1 and 3 only
        e. 1, 2 and 3

12. Calcium sulfide is sparingly soluble. The equation for the dissociation of CaS in water is:
    a. $CaS_{(s)}) \rightarrow Ca^{+2}{}_{(aq)} + 2S^{-}{}_{(aq)}$
    b. $CaS_{(s)})$ _ $Ca^{+2}{}_{(aq)} + S^{-}{}_{(aq)}$
    c. $CaS_{(s)}) \rightarrow Ca^{+2}{}_{(aq)} + S^{-2}{}_{(aq)}$
    d. $CaS_{(s)})$ _ $CaS_{(aq)}$
    e. $CaS_{(s)})$ _ $Ca^{+2}{}_{(aq)} + S^{-2}{}_{(aq)}$

13. Calcium fluoride is sparingly soluble. The expression for its K_{sp} can be written as:
    a. $[Ca^{+2}][2F^{-}] = K_{sp}$
    b. $[Ca^{+2}][2F^{-}]^2 = K_{sp}$
    c. $[Ca^{+2}][F^{-}]^2 = K_{sp}$
    d. $[Ca^{+2}][2F^{-}]^2 / [CaF_2] = K_{sp}$
    e. $[Ca^{+2}][F^{-}]^2 / [CaF_2] = K_{sp}$

14. The solubility of AgBr is $3x10^{-6}$M. from this information, the K_{sp} of AgBr is:
    a. $6x10^{-6}$
    b. $9x10^{-6}$
    c. $6x10^{-12}$
    d. $9x10^{-12}$
    e. $9x10^{-36}$

15. The K_{sp} of CaF_2 is $4x10^{-12}$.From this information, the molar solubility in water of CaF_2 is:
    a. $2x10^{-6}$
    b. $1x10^{-6}$
    c. $4x10^{-6}$
    d. $2x10^{-4}$
    e. $1x10^{-4}$

Part B

Write balanced equations to show how each of the following ionic solids dissolves in water.

a) $Mg(NO_3)_2$

____

____

b) $Fe_2(SO_4)_3$

____

____

c) K_2CrO_4

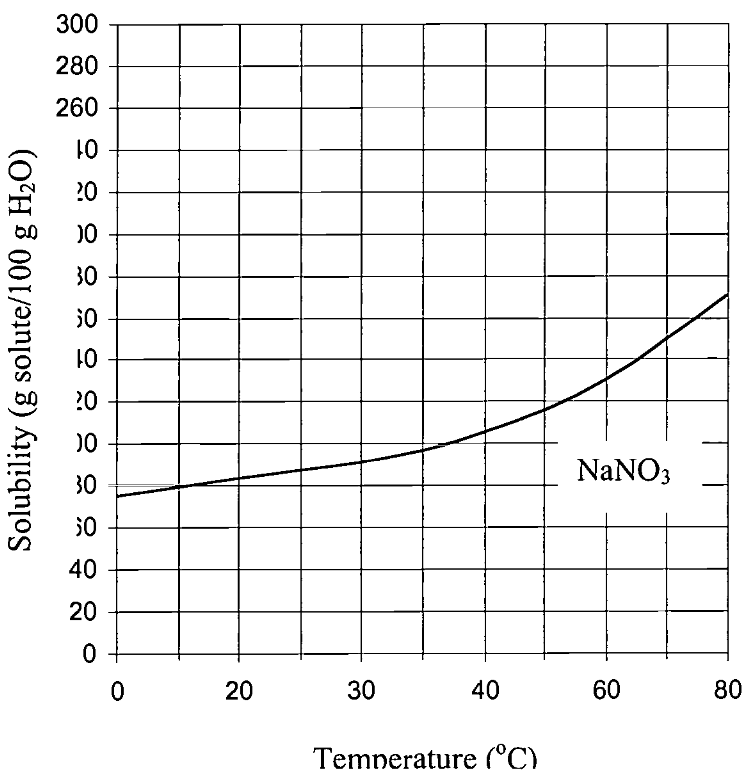
____

____

d) Complete the following table:

