

**AN ENVIRONMENTAL APPROACH TO THE GENERAL
CHEMISTRY CURRICULUM
FOR BASIC SCIENCE STUDENTS IN
HO CHI MINH CITY UNIVERSITY**

by

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B.Sc., Ho Chi Minh City University, 1981

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THE REQUIREMENTS FOR THE DEGREE OF
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**An Environmental Approach to the General Chemistry Curriculum for
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ABSTRACT

Science-Technology-Society (STS) has been accepted widely as a viable emphasis for science education around the world, and environmental education is one of the most important themes within this movement. Based on the trends of science curriculum reforms in Vietnam in the 1990's, the Ministry of Education and Training is advocating STS approaches in science courses. In addition, environmental issues have become more and more serious in Vietnam recently. The purpose of this study was to examine the effectiveness of a suggested environmental approach to the general chemistry course in a Vietnamese university context. The study also examined students' attitudes and knowledge as well as their perceptions about the program. The purpose of the study was to come to an understanding of how the suggested environmental approach within the STS emphasis is valued by science students and chemistry instructors in Vietnam.

The sample of the study consisted of forty eight first-year students in the Department of Chemistry, Ho Chi Minh City University of Education. The chosen environmental topics in this program were in accordance with content of the current general chemistry curriculum. The suggested environmental approach was consistent with the spirit of the recent education reforms in Vietnam and the aims and objectives of the chemistry curriculum. The resources required to implement these topics were available in the Vietnamese context.

Data for the study were obtained from a questionnaire on attitudes toward chemistry, a questionnaire on student feedback, observation checklists, interviews with six students, student essays and interviews with instructors. Students were asked to express their perceptions of the new approach, and instructors were asked to comment on the suggested environmental approach.

The findings showed that the environmental approach interested and motivated students to study General Chemistry. This approach had positive effects on students'

learning, especially in terms of their awareness of environmental issues. Students also had more opportunity to reinforce the concepts and principles they had learned in General Chemistry, which they saw as being unique from those of other programs they attended.

DEDICATION

This thesis is dedicated to my very dear father, Vo Phuoc Ngo and mother, Pham Thi Hong An who made many sacrifices for my studies, and who always believe that education is the best gift that parents can give their children. Thank you for all of your love. Without you this thesis would not be possible.

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Chapter 1

The Problem for the Study

Background to the problem

Following the reunification of Vietnam in 1975, massive changes have occurred in the country's educational system. In 1990, the former Ministry of Education, the General Department for Vocational Training, and the Ministry of Higher and Secondary Technical Education were fused together as one "Ministry of Education and Training." The first five years after reunification were also marked by a severe shortage of well-qualified people in the general work force, poor economic conditions, and very few resources for educational purposes (World Education Services, 1994). The government has undertaken enormous efforts to alleviate illiteracy, yet there remain some persistent problems in the remote mountain areas and in the Mekong Delta area, where there are inadequate schools and a shortage of teachers.

The educational system in Vietnam has been organized into two levels of administration: the centrally-based administration for the country as a whole, and the locally-based provincial administration. Both of these belong to the Ministry of Education. All universities are directly administered by the Central Ministry, while kindergarten, elementary, secondary and high school are administered by the General Department of Education in each province.

The national incentive to upgrade the educational system led to the development of a plan in 1990 to restructure post-secondary science education in Vietnam. A consortium of eleven universities was formed to undertake the incumbent science curriculum development and teacher education. The broad intention of this plan is to establish a "University Credit System," which includes two phases of work for undergraduate students of science. The first phase, general higher education phase, will be taught in community colleges across the

country. After two years of study in this basic science program, students will transfer into university for the second phase of their education—the science specialization (fisheries, agriculture, engineering, etc.) This University Credit System will thus enable improved access to a basic science education, particularly in the more remote areas of the country, and a solid foundation for further study of science in applied contexts.

While the broad purpose for this restructuring is to increase access to basic science education and, therefore, to improve the scientific and technological literacy of the Vietnamese citizenry, there are many problems and conditions that help to shape the specific nature of the impending reform. The country has been somewhat isolated from the professional science and science education communities for the past twenty years, and textbooks and teaching methods reflecting current understandings in science are lacking. The condition of teaching laboratories is very poor in certain areas of the country, and this, in part, has led to a rather “rhetorical” science education, that is, one which relies heavily on rote memorization, at the expense of a “broad and deep understanding” of the subject matter which reflects the fundamental principles of science. Frequently, the need to learn by memorization is exacerbated by the lack of practical, concrete laboratory activities that are relevant and motivating for students.

Under the open door policy, especially since the lifting of the United States embargo, the government now is making a great attempt to rebuild a new educational system at all levels to meet the needs of a country which is developing eagerly and rapidly after several decades of war. The conditions for university science education and the need for reform require analysis of the purposes of a science education. There is a need to develop an appropriate science curriculum and program of studies that reflects the true nature of the scientific enterprise, the inter-relations among science, technology, and society, as well as the historical and philosophical bases for scientific theories and achievements. Further, effective teaching strategies must be prepared to insure the success

of a greater diversity of students in developing cognitive and problem-solving abilities in science.

Context of the problem

The current status of science education in Vietnamese universities

At the National Conference of Rectors and Directors of Universities and Colleges in Ha Noi, Vietnam, August 1994, the Minister of Education and Training of Vietnam said:

Through education, people can perceive scientific and technical achievements in reality, and generally, there is a "considerable time-lag" between education and such achievements. At the moment, since our education still emphasizes "pure science", it can not keep up with technical achievements, and still focuses more on theory than on practical activities. Tran Hoang Quan, *Tiep tuc Doi moi nen Giao duc Vietnam. (Continuing the Higher Education Reform in Vietnam, p.15)*

At that National Conference, many educators in Vietnam also expressed dissatisfaction with the state of science education in the universities of our country. Most of the speeches indicated a crisis in science education. The following summary of their conclusions identifies the elements of this crisis:

- Student knowledge of basic science is very low and lacking in modernization.
- Most students do not enjoy science and do not see the value of science in their daily lives. They usually consider traditional science lectures to be dry, too difficult to comprehend, irrelevant and uninteresting.
- University science programs are dominated by the "old curriculum". Very little or none of the social and technological implications of science are presented in the science curriculum; even though these implications are related to the urgent issues that the country or the rest of the world pays attention to.
- The classical lecture is the dominant teaching method in most science classrooms of universities. This lecture approach does not help to develop the

independent and creative thinking of students. Such teaching seems to discourage students from continuing their study of science.

- Science teaching is focused almost exclusively upon the goal of preparing students for examinations, completing the required units, and preparing them for the next course. The students can only “accept” the knowledge without expanding their understanding into the basic concepts and principles of science and the nature of scientific progress.

The need for environmental education

The need for developing scientific literacy through science education has emerged since the 1950's. Hurd (1958), one of the first people to use the term, used it to describe an understanding of science and its application to our social experience. The relationship between science and society was then categorized into the general theme Science-Technology-Society (STS). Gallagher (1971), one of the first persons to formally propose that science education be oriented around a Science-Technology-Society theme, believes:

For future citizens in a democracy, understanding the interrelations of science, technology, and society may be as important as understanding the concepts and processes of science. (p. 337)

According to STS advocates, science education in the 1970's and 1980's was oriented to be more relevant to societal concerns. Three approaches: “humanistic education, values education, and environmental education, deserve special attention as part of the Science-Technology-Society thrust” (DeBoer, 1991, p. 179).

In 1972, the UN Conference on Human Environment in Stockholm was instrumental in bringing countries together to consider the future of the earth. After that, there were a number of studies expressing environmental concerns in different countries. There is now a general acceptance of a series of major global environmental problems:

- global warming;

- damage to the ozone layer;
- deforestation, particularly of the tropical rain forest;
- acid rain;
- soil erosion;
- desertification;
- the threat to endangered species of plants and animals.

(Sutton, 1994, p. 11)

Together with the increasing awareness of environment on an international scale, environmental education has come to be one of the most important approaches of STS education. Bybee (1979) suggested four goals of science education related to the “ecological perspective”:

- (1) the full development and nurture of the individual,
- (2) the protection, conservation, and improvement of the environment,
- (3) appropriate use of natural resources, and
- (4) the development of a sense of community from the local to the international level.

(DeBoer, 1991, p. 182)

The emergence of environmental education is also marked by the establishment of the Journal of Environmental Education in 1969 and by congressional passage of the Environmental Education Act in 1970. This legislation defined environmental education as

the educational process dealing with man’s relationship with his natural and man-made surroundings, and includes the relation of population, pollution, resource allocation and depletion, conservation, transportation, technology, and urban and rural planning to the total human environment.

(Environmental Education Act, 1970, p. 1312)

Many environmental issues are related to the study of chemistry. For example, the control of automobile emissions is closely related to the chemistry of combustion processes; the quality of our water resources is related to methods of purifying substances. Therefore, environmental chemistry deals with those aspects of our environment that can

be understood and monitored using basic physical and chemical principles. In other words, chemistry has a role to play in finding solutions to most environmental problems.

Parallel with economic development and increasing population, Vietnam now is facing more and more serious problems in the environment. The need for an environmental education at all levels is one of the priorities nowadays. On planning the aims of Vietnamese education, the resolution of the Fourth meeting of the Central Committee of the Party (1994) suggested:

Our education should combine harmoniously culture and science with technology, and that the major point of renovation is to reject the tendency to ignore or undervalue environmental education, to separate science education from social issues, to break the balance between science education and technology-society-environment education. (p. 2)

Statement of the problem

The purpose of this study is to design an environmental approach to the teaching of the general chemistry course for first-year university students. The goals of the approach are to develop students' positive attitudes toward chemistry, to promote their understanding of the basic concepts and principles of chemistry and to develop students' awareness and knowledge about environmental issues. To this extent, the research questions of the study are:

(1) Does the suggested environmental approach help to promote students' interest and motivation toward the course and their awareness of environmental issues as well as their understanding of basic concepts and principles of chemistry?

(2) What teaching method could be used effectively to deliver environmental issues in the general chemistry course?

(3) How are the chosen environmental issues suitable for the general chemistry curriculum in Vietnamese context?

Significance of the study

It is very important for Vietnamese students to understand the environmental problems in Vietnam. This study provides students with the opportunity to develop an appreciation for contemporary problems in chemistry and to see real-life applications of their own chemistry lessons. It is also hoped that the suggested environmental approach in this study will increase students' interest and motivation in chemistry course.

