CHEMISTRY EDUCATION:
RESEARCH AND PRACTICE
2004, Vol. 5, No. 2, pp. 99-110

Theme Issue:
Chemistry and Environmental Education
RESEARCH REPORT (EMPIRICAL STUDY)

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THE INFLUENCE OF COMPUTER-ASSISTED EDUCATION ON ENVIRONMENTAL KNOWLEDGE AND ENVIRONMENTAL AWARENESS

Received 17 December 2003; revised 14 May 2004; accepted 19 May 2004

ABSTRACT: In this study, the degree to which computer-assisted education affects the environmental knowledge and awareness of university students was investigated. In this way, individual and student-centered learning in environmental studies is encouraged, and the students' success and knowledge are subsequently increased. This methodology is important for the students who will soon become chemistry teachers and will make contributions to environmental education. In this study, an environmental knowledge test of 35 questions and an environmental awareness scale of 13 questions were applied as a pre-test to 88 students. Following the pre-test, the students worked for 15 hours per week in an Internet class, in which they intensively applied computer-assisted methods for 2 weeks. The environmental knowledge test and the awareness scale, which were taken as pre-test modules, were applied again as a post-test and the results were compared. It was determined that after the computer-assisted instruction, students' environmental knowledge and awareness were increased, but the power of environmental awareness to describe the level of success is decreased. [*Chem. Educ. Res. Pract.*: 2004, *5*, 99-110]

KEY WORDS: *environmental education; environmental knowledge; environmental awareness; computer-assisted education*

INTRODUCTION

In the computer age in which we are living, with the most important value being knowledge, studies are performed in order to elucidate the importance of environmental education. With the development of technology and the passing of time, the traditional techniques, in which the teacher plays the most active role in the students' education, are being transformed into new techniques, which are technology-assisted and encourage learning and reasoning techniques. In pedagogical knowledge, the conception of new ideas is as important as the applications themselves. Most importantly, teaching techniques that are developed involving technological tools and applications provide great opportunities to educators and students.

The Internet-assisted education technique is a newly developed technique that has been widely used in recent years (Patterson, 2000; Donovan and Nakleh, 2001; Murov, 2001; Boschman, 2003). This educational technique has significant advantages when compared to traditional teaching methods (Treadway, 1996; Whisnant, 2000; Chasteen, 2001). With the Internet, in contrast to some fixed tools such as course textbooks, multimedia contents can reach larger audiences (Olsen, 2000). In a study conducted by Çarpi (2001), a web site was designed, in which scientific concepts for science lessons in higher education combined with links related to courses. In order to introduce innovation in curriculum, Daniel and Saat

(2001) developed an approach from Internet sources. In this approach, students reach solutions of given problems by using the computer and intensify their knowledge by performing exercises (Pfeifer, Lutz, & Bader, 2002).

Computer-assisted applications have been developed in the subject area of environmental education. The source which was prepared by the North American Association for Environmental Education (NAAEE) and was entitled "Computer-aided Environmental Education", involves the problems and promises of environmental hypermedia, computer simulation/modeling interactive software (Rohwedder, 1990). In other studies by the same author, the usage of multimedia and online education in environmental education will be very useful (Rohwedder, 1999; Rohwedder & Alm, 1995).

The factors affecting students' environmental knowledge, attitude, awareness and behaviors are investigated beginning in kindergarten at all levels of education by scientists. According to the results, educational models and curriculum suggestions are prepared. As an example we can cite the studies of Gillespie and deHaals (1979) and deHaals and Gillespie (1979) and deHaals and Gillespie (1979) that relate to planning environmental change and measuring environmental awareness. Palmer (1995) studied the effect of early childhood experiences, family and education on environmental conception and behaviors. Howe and Disigner (1988) investigated the variables in improving the responsible environmental behaviors. Musser and Diamond (1999), in their study on the environmental awareness of kindergarten students, examined the factors affecting the improvement of environmental knowledge and awareness. They found that the behaviors of the students were not related to the private applications that the parents actualize at home.