Compound	Formula	Soluble / Insoluble
Iron(II) hydroxide		
Ammonium carbonate		
Lead(II) chloride		

e) Given the solubility curve of sodium nitrate:



1. What is the solubility of sodium nitrate at 25 ^{0}C?

____

____

2. Calculate the mass of crystals formed if a saturated solution in100 g water is cooled from 50 ^{0}C to 20 ^{0}C.

____

____

3. Calculate the mass of water needed to dissolve 30g of sodium nitrate at 40^0C.

f) Sulfuric acid is a hygroscopic liquid. What can you predict about its solubility in water with respect to i) heat of reaction and ii) equilibrium. Justify your answer.

g) Give the formula and name of the precipitate that is produced when the following pairs of aqueous solutions are mixed. You do not need to give the formula of any other chemical.

a) $Ba(NO_3)_2$ + Na_2SO_4	
b) $CaBr_2$ + $AgNO_3$	
c) Na_2SO_4 + $Pb(NO_3)_2$	

h) Write a complete ionic equation for the following reaction

$CaCl_{2(aq)}$ + $Na_2CO_{3\,(aq)}$ _

i) Limestone $CaCO_3$, which is widely spread on Earth surface, enters the water supply. In the presence of dissolved carbon dioxide CO_2 (from atmosphere) the following reaction takes place in water:

$CaCO_3 + CO_2 + H_2O$ _ $Ca^{2+} + 2\,HCO_3^-$ $\Delta H<0$

When water containing Ca^{2+} and HCO_3^- ions is heated or boiled a white layer of scale forms. The scale is the substances that blocks hot-water pipes, and forms in the tea kettle when you boil water.

a)Based on the given information, determine the chemical formula of the white scale layer.

b) Using Le Chatelier principle, explain why the layer of scale forms when tap water is heated.

j) Answer the following parts independently:

1) How can you differentiate between each of the following solids?

Na_2SO_4 and K_2S

Observations, and (ionic or otherwise), where applicable, have to be given for any positive test.

2) On the basis of the solubility rules, suggest one procedure by which you might separate K^+ from Ag^+ ions mixed in an aqueous solution.[the cations are assumed to be in aqueous solution, and the common anion is the nitrate ion]

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k) The solubility product constant, K_{sp}, of PbS is $4x10^{-28}$ at 25^0C. Find the maximum mass of PbS that can dissolve in 200 cm^3 solution at the same temperature. Molar mass of PbS = 239g/mol.

l) The solubility product of $PbBr_2$ is $8.9x10^{-6}$ at 25^0C. Determine the molar solubility of $PbBr_2$

1. in pure water

2. in 0.20M KBr solution

Compare your answers in parts 1 and 2, and suggest a logical explanation for the discrepancy.

m) Will a precipitate of BaF_2 form if 0.015 mole $Ba(NO_3)_2$ is mixed with $2x10^{-2}$ mole of KF in a 200 cm^3 solution? Show all necessary calculations. K_{sp} $BaF_2 = 2x10^{-6}$.

n) The solubility product constant of a slightly soluble salt A was recorded at two different temperatures:

$T_1 = 25\ ^0C$ $\quad K_{sp\ 1} = 8.9x10^{-9}$

$T_2 = 90\ ^0C$ $\quad K_{sp\ 2} = 9.9x10^{-2}$

1. From the given data, determine if whether the dissociation of salt A is endothermic or exothermic? Justify your answer.