Since the science curriculum is under reform in Vietnam, universities are looking for environmental science courses. Certainly, a specialized credit course of environmental chemistry or an environmental approach should be included in the study of chemistry. It would be helpful to extend the suggested program in this study to an environmental chemistry course. This study also may provide a useful learning tool and, possibly, inspire Vietnamese instructors to develop their own teaching strategies in accordance with the general purposes and strategies discussed in this work.

Methodological stance

The study can be thought of in terms of two components: (1) the development of an environmental approach to the general chemistry curriculum for first-year students in Vietnamese universities, and (2) the field-testing of the suggested approach in Vietnam. The first component will utilize literature reviews of science teaching and science curriculum development dealing with environmental issues in North America, together with analyses of teaching strategies appropriate for the desired outcomes of the general chemistry course in the Vietnamese context.

The second component of the study will draw on quantitative and qualitative techniques to document and analyze the suggested environmental topics and learning activities in order to assess both the program design and the experience of teaching it. Data collection for the second component of the study occurred during six weeks in the

Department of Chemistry, Ho Chi Minh City University of Education. Data sources include student questionnaires, observation checklists, student essays and interviews with the instructors and students. Data include information about the events of teaching and learning chemistry in the Vietnamese setting. These data are analyzed for patterns and qualities that inform future implementation and teacher development in Vietnam.

Overview of the study

This is an exploratory study of the STS approach in the teaching of general chemistry in the basic science program in Vietnamese universities. Chapter One has introduced the problem for the study and argued for its significance. A brief discussion of the method of research and development has been included.

Chapter Two reviews pertinent literature on the development of STS in science education, science curriculum dealing with environmental issues for developed and developing countries, the role of environmental education in chemistry curriculum, and the progress towards addressing environmental issues in university chemistry. Emphasis is placed on the trends of science curriculum reforms in Vietnam, what has been done in making education relevant to social requirements, and the needs for introducing social issues in the science curriculum in Vietnam.

Chapter Three provides the overall design of the study, the description of the procedures, the instruments and the tasks used in the collection of data. Chapter Four presents an implementation plan of the environmental approach, the details of the designed learning activities, and the evaluation of the program. Chapter Five reports the data gathered and analyzed from the field test in Vietnam, paving the way for a discussion of the conclusions, implications, and limitations of the study in Chapter Six.

Chapter 2

Review of Literature

Introduction

This literature review comprises five sections. The first section begins with a brief overview of the development of STS in science education. The second section provides the overview of the studies related to environmental education that have particularly significant implications for STS education. Science curriculum dealing with environmental issues for developed and developing countries are outlined in the third section. The fourth section concerns the role of environmental education in chemistry curriculum, and the progress towards addressing environmental issues in high school and university chemistry. The last section examines the trends of science curriculum reforms in Vietnam, reviews what has been done in making education relevant to societal requirements, and identifies the need for introducing social issues in science curriculum in Vietnam.

Science-Technology-Society (STS) in science education

Changes in society and in science have forced a consideration of what is basic in science education. A major science education reform began in North America, with “Science, Technology and Society” (STS) as a new emphasis since the Soviet Union launched Sputnik 1 on the date October 4, 1957. The new science curriculum development in the United States went on for more than fifteen years with moral and financial support. Nevertheless, upon examination, the public educators in the United States indicated a crisis in science education; the goals for past social challenges were not adequate for present social challenges. The goal of science education during the 1960’s was:

The student should understand the structure of science disciplines and processes of scientific investigation. (Bybee and Trowbridge, 1990, p. 418)

With this goal, science educators developed programs emphasizing “pure science”. This goal was inappropriate for the majority of students and inconsistent with the historical goals of public education. The traditional elitist view of science education which emphasized “pure science” of the 1960’s and 1970’s has failed, according to some critics (Goodlad, 1984).

STS became one emphasis for science education in the 1980’s. It was one of five focus groups for the National Science Foundation supported research called Project Synthesis. The report of Project Synthesis became central to the National Science Teachers Association (NSTA) Search for Excellence in science education program. NSTA indicated that:

The goal of science education during 1980s is to develop scientifically literate individuals who understand how science, technology, and society influence one another and who are able to use this knowledge in their everyday decision-making. Such individuals both appreciate the value of science and technology in society and understand their limitations. (quoted in Yager, 1988, p. 181)

This is the ultimate goal for the integration of the STS theme into science curriculum. It is to achieve scientific and technological literacy for all learners in the issues directly related to their lives, and to empower them to use this scientific understanding in their everyday decision making.

The interrelationships of science, technology and society were anticipated by earlier analyses, for example, in the work of John Ziman in the United Kingdom (1968). A more recent study done by the Science Council of Canada (1984) also made recommendations for improving the state of science education. These included:

- Science education must provide a more accurate view of the practice, uses and limitations of science.
- Science education must include study of how science, technology and society interact.

- Students must be taught how Canadians have contributed to science and how science has affected Canadian society.
 - Teachers and curriculum planners must evaluate students' progress towards all the goals of science education, not just their learning of scientific content.
- (Science Council of Canada, 1984)

In the 1990's, there are continuing reforms in science education through North America and the United Kingdom. Although there were some past failures of implementation, STS reform proposals appear in curriculum discourse. Several international organizations such as the National Association for Science-Technology-Society (NASTS) and the International Organization for Science and Technology Education (IOSTE) have begun to design curricula frameworks for STS in science education. For example, the IOSTE-Kiel synopsis, Federal Republic of Germany on world trends in science and technology education provided recommendations by which STS education should be developed. This synopsis stated that:

STS curricula should provide balance in emphasis of different aspects of STS science content, including (a) the nature of science (the epistemology of science and technology ought to be treated as problematic), (b) social issues (e.g. pollution and nuclear war—but also smaller-scale local controversial issues that schools can engage directly), and (c) the content of the science discipline—how science influences social life and is itself influenced by the imperatives of social life. (quoted in Hart, 1990, p. 579)

An international survey of science educators indicated that 89% of science educators supported the teaching of social problems in science education. They agreed that the courses in STS should be required of all students (Bybee and Mau, 1986).

Environmental education and a goal structure for STS education

Modern citizens face decisions on issues related to science, technology and human values every day of their lives, especially in areas of environmental quality, health and medicine, waste management, and world population. There have been many reports on

environmental and global issues such as food additives use, energy consumption, water shortages, air quality, AIDS, genetic engineering and nuclear proliferation. Volk (1984) and Disinger (1986) have argued that environmental education is, in fact, STS education. They contend that there is a body of literature in environmental education that has direct implications for STS education.

The “environmental education” studies by Klinger (1980), Hines (1984), Ramsey, Hungerford and Tomera (1986), and a goal structure for environmental education (Hungerford, Peyton, and Wilke, 1980) have significant implications for STS education. From the research of Sia, Hungerford and Tomera (1986) and Hines (1984); Rubba and Wiesenmayer (1988) recognized that:

It appears that responsible environmental action is mainly a function of four factors: (1) knowledge of environmental issues, (2) knowledge of specific action strategies that might be applied to resolve an environmental issue, (3) the ability to take action on environmental issues (actually applying the action strategies) and (4) the possession of certain affective qualities and personality attributes. (p. 41)

These four factors were presented in the goals formulated by Hungerford (1980):

At level 1, the Ecological Foundations Level, environmental education seeks “to provide a learner with the sufficient ecological foundations knowledge to permit her or him to eventually make ecologically sound decisions with respect to environmental issues” (p. 43).

Level 2, the Conceptual Awareness Level, helps learners to understand that through citizen action, these issues will be resolved.

At level 3, the Issue Investigation and Evaluation Level, environmental education instruction aims “to provide learners with the knowledge and skills necessary for them to investigate and evaluate alternative means for the remediation of environmental issues” (p. 41). In this level, the learners are given an opportunity to put these skills into practice in the investigation and analysis of environmental issues.

At Level 4, Environmental Action skills Training and Application, environmental education seeks to develop in learners those skills needed to take positive action on environmental issues. “Learners would gain knowledge about actions that fit into consumer, legal, persuasive, political, and physical categories. Learners are also provided with opportunities to apply these actions to environmental issues and evaluate their effectiveness.” (quoted in Rubba and Wiesenmayer, p. 41)

The work in environmental education of Hungerford, Peyton and Wilke (1980); Hines (1984); and Sia, Tomera (1986) has important implications for precollege STS education. This literature suggested that:

If precollege STS education aims to help students develop the capabilities to make discriminating decisions on STS issues and take action on those decisions (a social responsibility view), then STS education can not be limited to the type of curricula and instructional activities one would find at the foundations and awareness levels of environmental education. (p. 42)

Environmental education is a fundamental part of the STS high school and university science curriculum.

From this view of a goal structure for STS education, we could conclude that there is general agreement that science curricula should be aimed toward developing the knowledge, skills and attitudes required for responsible management of the environment. The development of environmental literacy is a major goal of science education.

Science curriculum dealing with environmental issues in some developed and developing countries

In Canada, environmental awareness and sustainability issues have been studied in Canadian classrooms from Secondary school to University. Environmental topics are specified as part of the science curricula in physics, chemistry and biology. Studies of the local environment have provided the foundation for topics of study.

Environmental concerns have become a major issue in Canadian science curriculum because of the demand to include relevant “Canadian” content in the curriculum and to

address social issues related to conservation, pollution, and waste management. A review of the science curriculum documents indicates that:

- more environmental and geological topics are taught in most provinces in Canada.
- the majority of topics which could be defined as “Canadian studies” were related to environmental concerns (i.e., biotic and abiotic factors and their effect on biomes, communities and populations) and to geological concerns (i.e., land formation, erosion, soils, and mineral extraction), even if such topics appeared in a chemistry or physics curriculum. (Connelly, Crocker & Kass, 1985, p. 163)

Although environmental chemistry is a new field, it has appeared in chemistry curricula since the 1980s. Most of this work has been done in university academic departments or by Curriculum Revision Committees of provinces. The universities and community colleges are adding environmental science courses dealing with sustainable development, waste minimization, and conservation. Canadian educators in the school system are developing industry-school partnerships to give students a look at real-world problems, including waste management and other environmental issues that Canadian industry faces.

In 1991, the Faculty of Science at the University of Manitoba introduced a four-year undergraduate program in environmental science. The program included a range of science courses with an essential “environmental core” (Manitoba environment, 1993, p. 127). Students can earn a Bachelor of Science in a traditional subject, then study environmental issues in graduate study. The University of Winnipeg was the first Canadian university in developing a three-year environmental studies program. In 1994, this university launched several new courses in environmental health and sustainable urban growth. Students are encouraged to major in two separate areas such as sociology and chemistry to gain the depth of knowledge in diverse subjects (Manitoba Environment, 1995, p. 143).