Ballantyne (1998) examined the improvement of the students' environmental knowledge through interactive study recordings. Musser and Malkus (1994) developed a scale to assess the attitudes of school children towards the environment. Ballantyne (1996) designed an environmental concept improvement model in co-operation with environmental knowledge, attitude and behaviors. Ballantyne et al. (2001) developed environmental education programs focusing on the students' knowledge and attitudes related to the environment and their environmental activities. Similarly, Thomas (1989-1990) and Hites (2001) discussed the context of environmental education curriculum, educational techniques, educational tools and how to improve student motivation. Wenzel and Austin (2001) evaluated an introductory chemistry course that had an environmental awareness prior to 2001 in the field of environmental chemistry in the undergraduate laboratory. They suggested that the students needed to address sensitive issues more carefully. Randall (1997) recommends that environmental education should be supported with activities that could be done within the natural environment. Lee (1974), Davis (1974), Chrotowski (1985) and Stearns (1988) prepared sample lesson plans on various suggestions and applications of environmental chemistry in high school curriculum. Carlson (1993) describes a three-week intensive course in a general chemistry class, which consisted of two distinct phases: a one-week introduction to environmental chemistry and a two-week project involving a particular environmental program. In his research related to science, technology and society, Zoller emphasized the global environmental issues and importance of environmental chemistry in this context (Zoller, 2000, 2001; Tal, Dori, Keiny, & Zoller, 2001).

The main aims of the above-mentioned studies were to inform people about the environment and to create awareness in them about the environment that they live in. This clearly demonstrates the importance of the environmental awareness (Klemmer, Hütter-Klemmer, & Howard, 1996). It is very important to assess the knowledge of individuals on the environment, ecology, or pollution and their attitudes towards these issues during or after periods of education (Maloney, Wand, & Braucht, 1975). The environmental concept that the individual attains is the most important factor that explains their attitudes towards the

environment and environmental protection (Weigel & Weigel, 1978; Kuhlemeier & Bergh, 1999; Banerjee, 2001).

THE PURPOSE OF THE STUDY

The traditional and the computer-assisted teaching methods have been compared in many studies on acquiring and retaining knowledge, using pre- and post-tests and treatment-control groups' designs (Jackman & Moellenberg, 1997; Morgil et al., 2003). The advantage of computer-assisted chemical education applications, which have proven to be superior to the other teaching methods such as expository, question and answer, presentation and sample case applications, is explained. In computer-assisted teaching, the teacher can use the computer at different times and places according to the available software and hardware or the characteristics of the students and the subject for revision, evaluation, assessment, practice, application and instruction. The programs can also be used as practice, revision, one-to-one instruction and problem solving for applications (Brooks, Lui, & Walter, 1997; Penn, 2000). This study is planned in order to determine how computer-assisted education affects the university students' environmental knowledge and the development of their awareness.

EXPERIMENTAL DETAILS

The subjects

The study was conducted on 88 students consisting of 55 females, 22 of whom were in their 3rd year and 33 in their 4th year, and 33 males, 17 of whom were in their 3rd year and 6 in their 4th year, that were attending Hacettepe University, Faculty of Education, Department of Chemistry Education, and continuing their studies in the 2002-2003 spring semester. All of these students have been taking Internet classes in the Department of Chemistry Education since the 2001-2002 school year. In Turkey, students who attend courses at the Chemistry Education Department in the Faculty of Education for five years can become high school teachers after they graduate.

The environmental knowledge test (EKT)

The research data on the environment were collected through a test developed by researchers involving questions related to environmental knowledge. The test was named "The Environmental Education Knowledge Test for Students". The test consisted of 50 main questions and 5 information sources for each question prepared to assess the knowledge related to environmental education and determine its source. From the 50 questions prepared in this study, 35 questions were chosen and their answers were evaluated. The 5 choices prepared to determine the information source of the students were; a) through the parents (family), b) through the teacher (through education), c) through the visual or written press (media), d) through the computer-assisted teaching applications (CAT), or e) through the Internet (private application).