2. If salt A is blocking a pipe, what do you advice to unblock it? The use of hot water or cold water? Explain.

Appendix II
Chemistry Post-Test

Part I:

I. Circle the letter of the statement that best completes the sentence or answers the question:

1. Which of the following dissolves in water to produce a strong electrolyte?
    1. CH_3COOH
    2. CH_3COONa
    3. NH_4Cl

    [-A-] 2 only
    [-B-] 2 and 3 only
    [-C-] 1 and 2 only
    [-D-] 1 and 3 only
    [-E-] 3 only

2. $K_w=6x10^{-14}$ at $70^{o}C$. It can be deduced at $70^{o}C$ the
    [-A-] $[H^+] = \sqrt{6}x10^{-14}M$
    [-B-] $[H^+] = \sqrt{6}x10^{-14}M$
    [-C-] $[OH^-] = \sqrt{6}x10^{-7}M$
    [-D-] $[H^+] = 3x10^{-7}M$
    [-E-] $[OH^-] = 3x10^{-7}M$

3. Which of the following is (are) a correct operational definition of an acid?
    [-A-] An acid turns litmus blue
    [-B-] An acid solution reacts with zinc to produce hydrogen gas
    [-C-] An acid increases the $[H^+]$ in aqueous solution
    [-D-] When diluted, an acid solution tastes bitter
    [-E-] All of the above are correct operational definitions of acid

4. Which of the following is a correct conceptual definition of a base? A base is a substance that:
    [-A-] tastes bitter in diluted solution
    [-B-] increases the $[H^+]$ in an aqueous solution
    [-C-] increases the $[OH^-]$ in an aqueous solution
    [-D-] reacts with acids to produce salts
    [-E-] All of the above are conceptual definition of a base

5. Which of the following dissolves in water to produce a strong acidic solution.?

    [-A-] H_2S
    [-B-] CO_2
    [-C-] NH_4NO_3
    [-D-] SO_3
    [-E-] Two or more of the above

6. Which of the following oxides is considered acidic?
    [-A-] NO
    [-B-] NO_2
    [-C-] ZnO
    [-D-] H_2O
    [-E-] CO

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7. What is observed when some iron filings are added to dilute hydrochloric acid?

1. A colourless gas is produced
2. A choking gas is produced
3. A flammable gas is produced

[-A-] 3 only
[-B-] 2 and 3 only
[-C-] 1 and 2 only
[-D-] 1 and 3 only
[-E-] 1, 2 and 3

8. When dilute NaOH is warmed with NH_4Br solution, which gas is produced?

1. A chocking, pungent gas
2. An odourless gas
3. A colourless acidic gas
4. A colourless basic gas

[-A-] 1 and 4 only
[-B-] 2 and 3 only
[-C-] 1 and 3 only
[-D-] 3 only
[-E-] 2 only

9. When dilute NaOH is added to $Cu(NO_3)_2$ solution. Which of the following is obtained?

[-A-] A colourless gas forms
[-B-] A brown precipitate forms
[-C-] A blue prcipitate forms
[-D-] A green precipitate forms
[-E-] A red gas forms

10. Which of the following salts is acidic in aqueous solution?

[-A-] $AlCl_3$
[-B-] KCl
[-C-] COONa
[-D-] $NaNO_3$
[-E-] Two of the above are acidic

11. Complete the following sentence pH is defined as:

[-A-] log $[-H^+]$
[-B-] - log $[k_w]$
[-C-] - log $[OH^-]$
[-D-] log $[OH^-]$
[-E-] - log $[H^+]$

12. 0.1M HCl (aq) was gradually added to 25 cm^3 of 0.1 M $NaOH_{(aq)}$ in a beaker and the conductivity was measured at regular intervals. Which of the reported observations describes the variation of conductivity of the resulting solution as the acid is added until it is in excess?

1. The initial conductivity was high. It drops as the acid is added.
2. The lowest value of conductivity will be recorded when the volume of acid added is 25cm^3.
3. As acid is added beyond the equivalence point, the conductivity will increase slowly.

[-A-] 2 and 3 only
[-B-] 1 only
[-C-] 1, 2 and 3
[-D-] 1 and 2 only
[-E-] 1 and 3 only

13. The pH of an aqueous solution of 0.1M HCl can be increased by adding an equal volume of

[-A-] 1M $HCl_{(aq)}$
[-B-] 0.1M $HNO_{3(aq)}$
[-C-] water
[-D-] 1 M $HNO_{3(aq)}$
[-E-] Three of the above will increase the pH of the solution.