Reviews of undergraduate programs in academic chemistry education in North America support the view that environmental chemistry should be included in chemistry courses in university faculties of science. Environmental chemistry was introduced into the universities in British Columbia in 1990. Simon Fraser University, Faculty of Science introduced environmental science programs in 1995. Three environmental chemistry courses were introduced into a specific minor program in environmental chemistry. These courses are (1) Chemistry of the atmospheric environment, (2) Chemistry of the aqueous environment, and (3) Analytical environmental chemistry. Study focuses on the chemical and physical processes in atmospheric and aqueous environments, air pollution, waste water treatment, the principles and applications of air, water and soil analysis, and control of environmental problems. These courses naturally lead into discussions of air, water and soil conservation and respect for the environment (Simon Fraser University Calendar 1995-1996). The course outlines are shown in Appendix A. These courses are offered to third-year students who have requisite courses in chemistry.

In the United States, approaches to environmental issues in tertiary level have been greater than that at the primary or secondary levels. Different approaches have also been used for undergraduate and post-graduate programs. Bachert's (1971) survey of degree programs in conservation and environmental education in the United States showed that many colleges and universities provide undergraduate and graduate programs in environmental science.

Recently, there are a number of national organizations advocating reform in science education with regard to environmental issues. The American Association for the Advancement of Science (AAAS) is sponsoring Project 2061, which includes extensive work in environmental science (Berkowitz, 1993). Another project is the Scope Sequence and Coordination (SSC) project sponsored by the National Science Teachers Association (NSTA), which emphasizes on the approaches to understanding societal problems. Smaller

projects have been developed in California, Iowa and Texas, among other states, which emphasize a Science-Technology-Society approach to environmental problems.

Some developing countries have a long tradition in environmental education. India is one of the front-runners in this field. The philosophies of Buddhism and Hinduism have always been embedded in Indian education, and have focused on the conservation of plant and animal life. Attempts to incorporate environmental issues into Indian science education were made in the 1960s. In the late 1970s and early 1980s, the Philippines introduced environmental issues in the school curriculum. Indonesia related environmental problems into the relevant subjects in the school reform curricula in 1984 (Schneider, 1993, p. 42).

Environmental education in chemistry curriculum

Chemistry is the study of the composition of substances and their transformations. Chemical theories have led to the development of many new processes and products which directly affect our society; therefore, basic chemistry and the technological applications of chemistry are human activities which influence every aspect of our lives, and which are crucial for our health social welfare.

Environment education is considered an appropriate field of study for those interested in minerals, water resources, food supply, climate, etc. It is encouraging that people are becoming more concerned about how to live successfully on our planet. The solution to many problems related to the environment can only be found by citizens who are scientifically literate. Chemistry students should learn about the technological applications of chemistry and their impact on society in order to develop an informed view of everyday decision-making. Chemistry curriculum, therefore, should be focused on the interactions between science, technology, society and environment.

From the scope of chemistry and environmental study we can see that there are several important areas in environment. Manahan (1994) defined environmental chemistry

as the study of the sources, reactions, transport effects, and fates of chemical species in water, soil, and air environments and the effects of technology thereon.

Environmental chemistry deals with aspects of our environment that can be understood by the basic chemical principles involved. Any serious attempt to solve environmental problems must involve chemical analyses and processes. For example, how we control automobile emissions is closely related to our knowledge of the chemistry of the combustion process. Effective solutions of pollution problems will depend on public understanding of chemistry. It is very important that some background in environmental chemistry should be part of the training of every chemistry student. Students need to understand fundamental concepts in chemistry, the chemical composition of the environment, and its change due to production, consumption and waste. Such knowledge will enable students to understand the arguments presented to the public.

In recent years chemists have become more interested in environmental problems. Academic chemistry departments have found that environmental chemistry courses appeal to students, and many graduate students are attracted to environmental chemistry research. There has been an increasing number of environmental chemists among those of traditional chemical disciplines, together with an increasing attitude in curriculum debate that general chemistry curricula should focus, in part on environmental chemistry. The educational system in Canada has made significant progress towards addressing environmental issues and problems, particularly in high school level, university, college and in-service teacher education. Next, the potential for introducing environmental chemistry in Vietnamese universities is explored.

The needs for introducing social issues in science curriculum in Vietnam

In the first session of the International Committee on Education (ICE) for the twenty first century, Professor Pham Minh Hac, Vice Minister of the Ministry of Education and Training of Vietnam, commented on “the responsibility of education”:

Science education should establish new knowledge which intensifies personal and national abilities, so that they can compete in the increasingly global human society.

The studies undertaken by the Institute of Educational Sciences in Vietnam made recommendations for improving the state of science education. One of the most important perceived recommendations is for all our students to have a certain degree of scientific literacy to cope with an era of science and technology in a global society. Such issues as environmental protection, population pressures, health care and technology should be studied in Vietnamese classrooms, because the solution to these social problems can only be found by citizens who are scientifically literate. Students should be provided with the opportunity to act on societal and environmental issues that are related to science and technology. Educational reformers contend that curriculum divorced from the issues of everyday life should be replaced with an authentic science education which addresses the problems of the real-world.

In addition to these recommendations, issue-oriented science is being emphasized by the Science Council of the Vietnamese Ministry of Education and Training (Five-year Educational Reform Project 1991-1995 in Vietnam). The project supports an approach to teaching science that addresses societal and technological issues. Effective education highlighting an integration of science and technology and economic, environmental and societal needs was advocated by Professor Vu Van Tao (1993):

It is of primary importance and urgency to focus our attention to the environmental and societal sides of the process of education and training in order to annihilate the retardation in the achievements of technical transition in our renovation reality. (p. 3)

He noted that through the process of integrating science, technology and society, a new curriculum component, “environmental education” is beginning to emerge. It appears that the Science Council of Vietnam is advocating more environmental education.

At the National Conference of Rectors and Directors of Universities and Colleges in Hanoi, Vietnam, on August 1993, Dr. Quan, Minister of Education and Training, said that:

Through education, people can perceive scientific and technical achievements in reality, and generally, there is a “considerable time-lag” between education and such achievements. At the moment, since our education still emphasizes “pure science”, it can not keep up with technical achievements, and still focuses more on theory than on practical activities. (p. 15)

I believe that environmental education can be used to make science relevant to students, allowing them to study technological advances and the resulting societal issues in Vietnam.

It is important to emphasize that after several decades of war, the Vietnamese society has made quick changes in its economic structure in the 1990s. Because of the nature of the growing economy in Vietnam, environmental problems are accelerating and becoming more and more serious nowadays. Air pollution spreads beyond the big cities like Ho Chi Minh City; water pollution from the industrial wastes has seriously affected the daily life of the people. Environmental degradation is everywhere; factories have been built amid agricultural and residential areas; pesticide use is high and solid wastes have been disposed in highly populated areas. Vietnam is a developing country and is indeed a nation with serious environmental crises. The government in Vietnam has begun to institute measures to protect the environment. However, environmental education is still a theme which needs to be developed at various levels of education in our country.

We have not included environmental education in secondary school curriculum. Very few environmental issues have been introduced into science curriculum. For example, the environmental education topics have hardly been incorporated into our Chemistry revision curriculum Grade 8 by the year 1989 with only two small sections: (1) Air conservation aimed at reducing atmospheric pollution (topic II); (2) Treatments for water pollution (topic IV, Textbook of Chemistry 8). Except for pollution-related STS issues, which were dealt with in Grade 8 Chemistry, STS issues have not been emphasized in life science, biology, physics and chemistry curricula in our country.

The more notable position taken by the University Science Education Council of Ho Chi Minh City has been the formation of a number of courses of the environmental science in Ho Chi Minh City University since 1994. An "Environmental Biology" course was introduced into a training program for the Biology majors. Another was "Resources and Earth's Environment" course for the Geography and Geology majors. These courses have been introduced to the third-year. However, no Environmental Chemistry course has been introduced. We also have not seen any STS approaches to university chemistry education at the first or second-year university in Vietnam. My review of the current status of science education in our country supports my conviction that the Science-Technology-Society approach to the teaching chemistry is an excellent vehicle for implementing the recommendations of the Ministry of Education and Training for improving the state of science education in Vietnam.

Summary

It has been argued that reform is needed in science education. The Science and Technology in Society emphasis has been considered through the studies undertaken by the Science Council of Canada, the Association of Science Education in Great Britain, and Project Synthesis in the United States. These studies made recommendations for improving the state of science education, partly through STS approaches.

Studies in the past have shown that most of science educators supported the teaching of social problems in science education. There is general agreement that an STS emphasis is a growing component of science education that helps learners develop the capabilities needed to participate as citizens in the resolution of issues we face in society. In fact, environmental education has direct implications for STS education from the social responsibility viewpoint.

The work in the field of environmental education in North America and developing countries has shown that social and philosophical dimensions of science and technology

have been increasingly considered. Research on environmental education in chemistry curriculum shows that environmental chemistry courses have been introduced in undergraduate programs in numerous universities. It is necessary for us, as Vietnamese teachers, to know about the means and experiences of teaching environmental issues in chemistry courses.

Finally, the trends of science curriculum reforms in Vietnam have been examined. It appears that the Ministry of Education and Training in Vietnam is advocating STS approaches in science courses. Vietnamese educators, therefore, are encouraged to design courses which would increase the scientific literacy of all citizens. This review offers support for this study to introduce environmental issues in the general chemistry course for Vietnamese university students.

Chapter 3

Method and Procedure

The purpose of this study was to examine the effectiveness of the “environmental approach” to the general chemistry course which aims to develop the positive attitudes of students toward chemistry, to enhance students’ awareness of environmental issues, to improve students’ understanding of the basic concepts and principles in the general chemistry course for the first year students in Vietnamese universities.

This chapter includes the overall design of the study, the context of the study, and the description of the design procedure except the contents of the designed learning activities presented in Chapter 4.

Context of the study

The present Ho Chi Minh City University of Education enrolls a contingent of future high school teachers for the cities and provinces in the South Vietnam, especially for Ho Chi Minh City and the neighboring provinces. The University of Education offers post- graduate training and refresher courses, to train cadres for specialized branches of basic sciences.

The University annually admits approximately 500 students to regular undergraduate courses. Annually the University educates 3,500 – 5,000 students.

The University boasts a teaching staff of 450, consisting of 60 Professors, Associate Professors, doctors and over 100 Lecturers with postgraduate degrees. Apart from holding teaching positions inside the University, the University’s contingent of scientific cadres also undertakes teaching tasks at other universities and plays an active part in the educational reform under way throughout the Southern cities and provinces of

Vietnam. The staff assists in designing curricula, writing course books and giving refresher courses to high school teachers.