The environmental awareness scale (EAS)

The researchers developed "The Environmental Awareness Scale". A total of 122 students took part in the study while the scale was being developed. First, a sample form of 50 awareness statements was prepared in order to develop a relevant and reliable assessment tool that could be used to assess the students' knowledge about the environment as well as

environmental protection. During the preparation process, the students were asked to write an essay on their feelings and thoughts about the environment. After these manuscripts were examined, the ones that could be used as awareness statements were included in the sample form. The specialists on measurement and assessment examined these statements, which were believed to express environmental awareness. After being grammatically checked and corrected, some statements were removed from the scale and a sample form of 45 statements was produced. A 5-point Likert type scale was used to measure the awareness of the students towards the statements as "strongly agree", "agree", "neither agree or disagree", "disagree", "strongly disagree" (Anderson, 1981).

The principal components analysis was applied as a factor analysis technique in order to test the structural validity of the tool, that is whether it assessed a single structure (concept) or not. Structural validity is related to the characteristic that is being assessed. Factor analysis, being the strongest method of examining the structural validity, enables the assessment to be done with fewer factors by gathering the variables that assess the same quality (Kerlinger, 1973; Tabachnick & Fidel, 1989). Therefore, assessable concepts could be reached through factor analysis. Tabachnick and Fidel (1989) determined that the data collected from 200 participants were enough for the factor analysis. But, studies having 100-150 participants can also be found. Therefore, the number of participants of our study (N=122) was adequate.

A factor analysis and item analysis were conducted at the first step related to the reliability and analysis of the scale on the collected data. Some factor loading values of the 32 awareness statements among the 45 were found to be below 0.30. Some were found to be combined**,** and were removed from the scale. After repeating the analysis, 13 statements were included in the scale. The second analysis results showed that the first factor loading value of all awareness statements was 0.30 or higher. Moreover, none of the statements were found to have a second factor loading value that was close to the first factor loading value (>0.10). After the 32 awareness statements were removed from the scale, the factor analysis results led to a scale of two factors. Table 1 displays the information related to the scale that is used. The alpha inner awareness coefficient for the reliability of the scale was found to be 0.80.

Applications in computer-assisted chemical education

The intensive applications course engaged the participants for 15 hours per week for 2 weeks. Students formed groups of 4. After this, a work calendar was prepared and the applications that would be performed by the groups were determined.

First, students watched "Green Chemistry" a PowerPoint presentation prepared by the *American Chemical Society*, the *Royal Society of Chemistry*, and *Gesellschaft Deutscher Chemiker* (www.acs.org). In the NOP Project, in the experiments shown on the computer, the environmental effects of the chemicals used in the experiments, their ecotoxicologic characteristics and recycling of wastes that occurred in the reactions are given. Students reached the resources prepared by IUPAC and related with "Green Chemistry Education".

Again in the researches on the Internet, students learned that in 1993 The Interuniversity Consortium "Chemistry for the Environment" (INCA) was established (Tundo et al., 2001). INCA, is an institution supported by the OECD and IUPAC, and works towards environmental protection.

TABLE 1. *The results of the factor analysis of the 13 statements, after 32 statements were removed from the scale (N=122).*

Variable Question	Factor 1	Factor 2	Communality	Item total correlation
1. The emissions inspection of cars are nothing but an unnecessary workload for people.	0.78		0.5	0.32
2. TEMA (the Turkish Foundation for Combating Soil Erosion, for Reforestation and the Protection of Natural Habitat), which is an environmental foundation, should be encouraged and supported.	0.79		0.74	0.34
3. The usage of natural gas should increase.	0.74		0.72	0.31
4. The products made of recyclable materials should be preferred even though they are more expensive.	0.64		0.65	0.41
5. Energy saving light bulbs should be used even though they are expensive.	0.56		0.51	0.51
6. When buying aerosol deodorants, the ones that contain less damaging gases should be preferred.	0.56		0.62	0.60
7. Drinks in plastic bottles should not be preferred only because they are easier to carry, since they are difficult to recycle.	0.55		0.50	0.30
8. Technological development is worrisome to me because it causes environmental destruction.		0.67	0.63	0.67
9. I think that cell phones seriously damage the environment.		0.66	0.46	0.43
10. The research foundations should have chemical waste units.		0.62	0.67	0.69
11. Listening to music loudly at home causes noise pollution.		0.60	0.39	0.42
12. Individuals should gain awareness about the environment at all levels of education starting from kindergarten.		0.57	0.56	0.40
13. Individuals should be informed about the environment through media (TV, newspapers, magazines...).		0.58	0.68	0.43
Percentage of Variance	31.6	18.7		
Alpha inner awareness coefficient = 0.80				

Test procedure

EKT and EAS were applied to 88 students at the same time as a pre-test with a duration of 45 minutes. After attending 15 hours per week, the above-mentioned two week intensive course at the chemistry education Internet class, the same EKT and EAS were reapplied as a post-test to the students.