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14. Complete the following sentence. According to the Bronsted-Lowry definition, an acid is any substance that
    [-A-] decreases the pH of water
    [-B-] increases the pH of water
    [-C-] increases the $[H^+]$ in solution
    [-D-] can act as a proton acceptor
    [-E-] can act as a proton donor
15. Complete the following sentence. An indicator is generally a weak acid
    [-A-] which is colourless in acids pink in bases
    [-B-] whose anion has a different colour from the undissociated molecule
    [-C-] that has a k value of 10^{14}
    [-D-] whose cation has a different colour from the undissociated molecule
    [-E-] which is red in acids, blue in bases.

Part II:

I. Answer the following questions (grades are not giving for working)
1. What is the $[H^+]$ of a solution labeled 0.01M $KNO_{3(aq)}$?

2. 3.65g of HCl were dissolved in 500 cm^3 solution. What is the $[OH^-]$ in the resulting solution? [H=1.0, Cl=35.5]

3. What is the [H+] in a solution labeled $5.0x10^{-4}$ M $Ca(OH)_{2(aq)}$?

4. A solution of euphoric acid, H_2SO_4, has a $[H^+]$ of 10^{-2}. What is the pH in the given solution?

5. Indicate whether a 1.0 x 10^{-3}M NaOH solution is acidic, basic, or neutral?

Part III:

I. Write complete ionic equations for the following reactions that take place in water. Make sure to include all state symbols. Where heating is needed, assume the chemicals are heated.
    a) $HNO_3 + MgCO_3$

    b) $H_2SO_4 + KOH$

    c) $K_2SO_3 + HCl$

    d) $Ba(NO_3)_2 + H_2SO_4$

    e) $NH_4Cl + Ca(OH)_2$

II. The pH of 0.1 M $CH_3COOH_{(aq)}$ solution is 3. What is the $[OH^-]$ in the solution?

III. Nitrous acid, HNO_2, is a weak acid. Given K_a of (HNO_2) = 1.0×10^{-3}. Calculate the pH of 0.1 M HNO_2 solution.

IV. 0.040M sodium hydroxide (NaOH) solution was added drop wise to 40.0cm^3 of a certain HCl solution until complete neutralization is reached.

1. Give the scientific name of the procedure described above .

2. How can it be known that complete neutralization is reached?

3. Represent the neutralization reaction between NaOH and HCl by a molecular equation.

4. 10.0cm^3 of the base solution were needed for complete neutralization of the acid. Calculate the concentration of the initial acid solution.

5. Determine the pH value of the resulting solution when the conductivity of the solution reaches its lowest value .

V. HNO_2 and HF are both weak acids. HF is a stronger acid than HNO_2 .

1. Calculate the volume of 0.10M NaOH solution needed to neutralize 50.0 ml of 0.10M HNO_2 solution .

2. Deduce the volume of 0.10M NaOH needed to neutralize 50.0ml of 0.10M HF solution.

VI. An average adult produces between 2 to 3 l of gastric juice daily. Gastric juice is an acidic digestive fluid. It contains 0.03 M H^+ acidic solution. The purpose of the highly acidic medium within the stomach is to digest food and to activate certain digestive enzymes.