The teaching and research facilities of the University are organized into 14 departments: Mathematics, Physics, Chemistry, Biology, Vietnamese and Literature, History, Geography, English, French, Russian, Chinese, Political Education, Educational Psychology and Physical Education.

In the Department of Chemistry, annually full-time equivalent enrollment was 250 students. The Department comprises a teaching staff of 36, including one Associate Professor and five Ph.D. candidates, representing the following disciplines: General Chemistry, Physical Chemistry, Elemental Chemistry, Analytical Chemistry, Inorganic Chemistry, Organic Chemistry, Quantum Chemistry, Industrial Chemistry, and Chemistry Teaching Methodology.

In 1994-1995, 48 Grade 12 students from Ho Chi Minh City and the neighboring provinces passed the university entrance examination and enrolled in the Department of Chemistry of Ho Chi Minh City University of Education.

The sample in this study consisted of a 1994-1995 class of those forty eight first-year students ranging from 18 to 25 years of age, in the Department of Chemistry of Ho Chi Minh City University of Education. They majored in chemistry to become chemistry teachers in high schools in the future. All students have prerequisite courses in Chemistry 11 and Chemistry 12 from high schools. Mathematics and introductory physics courses are required concurrently. Students were also enrolled in the corresponding laboratory course for this chemistry course, the General Chemistry Laboratory.

Since Chemistry 11 and Chemistry 12 curricula in Vietnam do not include any environmental topics, the students in this study had not been taught about environmental issues, outside of having been exposed to environmental information from Vietnamese magazines, television and a radio broadcasting network.

During the program, all students were in the same class taught by the researcher. They were provided with the same opportunity for hands on investigation of environmental issues that illustrate how chemistry knowledge can be used to understand a real-world problem. They were also provided the opportunity for solving several environmental problems with the basic knowledge of chemistry.

No students withdrew during the program and most of them regularly attended the class. At the end of this program, students were given posttests to evaluate the effectiveness of the approach. Details of the instruments and the teaching procedures are provided in the following sections.

Before implementing the new approach to the course, the permission to conduct the research in the university was requested through a letter outlining the research proposal. Approvals were obtained from the heads of the university and the Chemistry Department (see Appendix D) in Ho Chi Minh City University of Education.

A meeting was arranged for the researcher and four other instructors who have taught the general chemistry course in Ho Chi Minh City University, in order to explain the purposes and the procedures that were involved in the study. The instructors were told that the research experiment would be undertaken by the researcher to collect data for the evaluation of the effectiveness of the environmental approach. The instructors would be asked to give their experience and comments about this approach.

After this initial meeting, all four instructors supported the research experiment and agreed to participate in informal discussion with the researcher. One of them volunteered to observe the class during the program. They gave me advice on preparing the appropriate facilities before starting the project.

Research design

The research involves the following steps:

- (1) The exploration of the advantages and the disadvantages of an environmental approach in the Vietnamese university context.
- (2) The choice of the topics related to the environment for the general chemistry course.
- (3) The choice of the teaching strategies.
- (4) The design of the learning activities for the environmental topics.
- (5) The design of the instruments used to gather data.

Instruments used to gather data

Data for this study were obtained from student questionnaires, observation checklists, students' essays and interviews with students and instructors.

Four instructors observed the class when it was convenient for them; one of these attended regularly. The observers were welcome to give their feedback on this new approach. They could also meet me in the General Chemistry office after each class, or every Monday, to discuss their observations. The observers sat quietly at the back of the classroom, joining the teaching and learning activities as appropriate. The classroom observation seemed to be normal, and it was presumed that the presence of the observers did not affect classroom behaviors significantly.

No effort was made to record the classroom interactions which occurred between the researcher and the students during the implementation of the new approach. Therefore, students and the researcher were working as they would normally, so that the teaching observed was typical of that normally used by the researcher.

In order to understand the interaction during discussion among students and students' experiences in the course, classroom observations were focused particularly on six students. The researcher used an Observation Checklist to evaluate students' skill in

group discussion, presentation, and verbal reports. This checklist was completed after the group discussion of each lesson. The items on the Observation Checklist were adapted from a study of the Province of British Columbia, Science and Technology 11. It included eight items, having a five-point scale in which students responded "not at all", "a little", "average", "a lot" or "very much" to various items shown in Appendix E.

The questionnaire on attitudes toward chemistry was developed and administered to the students as a posttest in the final week of classes. This instrument, which is a Likert-type test, was constructed with eight items. Some of the items were taken from the study of Gogolin and Swartz (1992). Students were asked to respond "strongly agree", "agree", "disagree", "strongly disagree" to the items. It required fifteen minutes to complete and was easily scored. The questionnaire is shown in Appendix F.

The questionnaire on feedback from students gave data regarding the students' opinions about this teaching approach. This instrument was administered in the final week of classes. This instrument has a five-point scale in which subjects respond "not at all", "a little", "average", "a lot" or "very much" to the items. This questionnaire is shown in Appendix G.

During the final week of the teaching approach, students were asked to write and submit an essay expressing their feelings and thoughts about the new classes. Since all the answers from the students were treated as confidential, no names were recorded on the questionnaires and essays so individual students were anonymous.

Six students were interviewed about their perceptions of the environmental approach and their experiences of taking the new classes. This instrument was a semi-structured, open-ended interview. The interview questions were designed to elicit responses to the following matters:

- The questions were relatively friendly and minimally threatening as "openers" (Jickling, 1991). Probes encouraged students to comment further about

their interest and motivation in chemistry, how the environmental approach affect their learning chemistry, and how useful this approach was. These questions were minimally structured and gave the students considerable scope to say what was on their minds.

- Students were encouraged to freely express themselves.

The interview was conducted in the classroom during two hours. Audio-tapes were used to record each interview. The interview questions to the students are shown in Appendix H.

After finishing six weeks of teaching approach, a second meeting with four chemistry instructors was organized, they were asked to give their comments on the new approach through an interview. Questions were designed to gain information about instructors' perceptions of the environment and their opinions about the general chemistry curriculum in Vietnam. Probes encouraged them to comment further on what students should learn about, how it should be organized for teaching, and what the learning outcomes of environmental education should be. Focus group interviews were chosen for this instrument because they provided a shared- view of the new approach among four instructors, who were able to hear each other's responses and to make additional comments beyond their own original responses. Therefore, the three instructors who did not join the new classes, could consider their own views in the context of the views expressed by the one instructor who did observe the classes regularly. This interview was audio-taped and lasted about two hours. The interview questions for the teachers is shown in Appendix I.

Study procedures

The advantages and disadvantages of an environmental approach in the Vietnamese university context.

Advantages

The environmental approach in teaching chemistry is expected to promote students' understanding in chemistry, to develop the positive attitudes of students toward chemistry, to help them develop an appreciation for contemporary problems in chemistry and to see real-life applications of their own chemistry lessons. Moreover, this approach could be used as the science-technology-society (STS) movement in science curriculum.

Vietnamese universities are currently being restructured. New approaches to science teaching are welcomed. Vietnamese students seem to be interested in the science technology advances. They want to know about the contemporary problems in science and their impact upon society that have not been presented in the science curriculum in Vietnam. They are also expecting to take science courses in a new way that would be different from what they are used to. So they have quickly been attracted to the environmental topics implemented in the general chemistry course.

The Ministry of Education and Training of Vietnam advocates the establishment of a modern syllabus that is practical and suitable for the Vietnamese context. Hence, this environmental approach to the teaching of chemistry is a suitable vehicle for implementing the above recommendation.

Environment has become an important issue at the universities in Vietnam nowadays; and environmental issues have received new interest in science education. A number of courses on the environmental science have been formed in Ho Chi Minh City Universities since 1994 such as "Environmental Biology" for the Biology major students; "Resources and Earth's Environment" for the Geography and Geology major; however,

“Environmental Chemistry” has not been introduced to the chemistry students. We have not seen any environmental approaches to university chemistry education at the general higher education level. Therefore, this approach was supported by the chemistry instructors, and administrators at the Ho Chi Minh City University of Education.

Environmental pollution is one of the most important issues in Vietnam. At the present time, Vietnam is raising a lot of urgent issues, there have been a lot of important studies on global environmental problems and local effects, dealing with the real-life significance of the Vietnamese context that are very useful for the teaching of these environmental topics.

Environmental issues are often mentioned in Saigon Liberation (a Vietnamese newspaper) and the Today's Chemistry (a Vietnamese journal), and articles from these newspapers were assigned to supplement our text. Video resources of Vietnam and Eastern Asia were provided by the Department of Technology and Environment, and by Ho Chi Minh City Television Network. These supplemental resources provided wonderful background for student discussions in this approach.

Before designing the appropriate learning activities for this approach, I collected local, regional, national resources about environmental issues. I spent several days contacting authorized personnel in the community, agencies or institutes in Ho Chi Minh City. My purpose was to find resources appropriate for the study of contemporary problems in environmental pollution in Vietnam, and control and treatment processes at the moment. These are unpublished resources available in Ho Chi Minh City libraries.

(1) At the office of Ho Chi Minh City Department of Technology and Environment (So Khoa hoc, Cong nghe va Moi trung thanh pho Ho Chi Minh), I was provided a document of laws and standards on pollution control in Vietnam . I was shown videotapes of environmental issues that can be ordered from An giang Department of Technology and Environment (So Khoa hoc, Cong nghe va Moi trung An Giang).

(2) Through contact with the officials of The Sub-Institute of Investigation and Planning for Hydraulic Work of South Vietnam in Ho Chi Minh City (Phan vien Qui Hoach va Khao Sat Thuy Loi phia Nam), I had an opportunity to learn about the national water quality studies in our country such as "Water quality monitoring in the Lower Mekong Basin", a big project with financial support from the Swedish International Development Authority. I obtained water quality data of the Saigon river taken in 1994. Other water pollution materials were also provided.

(3) At Ho Chi Minh City Water Supply Company (Cong Ty Cap Nuoc thanh pho Ho Chi Minh), I was told that a strategy for ensuring the safety of drinking water has been developed. Disinfection has been carried out in Ho Chi Minh City by chlorination. Several results on water sample analysis were collected.

These particular investigations offered suitable materials for my teaching approach and I was able to design learning activities around the resources I collected. It was my belief that local, regional and national resources would be interesting and motivating for students.

The above resources are presented in Appendix C.

Disadvantages

There are some disadvantages that may effect on the success of the environmental approach to science teaching in Vietnamese context.