RESULTS

In this study, computer-assisted technological applications were used in order to develop environmental knowledge and awareness. While obtaining the knowledge related to the environment, in order to make students obtain environmentally related knowledge, the opportunity to conduct environmental experiments, concepts, pictures, short films, tables,

graphics and animations on the Internet was given to the students. Students learned according to their speed. Each value was calculated from the values of means and percentages of each student. For the environmental knowledge test, the observed average difference of females and males (in the 3rd and 4th year) favored males (about 3%) in the post-test applications. The increase in the average of the 3rd year female students in (X_{pre}=15.95; X_{post}=26.77, $t_{[21]}$= 16.309, sig. 0.000), the 3rd year male students (X_{pre}= 18.00; X_{post}=27.37, $t_{[16]}$= -8.977, sig. 0.000), the 4th year female students (X_{pre}= 20.00; X_{post}=26.39, $t_{[32]}$= -7.488, sig. 0.000) and 4th year male students (X_{pre}= 19,625; X_{post}= 28.44, $t_{[15]}$= -6.535, sig. 0.000) in the EKT were found to be statistically significant. The same significance could be observed for the awareness. For the environmental awareness test, a larger increase in the male students was observed. As a result, in the statistical evaluations, in the post-test applications, a significant difference was observed in favor of males.

The distribution of the resources that identifies how the students acquired their knowledge about the environment display differences in the pre- and post-test results. The students preferred "through the teacher" in the pre-test, whereas "through computer-assisted educational applications" was more dominant in the post-test results (see Tables 2 and 3).

TABLE 2. *The pre-test and post-test results of the questions of Group 1.*

Question	Result of environmental knowledge (%)			
	Pre-test		Post-test	
	Female	Male	Female	Male
1. What is the reason for the recent tornados, storms, floods and fires?	41.8	63.6	92.7	93.9
2. What is the substance that causes the disintegration of the ozone layer?	87.3	90.9	89.1	93.9
3. What caues the greenhouse effect?	72.7	78.8	96.4	97.0
4. How does pollution make it into the atmosphere?	94.5	93.9	98.2	100
6. What does the abbreviation CFC mean?	81.8	42.4	92.7	75.8
7. What are the main sources of the water pollutants?	94.5	87.9	100	100
8. How do toxic metals get into organisms?	63.6	72.7	98.2	100
10. What is a pesticide?	72.7	57.6	100	100
11. Why are catalytic converters used in vehicles?	89.1	90.9	100	97.0
12. How is the quality of the weather determined?	61.8	66.7	100	84.8
14. Why does global warming occur?	87.3	87.9	96.4	100
16. How should drinking water be examined in a hygienic matter?	81.8	93.9	94.5	100
17. What are the effects of SO_2 gas on plants?	78.2	78.8	100	90.9
18. NO, NO_2, O_2, CO_2, CO, which of these gases does not pollute the atmosphere?	92.7	100	100	100
20. NO, NO_2, CF_2 Cl_2, He, $CFCl_3$, which of these gases does not damage the ozone layer?	74.5	78.8	76.4	97.0
22. Which aspect of petroleum does not damage the environment?	74.5	60.6	89.1	87.9
23. What is the cause of soil pollution?	66.6	75.8	67.3	81.8
26. What is the name of the science that investigated the relations between organisms and the physical environment and communication among living things?	72.7	78.8	78.2	84.8
31. Why is green chemistry important?	76.4	66.7	81.8	90.9