1. Calculate the pH of gastric juice solution in the stomach. [log 3=0.48]

2. From the text, explain why drinking water during a meal causes digestive problems

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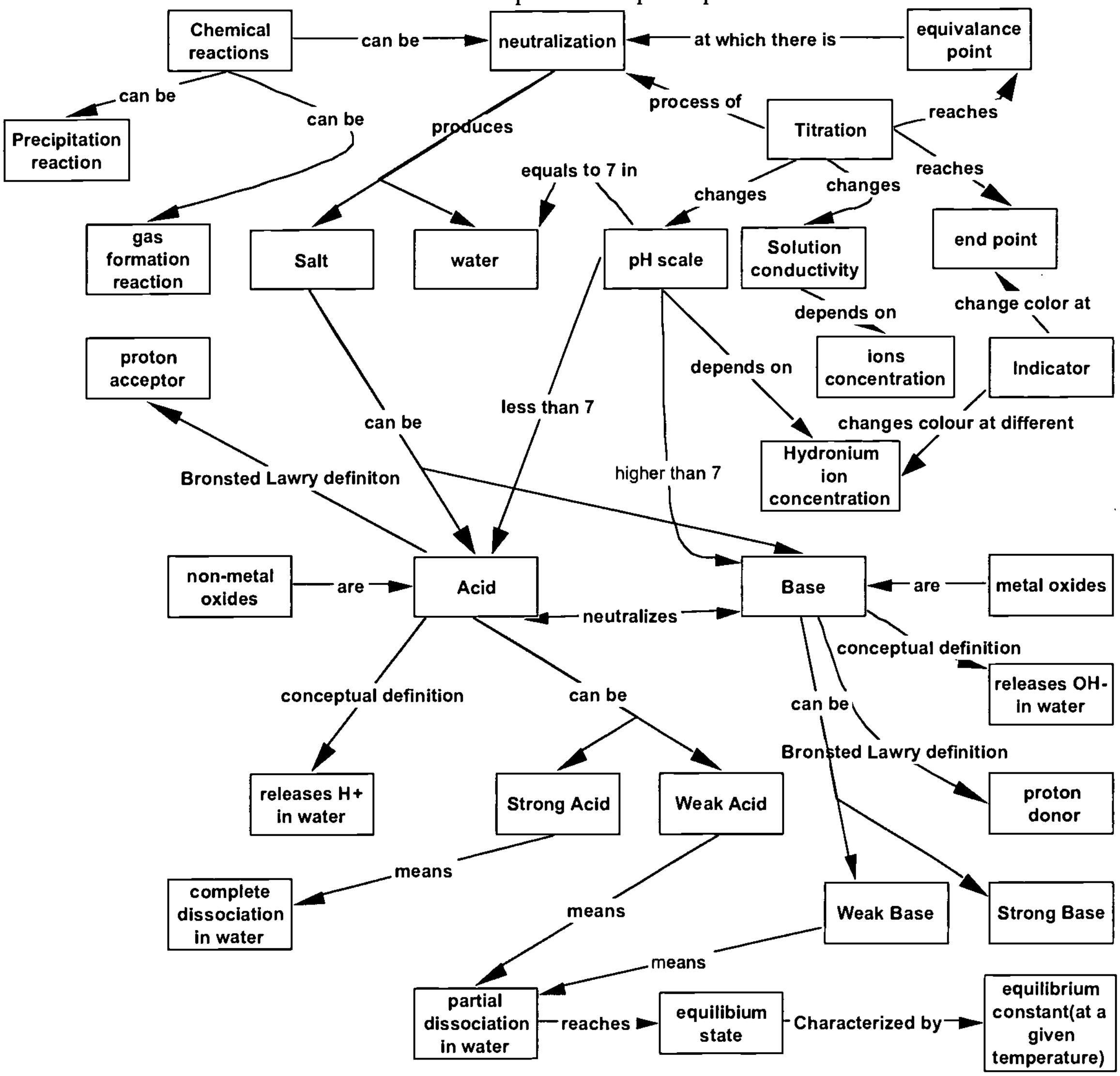
Appendix III
Expert Concept Map



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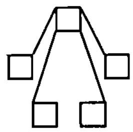
Appendix IV

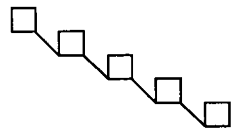
Scoring Rubric of the Concept Map

Student Name:

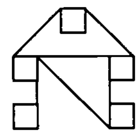
1. Map Structure: a. Spoke



b. Chain



c. Net



2. # of Correct Hierarchy levels:________________

3. # of Correct Cross-Link:____________________

4. Quality of Propositions

   Invalid proposition: ________________________x 0 =____________

   Possible relationship: ______________________x 1 =____________

   Correct-label proposition: __________________x 2 =____________

   Directional correct proposition: ____________x 3 =____________

5. Convergence Score =____________

6. Salience Score =____________

Total =____________

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