The lack of relevant textbooks and new materials in science teaching is a serious problem in Vietnam nowadays. It is rather difficult to find relevant materials and appropriate references about the global environment in the university libraries. Most of resources used were provided by UNESCO and some international development agencies; they have been gathered in Ho Chi Minh City Central Library. Instructors need to guide students about which documents they should read and how they could find them in the Central Library. Besides books, other materials that are useful to the approach may be

difficult to get. A film examining the multitude of specific, social and economic issues related to a specific, environmental problem of Vietnam and the Eastern Asian countries could be ordered through Ho Chi Minh Television Network with university requests. This factor may cause obstacles to any environmental approach in science teaching, since instructors need to contact the authorized person at appropriate agencies to get materials for their students. The new approach may require instructors to spend more time preparing supplemental resources for teaching a topic.

Specialized journals on the environment and published statistical documents related to environmental issues in our country are lacking. Although there are some articles written on environmental problems in the Vietnamese Journal of Science Technology and Environment, most of them could not satisfy a variety of supplemental references on national and local environmental problems. These articles usually do not contain statistical data of environmental quality in our country that are very useful for teaching about environmental topics. Rather, they tend to provide simple understandings of the causes, consequences and effects of our actions on the environment.

Environmental awareness and sustainability issues have not been studied in high schools. Therefore, students' understanding about environmental awareness and sustainability issues and the relationship between science, technology and society have been low. Therefore, this approach may be unfamiliar to them, at least at the first stage of the learning process.

Vietnamese students have been familiar with the note-taking style and passive learning. They were embarrassed and reluctant, at least, in the first stage, to take part in group discussion or other learning activities that were included in the approach. They also seemed to feel that there was too much work to do in this new style of teaching; however, it is promising that they will be more excited about this new approach, with more exposure to the STS emphasis.

Other limiting factors include overcrowded classes, poor facilities, the lack of laboratory equipment, unsuitable classrooms with insufficient space, traditional furniture arrangements, and the lack of overhead projectors.

The choice of the topics in environment

The general chemistry curriculum has been revised and published by a team of chemistry educators for the Ministry of Education and Training in Vietnam on 1994. The approaches and topics used in this study were not considered in the design for the new course. The focus here was an infusion of STS materials, especially on environmental issues into the existing chemistry curriculum.

Several criteria were used to consider appropriate environmental topics for this approach:

(1) The topics should prepare students to have an awareness about the interrelationship between science and concrete social issues.

Contemporary societal issues were the first major consideration in the choice of the topics. It was my concern that societal issues be included in the five underlying missions of science education all over the world nowadays. The goals for science education in Vietnam are in transition; therefore, science education with emphasis on environmental concepts, world problems, decision making, and interdisciplinary studies related to the goal of teaching students how to deal with societal issues, should be developed. There are social obligations to educate the youth in their responsibility towards environmental and natural resources conservation, and social health in Vietnam. Societal issues should further students' ability to apply the concepts and principles learned in the classroom to actual life. Learning processes were designed to guide students towards an understanding of the concepts and principles of chemistry, as well as the societal issues and technological impacts involved in the application of scientific knowledge. This kind of understanding

would hopefully better prepare students to make responsible decisions concerning science related social issues.

(2) The topics should help students to have an overall understanding or perception about the relationship between environmental issues and the global issues.

Environmental problems are related to a global perspective, so the understanding and solutions require both local actions and global cooperation. Many global issues could enhance students' understanding of the value of what they are learning in science. For example, acid rain, the greenhouse effect, the deforestation, damage to the ozone layer are global environmental problems resulting from the activities of human kind. Using these issues for teaching chemistry could help students to broaden their understanding and perceptions of global issues.

(3) The topics should be selected and analyzed to an appropriate level with the students' understanding and current curriculum.

Environmental issues often relate to different fields of study such as physics, chemistry, biology, geography. One of the problems when presenting environmental issues to students is that they should not be too difficult, too easy or not relevant to the knowledge required by the learning objectives or by the curriculum.

(4) The topics should develop the interests and motivation of the students.

Motivation was a consideration which lies at the core of the choice of these topics. Research evidence in our country clearly indicates that students are bored with traditional science classes. These topics attempt to provide learning experiences that could motivate students; to enable them to see intrinsic value of chemistry to everyday lives. It is hoped that as students find meaning and value in the content of topics, they should become more interested and fascinated.

(5) The topics should be designed around resources which are available in the Vietnamese context.

The environmental approach could not be successful if resources for it can not be supplied adequately. Information related to environmental issues should be real and up-to-date for effective learning.

The resources required to implement these topics were readily available in our surrounding communities including the public library, Vietnamese television and radio broadcasting network, the Institute of Science-Technology and Environment; and many agencies dealing with monitoring environmental quality.

I decided that the following topics need to be integrated in the General chemistry course: (1) Acid rain, (2) Air pollution, and (3) Water pollution.

These topics provided a contemporary theme in a traditional course. Each of them crossed several traditional chapter headings and tried to unify the content of current general chemistry curriculum around the environmental issues. I found that:

(1) *Acid rain* motivates students to understand the oxidation states of sulfur and the real-life significance of the pH scale. The chemical reactions of hydrogen sulfide, sulfur dioxide and sulfur trioxide provide examples in stoichiometry calculations, illustrate Le Chatelier's principle, and appear again in evaluating equilibrium-constant expressions. The acidic properties and solubility of these compounds and their chemical reactivities are covered as part of a discussion of the chemistry of the nonmetals.

(2) *Air pollution* allows students to review their understanding of the elements of oxygen, sulfur, group 6 in the periodic table of the elements. Some inorganic gases such as carbon monoxide, sulfur dioxide, nitrogen dioxides and their acid-base reactions in the atmosphere are interrelated. Pollution is also caused by natural sources. For example, volcanoes are also emphasized as a huge source of sulfur oxides and lightening as a great source of nitrogen oxides. This helps students to reinforce their understanding of the natural sources of environmental pollutants.

(3) *Water pollution* provides students the opportunities to understand the solubility of gases in water with Henry's law, solutions, and acid-base reactions. The chemical reaction of water acidity and carbon dioxide in water, calcium and other metals in water provide examples in calculations of species concentrations.

Through our General Chemistry Syllabus (see Appendix B), we can see that the above chosen topics were related to the content of the current course.

I also believe that these topics make the course more relevant to the students' interest because they help to develop an appreciation for contemporary problems in chemistry and to see the real-life applications of students' own chemistry knowledge. Furthermore, the environmental topics outlined above enrich students' knowledge and prepare them to become informed citizens in Vietnamese society.

These considerations support my conviction that the chosen topics are in complete agreement with the spirit of the science education reform in Vietnamese university.

The choice of the teaching strategies

The effectiveness of an environmental approach in chemistry teaching depends greatly on appropriate teaching strategies. I agree with George Bodner who said in his "Forum" paper, "Changing the curriculum—the topics being taught—is not enough to bring about meaningful change in science education, we also need to rethink the way the curriculum is delivered." (Bodner, 1992, p. 69)

This research study was expected to apply a new style of teaching that may be different from what most Vietnamese instructors are used to, especially to the goals of the STS approach. Hence, this teaching approach did not take the form of lectures with the note-taking style and rote memorization. I believe that this approach could help the students to appreciate chemistry as a basic and enjoyable science which has great value to their everyday lives.

The following points were kept in mind as I designed the teaching strategies for the approach through the new class.

- Students will be actively involved in learning chemistry.
- The classroom activities are designed around demonstrations with questions or tasks. The inquiry method is used mainly in these activities.
- This approach is designed for students to learn in a spirit of cooperation and interaction between the instructor and students, or between students.

The instructional method I had used in my teaching had been lecture method that emphasized on note-taking, memorization and assignment solving. From the experience of teaching this course for several years, my students had been “passive recipients” of knowledge and had not had opportunities to develop their independent and creative thinking. I have replaced formal lectures with a more active and dynamic teaching strategies utilized in this approach.

I selected and utilized a model that I believe it can be most suitable to the chemistry instruction. That is the learning cycle model: Demonstration-Exploration-Discussion. In this study, this learning cycle model included some instructional techniques such as group discussion, demonstration, field-trip learning. The environmental topics that illustrate the concepts and principles in chemistry were obtained by the students through this learning cycle. At first, I provided students with the opportunity to observe a demonstration that can be an experiment or a concrete model (video films, slides, or a pollution view), students then analyzed and made hypotheses to form theories. Finally, discussion helped them to refine theory.

In this learning cycle, students are placed at the center of the learning process, while the instructor only serves as a facilitator. With this teaching method, students do not have to take lots of notes because they receive the materials beforehand and read them at home.

Moreover, students can learn chemistry by direct experience of the real-life applications of their own chemistry knowledge, not just deal with pure lectures that they used to.

The learning cycle model of Demonstration-Exploration-Discussion was developed by Theodore L. Miller, Professor in Ohio Wesleyan University, Delaware, Ohio, U.S.A (Figure 1). He employed this learning cycle and introduced it in the article "Demonstration-Exploration-Discussion: Teaching Chemistry with Discovery and Creativity" (Miller, 1993).

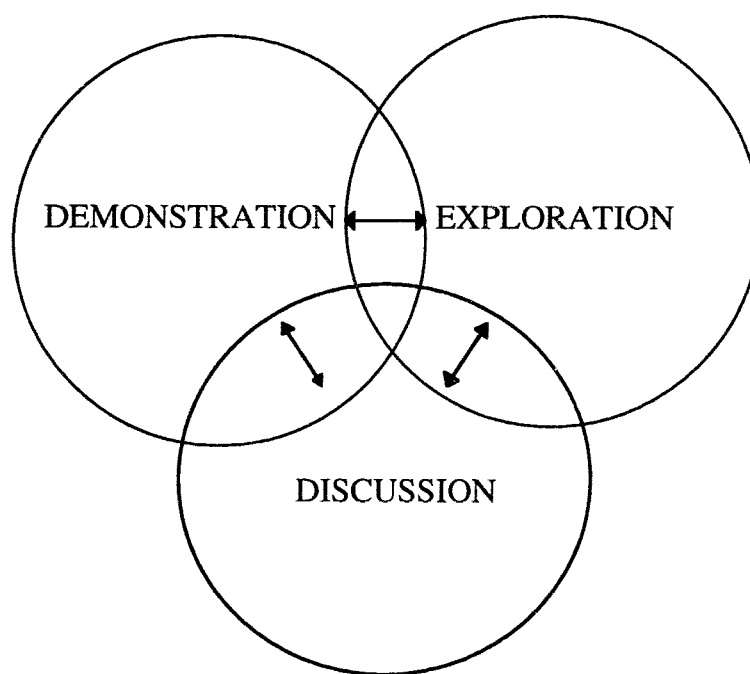


Figure 1: The Demonstration-Exploration-Discussion model

Three steps in this learning cycle model are:

(1) *Demonstration*, the process of showing something to another person or group. It can be an experiment if it involves a problem or it can be a concrete model and example for which the solution is not immediately apparent to the class. Students can watch something happening before their eyes. It can be given inductively by asking several question but

seldom giving answers, or it can be a simple observation of a phenomenon and verification of a process. The demonstration can be conducted in several ways: teacher demonstration, teacher-student demonstration, student-group demonstration, individual student demonstration, or guest demonstration (Trowbridge and Bybee, 1990, p. 232).