TABLE 3. *The pre-test and post-test results of the questions of Group 2.*

Question	Result of environmental knowledge (%)			
	Pre-test		Post-test	
	Female	Male	Female	Male
5. Give examples of the gases that threaten human health.	23.6	36.4	27.7	45.5
9. Give examples of the damage that gas pollutants do to environment.	41.8	24.2	45.5	48.5
13. Why do halocarbons damage the ozone layer although they do not have any chemical reactions?	36.4	39.4	100	97.0
15. What is LAB?	27.3	33.3	100	100
19. Fog, dust, NO gas, smoke, smoke vapor, which of these do not exemplify a particle?	49.1	51.5	89.1	93.9
21. State a type of energy that is not clean.	12.7	18.2	23.6	33.3
24. What is the source of smog in large cities?	36.4	57.6	41.8	63.6
25. Which event does not affect the pollution caused by cars?	14.5	6.1	18.2	45.5
27. Tin, iron, copper, aluminum, steel, for which of these does it take the longest to decompose?	3.6	3.0	21.8	12.1
28. Iron, silver, lead, magnesium which of these elements poison birds and fish?	36.4	48.5	67.3	97.0
29. Which factor is not essential for preserving the global environment and protecting the eco-system?	23.6	21.2	70.9	57.6
30. Give examples of stationary sources that cause air pollution.	14.5	27.3	45.5	42.4
32. Give one example of the processes that must be performed to deal with laboratory waste.	9.1	9.8	34.5	15.2
33. What is the green reagent that is used for extinguishing a fire?	7.3	9.1	72.7	90.9
34. What is the green reagent that is used for dry-cleaning?	7.3	6.1	58.2	63.6
35. Which law aims to protect the global environment and eco-system?	32.7	33.3	87.3	97.0

The results were examined in two groups for the EKT pre-test and post-test results based on the questions and the female-male difference was calculated separately at the same time. While evaluating pre-test and post-test results based on questions, 88 students' results given to each question were evaluated as wrong or right, and subsequently the total of the correct questions were determined and a % value of their environmental knowledge was determined.

The questions of the EKT average in the pre-test results of which were above 50% were named **Group 1**, and the ones that of which were below 50% were named **Group 2** out of the 35 questions. As displayed in Table 2, the answers, for which the level of information was calculated to be above 50%, were the ones that had either been main subjects in education or were being discussed in the media. Also, the evaluated results are related with multidisciplinary mentioned knowledge. These especially exist in primary school and secondary school curriculum.

The questions for Group 2 were evaluated to be related to recent environmental issues. It was observed that the subjects of the chemistry-assisted environmental education, which had been touched upon during the last 10 years, were found to be unknown to the students. However, as displayed in Table 2 and 3, after the computer-assisted chemistry applications, their knowledge concerning environmental issues had increased. In applications, students

realized active learning and reached knowledge sources that were determined by the researchers (Charlesworth & Vician, 2003).

The statistical evaluation of the results

In the results of the paired sample statistics conducted for the significance of the difference between the pre- and post-test results of EKT, the post-test grades of the students were found to have significantly increased [$t_{[87]}$= 16.81, $p<0.05$]. The pre-test average grade of the students was 18.52 whereas that of the post-test was found to have increased up to 27.01. This finding shows that the application has an essential effect on increasing the success rate.

The results of the regression analysis that was made in order to calculate the effects of the EAS pre-test results on the EKT results are as follows (Table 4).

TABLE 4. *The regression analysis results of the effect of the pre-test EAS results on the EKT results.*

Model Summary			
R	R Square	Adjusted R Square	Std. Error of the Estimate
0.175	0.031	0.020	4.008

ANOVA					
	Sum. Of Squares	df	Mean Square	F	Sig.
Regression	43.915	1	43.915	2.733	0.102
Residual	1382.04	86	16.07		

When the pre-test analysis results were examined, the EAS results were not observed to have significantly affected the success [$R=0.175$, $R^2=0.031$, $F_{[1,86]}$= 2.733, $p>0.05$]. Only 3.1% of the total variance of the achievement was related to the EAS results. The statistical evaluation of the same operation on the post-test EAS and the EKT results is as follows (Table 5).