(2) *Exploration*, the process of fact finding. This process provides students the opportunity to analyze and make hypotheses based on their knowledge. It also encourage students to inquire why something occurs and therefore it requires students to think. During the exploration, instructors can evaluate students' understanding and background related to the lesson's objectives.

(3) *Discussion*, the process of theory refining. This process emphasizes the cognitive development of the individual. The presentation of problems in a discussion requires students to think before they can formulate answers. In order to answer questions, students learn to evaluate, analyze, and synthesize knowledge. Finally, a discussion gives feedback to the teacher. Discussion can also take place among students.

The three steps of this model were applied as the teaching strategies in this environmental approach of my study. For example, in the Learning activity 1 (page 47, Chapter 4), each group of students first performed a "pH testing" demonstration. Students were asked to observe the change of color of dilute sulfuric acid when adding 1 or 2 drops of indicator solutions (methyl orange) in different concentrations of the sulfuric acid solutions. The students then observed the rate of reactions of the above sulfuric acid solutions with small bits of calcium carbonate. Then, they were asked to observe and record the effect of the concentration of sulfuric acid on the reaction rate and perform tests on this experiment whenever they wish. After observing, testing, concluding and formulating hypotheses, students wrote down the steps that were used. Finally, students discussed in groups to develop conclusions from this demonstration.

An excellent introduction and science teaching examples of the learning cycle have been developed by Robert Karplus and colleagues. Robert Karplus (1977), Physics professor at the university of California, suggested that if science teachers can identify students' reasoning patterns, they can help them develop more advanced patterns with careful selection and sequencing of curriculum materials. He introduced a learning cycle in Science Curriculum Improvement Study. The learning cycle of Exploration-Concept Introduction-Concept Application, was studied in science classrooms. Some suggestions of the teachers involved in these early studies include topic introduction through exploration and discussion, liberal laboratory experience, open-ended questions and experiments, and discussion among students.

I found that the learning cycle of Demonstration- Exploration-Discussion method is more suitable to my approach because it is much more dynamic in practice.

The classroom become a place to explore and evaluate, to create and synthesize, and to ask questions—an atmosphere, that from my point of view, promotes critical thinking while students learn a specific body of information.

Discussion can produce exploration, or it can lead to another demonstration. A demonstration can generate exploration or it can precipitate discussion. The classroom activities center around demonstrations and student discovery. Discovery and creativity may occur at any of the intersections: demonstration, exploration or discussion. (Miller, 1993, p. 188)

Moreover, in this method students had an opportunity to practice being scientists; they observed, discovered, formulated hypotheses, tested their hypotheses, created, and expanded their knowledge.

It is my belief that this teaching model is most suitable for the teaching approach investigated in my study. This model, combined with the STS emphasis on environmental topics, is necessary for the study to achieve the selected goals.

Chapter 4

Descriptions of the Design and Implementation of Learning Activities

This chapter consists of the principles of the design, the context and content of the learning activities, the implementation plan of the teaching approach, the details of the designed and implemented learning activities and self-evaluation of the environmental approach.

The design of learning activities

Learning activities in this study were designed in accordance with the purposes of the STS approach. The guiding principles included the following:

(1) The learning activities should provide students the opportunity to learn in practice.

Because learning science occurs in many ways—listening, reading, drawing, experimenting and using equipment, practical investigations are especially important. Activities should enable students to work back and forth between theoretical ideas and their applications. Fieldwork and experimentation were organized in this approach with familiar and interesting environments, in order to extend and challenge students' own understandings. For example, a practical learning activity in this design was an environmental chemistry experiment of "Dissolved oxygen measurements." Water samples were collected from Saigon river. This activity guided students towards the study of the solubility of gases in water and water pollution in the Saigon river. Students had an opportunity to work from concrete and familiar phenomena to the abstract and unfamiliar.

(2) The learning activities should engage students in relevant and useful needs.

One of the goals of science education is for all students to have a certain degree of scientific literacy to cope with an era which is driven by science, technology and society.

Students must be provided in this approach with the opportunities to act upon the societal and environmental issues which are associated with current science curriculum. Therefore, most activities were designed to enable students to experience chemistry education holistically in terms of its science-technology-society connections. For example, through examining current data on the average pH values in the Saigon river from January to December, students were provided the opportunity to understand the significance of the pH scale of a solution and to investigate the effects of acid rain on the pH changes of water in the Saigon river seasonally. Societal issues, environmental impacts and scientific knowledge were all explored in this activity.

(3) The learning activities of the social issues and problem-based design should be valuable as a means of increasing the students' interest and motivation in chemistry.

One of the learning activities illustrating this principle was a visit to Saigon river and Tanhoa canal in Ho Chi Minh City. This activity provided students with the opportunity to understand a real-world problem, to observe and investigate the local evidence of the environmental pollution and to examine possible solutions. This activity fascinated students in terms how much they can learn from the Vietnamese context.

(4) The learning activities should provide students with a supportive learning environment.

Activity designs should consider the reference resources likely to be available in our context. Libraries, textbooks, videotapes, and laboratories should be considered as important supports for the activities. The science learning environment should also be safe and support the learning of all students. Students should be able to ask questions, take risks in learning and plan their activities in the confidence that their ideas will be valued and respected.

In this study, students were provided relevant materials that they could read at home, they were assigned questions or tasks that required them to show their creativity.

For example, one learning activity was to consider the moral, economic and scientific questions raised from a situation in Vietnamese society. Students were asked to discuss and write reports using their own ideas about the consequences of various activities (see learning activity 8). Practical activities, including fieldwork, can be dangerous. Therefore, activity designers and teachers should be aware of safety conditions and to minimize risks involved in practical work.

(5) The learning activities should be designed in the time available.

Many educators have argued that STS is more complicated and difficult than "pure" science, and that it takes valuable time away from the "pure" science which needs to be taught. Learning activities were designed to ensure that students learned chemistry concepts "deeply". In the first learning activity in this design, for example, students worked in groups to explore different points of acid rain from a demonstration of sulfuric acid. It required much time to ensure that students grasped their discovery through demonstration, exploration and discussion. Time is a crucial criterion in design learning activities.

The context and content of the topics

Environmental problems are accelerating and becoming more and more serious in Vietnam nowadays. The first problem concerning our environment is the ecological impact of the war. 72 million litres of the herbicides known as Agent Orange, Agent White and Agent Blue were sprayed on 16% of South Vietnam's land area (Robinson and Storey, 1991, p. 37). It is said that the deforestation caused by spraying these chemicals would have been enough to supply Vietnam's timber harvesters for 30 years. The most seriously affected regions were the provinces of Dongnai, Songbe, and Tayninh. The 40 million litres of Agent Orange used contained 170 Kg of dioxin (2,3,7,8-TCDD). Dioxin is the most toxic chemical known, highly carcinogenic and mutagenic. Today, over 20 years

after the spraying, dioxin is still present in the food chain. In addition to the spraying, large tracts of forests, agricultural land, villages and even cemeteries were bulldozed. In mountain areas, landslides were deliberately created by bombing and by spraying acid on limestone hillsides. By the war's end, the lush tropical forests have not grown back and wildlife populations have not recovered. The land that is scarred by bombing has filled up with water and become breeding grounds for harmful diseases. Until now, these impacts have caused some serious environmental problems in the provinces of Dongthap, Mekong Delta, Dongnai. For example, the Mekong Delta in Vietnam has an area of 4 million hectares and about 40% of it is affected by acid sulfate which make the soil unproductive. The most significant of these pollution sources are: soil erosion in most of the region in the Lower Mekong Basin, soil acidification in the Plain of Reeds, and pollution from agro-chemicals within the agricultural areas of the whole region, (Mekong Secretariat; prepared by Water quality Institute Denmark, 1992).

The second problem concerning our environment is urbanization, environment-protection policy, and distribution of the private industry sector. The rapid development of Vietnam has almost focused on the big cities. This leads to the migration of people from the rural areas to the urban areas and, therefore, the infrastructure of the big cities has become over-burdened. The national policy on environmental protection needs to be considered thoroughly. The development of the private industrial sector is almost uncontrollable. Many factories located in the urban areas result in stresses on the surrounding environment and people's health. Increasing population, industrialization and urbanization, increases the rate of water and air pollution.

Three main water pollution sources in Vietnam are household waste water, industrial waste water and agricultural waste water. Running water is becoming common in private households. Urban families mainly use running water for consumption, but

suburban people still depend on various water sources such as canals, rivers, wells and rain water to satisfy their daily living demands. The sewage flowing into the water sources contains organic and detergent materials used for household cleaning purposes. Rubbish in canals is also a threat for water. The total waste from Ho Chi Minh City is surprisingly large. One of the most obvious consequences from industrial pollution for Ho Chi Minh City is the extreme pollution of its canal and river system. We can see that these canals contains nothing but black mud emitting an extremely uncomfortable smell. This is due to the presence of hundreds of industries such as textile industries, chemical industries, rice mills, etc. These industries send their pollutants to these canals through discharged water, which increases the rate of water pollution in the large rivers in Vietnam such as Saigon River and Dongnai River.

The increased use of fertilizers and pesticides for agricultural development in meeting food needs causes pollution problems. Rain water draining from treated fields carries dangerous amounts of fertilizers and pesticides, adding to pollution of rivers and oceans. Traces of DDT have been found in most of the surface waters of Vietnam.

Motor vehicles contribute heavily to air pollution. In Ho Chi Minh City, automobiles account for over half of the pollutants added to the atmosphere. Just in Ho Chi Minh City, the number of vehicles is up to 1,048,403 (A statistical analysis of the motor vehicles transportation situation in Ho Chi Minh City, 1995). Most motor vehicles in Vietnam consume petrol, and the incomplete burning of petrol and air mixture in the engine creates toxic gases discharged through the exhaust-pipe. Other sources include industrial processes, combustion for cooking and solid waste incineration.

These issues directly concern human health and the quality of our lives. Due to many urgent issues, plans for permanent monitoring of interrelated problems have begun in Vietnam since 1990.

The implementation plan of the approach

The suggested environmental approach was implemented in April 1995 at the Ho Chi Minh City University of Education. It was placed at the end of the general chemistry course time after students have learned the basic concepts and principles in chemistry. Both the Chemistry Department and the University Board had given approval to the field-testing of the suggested approach. The class was taught by the researcher over six weeks with four teaching hours per week (one teaching hour equals 45 minutes).

Forty-eight students in the class were divided into eight self-selected groups (six students per group). Each of students took a fixed seat during the class period which facilitated the observer's work and group discussion (The map of the class is given in Appendix J). The target group for the study was selected randomly among the eight groups.

Week 1

The meeting in the first week of the program was used to acquaint students with the overall plan of the program.

The students were told that the purpose of the program was to help them gain a basic knowledge on the environmental issues faced by Vietnamese society, and to help them to see how their knowledge of general chemistry could enable them to take part in solving these problems. They were informed that the activities included in the program would relate closely to the real-life situations that occurred around them, and that they would be not only the learners but also problem solvers.

The students were also told that they would not only sit back in class and absorb information but also be actively involved in group discussions and class debates. They would have opportunities to share their ideas with their peers and the instructor.

The following plan outlines the schedule, goals and implemented learning activities for the course:

Week 2

On April 18, we worked with the topic “The oxidation states of sulfur and pH scale. Acid rain”, including three learning activities (activities 1, 2, 3).

Week 3

On April 25, we explored the topic “Carbon monoxide, nitrogen oxides and hydrocarbons. Air pollution”, including two activities (activities 4, 5).

Week 4

On May 3, we worked with the topic “The solubility of gases in water and the oxidation reduction stoichiometry. Water pollution”, including two activities (activities 6, 7).

Week 5

On May 9, we went on Seminar/ workshop: Environmental pollution in Vietnam, including activity 8.

Week 6

Evaluation and feedback

The questionnaire on attitudes toward chemistry was given to the students as a post-test, requiring about 10 minutes. The feedback questionnaire was then distributed, and took about 15 minutes to complete. The students were asked to write an essay at home which was submitted to the researcher the next day. The six students of the target group stayed behind and were interviewed for two hours.

Learning activities

Activity 1: The investigation of acid deposition and pH scale

- Learning outcomes:

Students should be able to:

- describe the important oxidation states of sulfur.
- analyze the sulfur cycle.
- explain the kinetics of atmospheric oxidation of sulfur dioxide.
- draw generalizations from their observations of colored change of indicator paper.
- understand the nature of pH scale, acids and bases.
- realize that there are two major acidic pollutants (H_2SO_4 and HNO_3).
- explain with appropriate equations, how oxides of sulfur and nitrogen can give rise to acid rain.
- evaluate some effects of acid rain on materials and on living organisms.

- Prerequisite:

Students have learned the topics:

- Chemical reactions and solution stoichiometry.
- Chemical kinetics.
- Chemical equilibrium.
- Acids and bases.

- Materials:

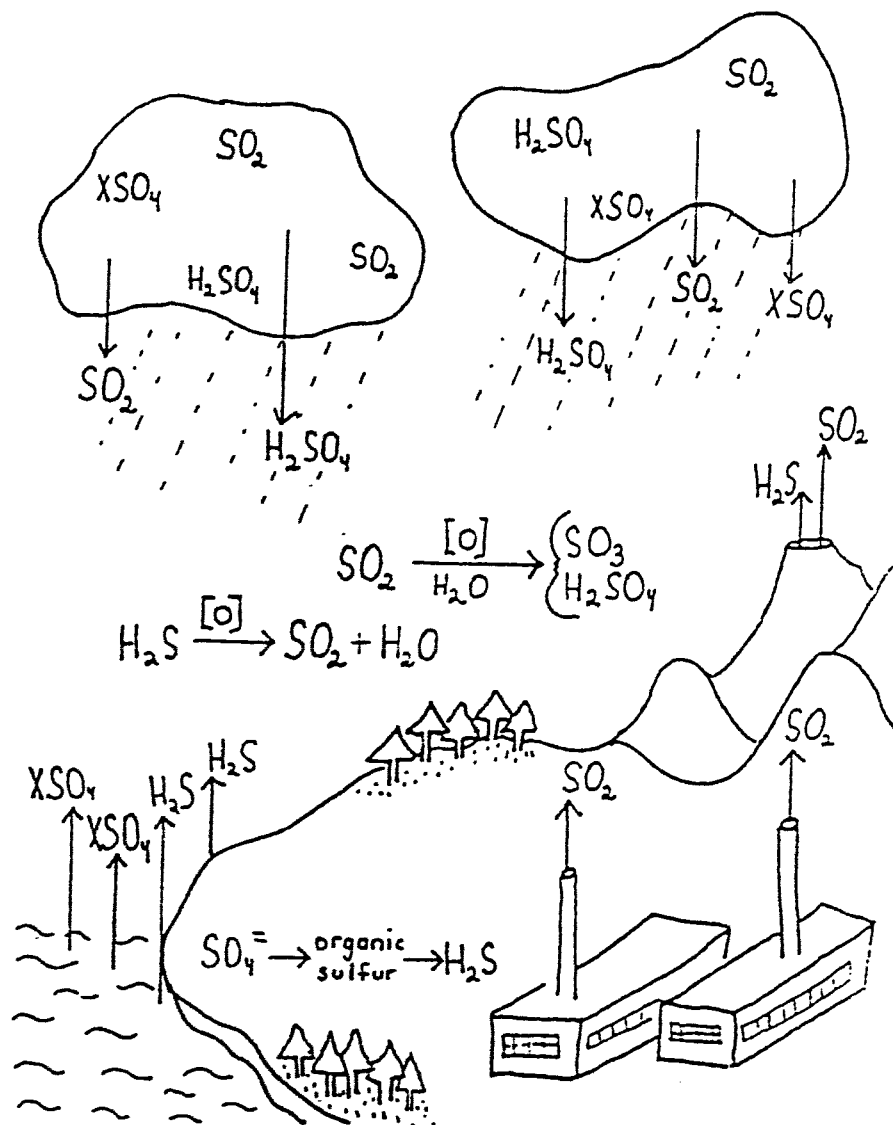
- Reading paper:

The sulfur cycle in environmental chemistry. Manaham (1994, pp. 43- 44)

- Poster: (see Figure 2)

Figure 2: A diagram of the sulfur cycle: sulfur enters to the atmosphere as H_2S , SO_2 , and sulfate salts from sea spray. Water droplets transport sulfuric acid and sulfate salts to the Earth's surface.

From Steams C. (1988), p. 232.



- Demonstration:

<i>Apparatus</i>	<i>Reagents</i>
8 glass containers (1L)	Dilute sulfuric acid
8 graduated cylinder (125 mL)	Indicator paper
8 medicine droppers	Calcium carbonate CaCO_3 (small bits)

- Procedures:

- Phase 1:

A simplified diagram of the sulfur cycle was posted on the blackboard at the beginning of the activity. Students investigated the diagram that showed the environmental processes, and the class was given time to explore the diagram. Students then were provided the discussion questions on the concepts and principles of chemical reactions of hydrogen sulfide, sulfur dioxide and sulfur trioxide.

- Phase 2:

Each group of students was provided a set of demonstration materials, and students carried out the demonstration. The number of drops of dilute sulfuric acid required to change the pH of a litre of water from 7 to 6 then to 5 and to 4, emphasize the logarithmic nature of the pH scale. Students observed the rate of reactions of the above sulfuric acid solutions with small bits of calcium carbonate.

Students were asked to observe and record the effect of the concentration of sulfuric acid on the reaction rate and perform tests on this experiment whenever they wished. Students then discussed in groups to develop conclusion from this demonstration. Finally, students continued to discuss in groups the following questions:

- Questions:

- (1) What are the main features of the sulfur cycle?
- (2) Which factors affect the rate of SO_2 oxidation in the atmosphere. Why?

- (3) Use the sulfur cycle to explain the causes of acid rain.
- (4) What is the pH scale?
- (5) What are two major acids involved in acid deposition?
- (6) Why is normal "clean" rain slightly acidic (pH= 6.4)?
- (7) Give some effects of acid rain on materials and on living organisms.

Activity 2 : The erosion of carbonate stone by acid rain

- **Learning outcomes:**

Students should be able to:

- note the erosion phenomena by acid rain on carbonate stone.
- describe the effects of acid deposition on humans and human-made artifacts.
- evaluate the role of erosion on historic monuments.

- **Prerequisite:**

Students have learned about the topic chemistry of dissolution.

- **Materials:**

Slides of the erosion of historic monuments in Vietnam.

- **Procedures:**

Instructor showed the pictures of the well-known historic monuments in Vietnam such as the Marble Mountains (Ngu Hanh Son), Phong Nha cave, Tomb of Khai Dinh, Tomb of Minh Mang, and the Thien Mu pagoda: the instructor guided students to observe the corrosion of these monuments. Students then analyzed to explain this corrosion phenomenon. They were also invited to come up and watch the slides whenever they wished. Discussion concentrated on the questions below:

- **Questions:**

- (1) Which monuments show signs of corrosion?
- (2) Explain the causes of this corrosion.

(3) Discuss several strategies for controlling acid deposition. Which are considered to be the most effective by ecologists?

Activity 3 : The effect of rain on the pH level of a river

• Learning outcomes:

Student should be able to:

- realize the real-life significance of the pH scale.
- describe the nature of the pH scale.
- compare rain water samples based on their pH values.
- use the diagram to identify the pH of a water source.
- analyze a pH diagram.

• Prerequisite:

Students have learned about the topic acids and bases, and have a basic understanding of diagram analysis.