TABLE 5. *The regression analysis results of the effect of the post-test EAS results on the EKT results.*

Model Summary			
R	R Square	Adjusted R Square	Std. Error of the Estimate
0.023	0.001	-0.011	2.23

Anova					
	Sum. Of Squares	df	Mean Square	F	Sig.
Regression	0.224	1	0.224	0.045	0.833
Residual	428.765	86	4.986		

When the results of the post-test analysis were examined, the EAS results were again found to have no effect on the achievement [$R=0.023$, $R^2=0.001$, $F_{[1,86]}=0.045$, $p>0.05$]. Only 0.1% of the total variance of the achievement was related to the EAS results.

In the paired sample statistics results that were calculated for the significance of the difference between the EAS pre- and post-tests, the students were observed to have a significant increase in their post-test EAS results [$t_{[87]}=7.164$, $p<0.05$]. The EAS post-test average of the students was 47.92, whereas it increased up to 57.40 after the application. This finding displays the essential effect of the application on increasing the environmental awareness. The Pearson Correlation was 0.069 and the significance value was 0.524.

As observed in the statistical evaluation of the results, the EKT results increased 20% after the computer-assisted chemistry education. The increase in the EAS results was 10-

12%. The computer-assisted education based on questions increased the level of information for the questions posed to Group 2.

CONCLUSION

Through the evaluation of the study on whether the environmental awareness and the level of knowledge of the university students, who would soon become chemistry teachers, were affected by the computer-assisted education, the following important results were achieved and can be summarized as follows:

- There was a 20% increase in environmental awareness and a 10-12% increase in the environmental knowledge of the students as a result of the intensive course utilizing the Internet. The computer-assisted education applications and, particularly, the Internet provided an increase in the environmental awareness and knowledge levels of the students by affecting their awareness. The students learned the instructional content and activities related to the environment and environmental protection during this application. Similar results were determined in the studies of Brooks, Lui, and Walter (1997).
- The awareness of the students related to environmental protection was observed to have increased within the study. For example, questions 11, 14, 16, and 23 on the environmental knowledge test (EKT) were related to environmental pollution. An increase of 10-15% was observed between the awareness of the male and female students on these issues before and after the computer-assisted education applications.
- Computer-assisted teaching increases the level of information of both female and male students concerning the subject of the environment. In the statistical evaluations, while in the pre-test, a significant difference between males and females was not observed, in the comparison of post-test results, a significant difference in favor of males is observed.
- For the pre-test results of the relationship between the EKT success rate and the environmental awareness, the contribution of the students' environmental awareness to their achievement had been 3.1% before the computer-assisted teaching application. When the post-test results were evaluated after the computer-assisted chemistry education applications, the success rate had decreased to 0.1%. While the contribution of the environmental awareness to the EKT results decreased from 3.1% to 0.1%, the 20% increase that was observed in the EKT results stems from the intensive course applications in the Internet class.
- The environmental awareness and knowledge of the students improved as a result of the computer-assisted education within the study. Therefore, their environmental attitudes could be assumed to have been improved. In a similar study (George, 2000), the results displayed a change in the students' attitudes towards science when their knowledge increased. Manzanal, Barreiro, and Jimenez (1999) evaluated the attitudes of the students who were doing ecological field studies towards environmental protection and found positive improvements within the results. Again, Papanastasiou and Zembylas (2002) determined that achievement in science is related to the attitudes of the students towards science. These evaluations support our results.
- In 1993, Musser assessed the attitudes of the 3rd, 4th and 5th year students towards recycling, reusing and decreasing pollution and found that the students, who could control their behaviors and were responsible, had positive attitudes towards the environment. Again, Musser investigated the relationship between the environmental attitudes and interests of the school children and their ages, gender, awareness and fears in 1996. Environmental interest was observed to be correlated with the environmental

attitudes and awareness as a result. Therefore, the environmental attitudes of the students are indicators of their environmental interests and this awareness is related to environmental knowledge.

ACKNOWLEDGEMENTS: We are grateful to the Hacettepe University Research Fund and the German DAAD (Deutsche Akademische Austausch Dienst) Foundation for providing the materials and the equipment for this study.

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