• Materials:

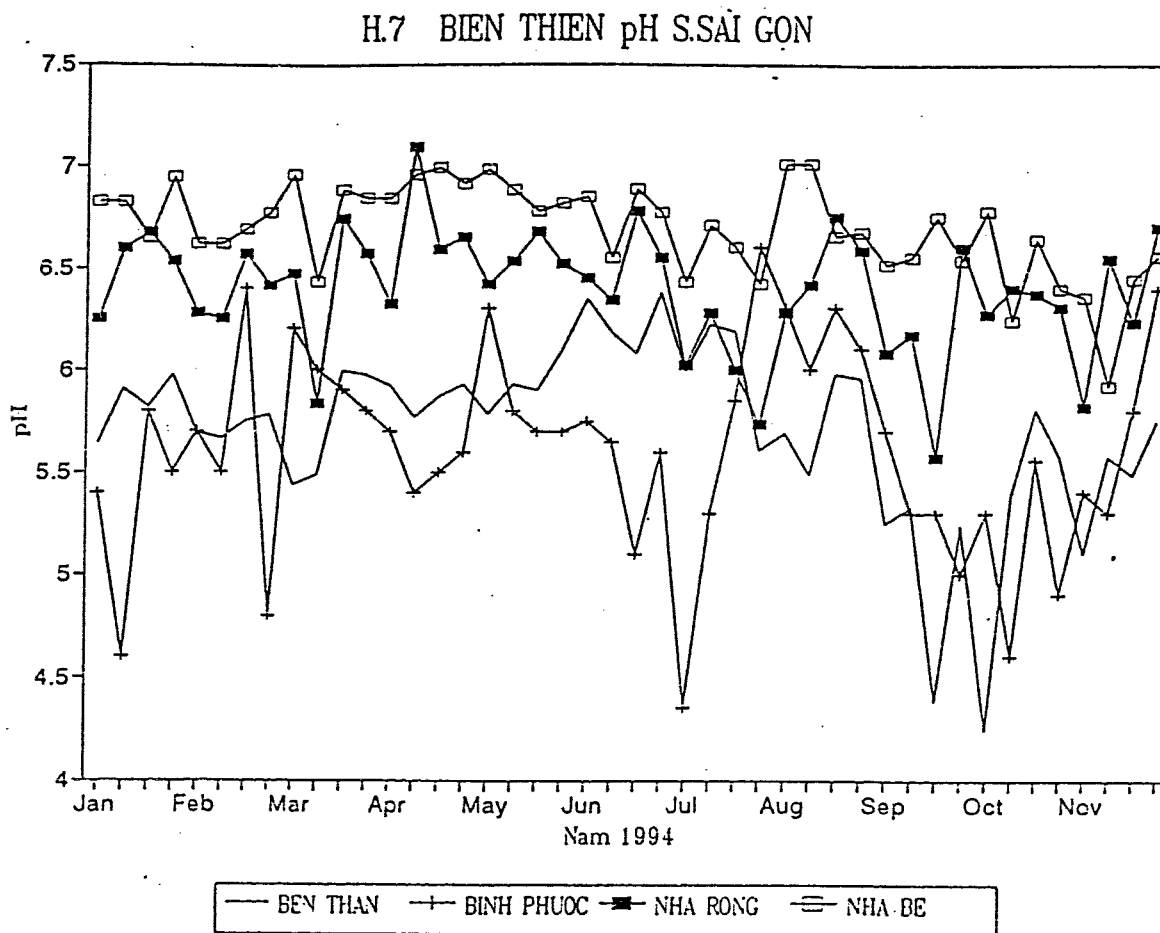
- The statistical data of rain water quality in some areas in Vietnam:

Table 1: The pH values of rain water in 1994

Areas	pH
Ho Chi Minh City	5.4 - 7.0
Mekong Delta	6.9 - 8.4

From Nguyen, Thanh Tin & Pham, Gia Hien (1994), p.9.

Figure 3: The diagram of pH values at various places in the Saigon River (from January to December, 1994).



From Nguyen, Thanh Tin & Pham, Gia Hien (1994), p.16.

- **Procedures:**

Instructor distributed statistical data on the average pH of precipitation in Ho Chi Minh City, and a pH diagram of water in the Saigon River. The whole class explored the real-life significance of pH. The class was divided into groups for discussion. The instructor went from group to group to facilitate student discussion. After twenty minutes of discussion, one member of each group started the presentation of the groups' ideas and

came up with possible conclusions. The presentation lasted twenty-five minutes and then ended with “detective work” that was given to the students as homework.

- Questions:

(1) From Table 1, compare the rain water quality of the Ho Chi Minh City and Mekong Delta areas.

(2) Use the diagram to identify the months that correspond with the lowest pH.

(3) From Figure 3, compare pH values at four various places in the river. Explain why.

- Homework:

Write a report about the reasons that acid rain is considered a secondary pollutant.

(Approach this task from a national as well as a global perspective)

Activity 4 : An investigation of air pollution

- Learning outcomes:

Students should be able to:

- list the names and formulas of major air pollutants.
- describe the formation of carbon monoxide and hydrocarbon from automobiles.
- describe sulfur dioxide and nitrogen oxide reactions in the atmosphere.
- explain the production of air contaminants in motor vehicles exhaust and their role in air pollution.
- analyze real data on air pollutants.
- evaluate air pollution from real data.
- realize the pollution caused by a natural source – volcanoes.

- Prerequisite:

Students have knowledge about the properties and reactions of oxides of carbon, nitrogen, and sulfur; chemical measurement; chemical reactions; gases and their properties; and calculations involving concentration.

- **Materials:**

- Reading papers:

- (1) Nitrogen dioxide and its determination in the atmosphere.

From Shooter D (1993), p. A133-A137.

- (2) Production and control of carbon monoxide, sulfur dioxide sources and the sulfur cycle, sulfur dioxide reactions in the atmosphere.

From Manaham (1994), pp. 327-330.

- (3) Atmospheric particles from volcanic eruptions.

From Spiro, T. G. & Stigliani, W. M. (1980), pp. 97-107.

- Statistical data on air pollution caused by auto exhaust in Vietnam (see Tables 2, 3, and 4)

- **Procedures:**

- Phase 1:

Instructor presented a short lesson to the class on the applying chemical principles to the problems of air pollution dealing with general chemistry topics:

- (1) The formation of carbon monoxide and hydrocarbon from automobiles.

- (2) The fate of atmospheric CO and lead pollution.

- (3) Sulfur dioxide and nitrogen oxides reaction in the atmosphere.

- (4) Natural and man-made particles loading of atmosphere.

Students , were then asked to use the concepts, principles, chemical processes and calculations to solve the problem sets.

Problem sets:

- (1) List the names and formulas of major air pollutants.

- (2) Use the Claus reaction: $2\text{H}_2\text{S} + \text{SO}_2 \rightleftharpoons 2\text{H}_2\text{O} + 3\text{S}$

to identify the oxidant in this reaction.

(3) Which unstable, reactive species is responsible for the removal of CO from the atmosphere?

(4) One expert said: "Natural pollutants are produced in greater quantities than anthropogenic air pollutants, so what are we worried about? Why should we spend billions to reduce air pollution?" Using your knowledge of air pollution, analyze this statement.

(From Chiras, 1994, p. 368)

Table 2: Annual emissions of air pollutants in Vietnam by source (1993)

Pollution sources	Major pollutants (millions of tons)				
	CO	Particles	Ox	CmHn	NOx
(1) Transportation:					
- Gasoline auto & motor	53.3	0.5	0.2	13.8	6.0
- Diesel auto & motor	0.2	0.3	0.1	0.4	0.5
- Airplane	2.4	0.0	0.0	0.3	0.0
- Train & ship	2.0	0.4	0.5	0.6	0.8
Total	58.1	1.2	0.8	15.1	7.3
(2) Stationary fuel combustion	1.7	8.1	22.2	0.7	8.8
(3) Industrial processes	8.8	6.8	8.6	4.2	0.2
(4) Treatment of solid wastes	7.1	1.0	0.1	1.5	0.5
(5) Miscellaneous	15.3	8.5	0.5	7.7	1.5
Total	91	25.5	30.2	29.2	18.3

Table 3: Emissions of air pollutants in Vietnam from auto and motor exhaust in 1993

Air pollutants	Molecule	Mass (tons)
Carbon monoxide	CO	123,685.0
Carbon dioxide	CO ₂	1,633,630.0
Nitrogen oxides	NO _x	9,421.0
Hydrocarbons	C _m H _n	7,296.0
Aldehyde	R-CHO	469.5
Lead	Pb	131.0
Sulfur dioxide	SO ₂	2,769.0
Carbon	C	1,726.0

Table 4: Estimated emissions of air pollutants in Vietnam from auto and motor exhaust in the year of 2000.

Air pollutants	Molecule	Mass (tons)
Carbon monoxide	CO	1,489,859.0
Carbon dioxide	CO ₂	17,156,566.0
Nitrogen oxides	NO _x	99,176.9
Hydrocarbons	C _m H _n	82,631.0
Aldehyde	R-CHO	5,039.5
Lead	Pb	1,521.7
Sulfur dioxide	SO ₂	27,749.0
Carbon	C	17,202.6

These statistical data are from Nguyen, Thi Tra Vinh (1994), pp. 11-13.

- Phase 2:

Each group of students was asked to do library research on the data on air pollution in Vietnam a week before starting this activity. The groups presented their data tables and the instructor helped them to choose three from these (Tables 2, 3, and 4 are shown above). The class was divided into groups to investigate the tables and discuss the questions. These questions were asked by instructor or raised by students.

- Questions:

- (1) Investigate Table 2. Which is the major pollution source of air pollutant emissions?
- (2) From Table 3, identify the elements that damage our environment.
- (3) Based on Tables 3 and 4, evaluate projected air pollution in Vietnam in the year 2000.
- (4) Describe how each major pollutant is produced, and give the relevant chemical equations of the reactions involved.

Activity 5 : View video

- Learning outcomes:

Students should be able to:

- analyze the main air pollutants in Vietnam.
- describe some effects of each major pollutant on human health.
- evaluate the air pollution situation in Vietnam.

- Prerequisite:

Students have studied chemical reactions, and gases and their properties.

- Materials:

Video: Air pollution in Vietnam, PAL, 22 min., Vietnamese Technology and Environment Film, 1993.

This video seeks to provide a broad understanding of the problems of air pollution in Vietnam. It shows the effects of contaminants on human health, gives a analysis of the

main pollutants, examines problems of air pollution in the big cities of Vietnam and explains what has caused man-made pollution, and what is being done to help solve the problems through technological and legislative controls in Vietnam.

- Procedures:

After watching the video, students worked on the questions in groups. The twenty minutes left in the period was used for debating the groups' ideas and coming up with possible conclusions. Finally, each group made a short report to the class.

- Questions:

- (1) How do air pollutants affect human health?
- (2) What are the causes of air pollution in Ho Chi Minh City?
- (3) Could you suggest possible methods of reducing the discharge of pollutants into the atmosphere?

Activity 6 : Laboratory work on pollution

- Learning outcomes:

Students should be able to:

- determine whether there is dissolved oxygen in water.
- analyze the Dissolved Oxygen (DO), and Biological Oxygen Demand (BOD) parameters of a water sample. (DO is the solubility of O₂ in one litre water; BOD is the number of milligrams of oxygen needed to carry out the overall oxidation reaction in one litre of water)
- evaluate the pollution level of a water sample.

- Prerequisite:

Students have covered the topics:

- The solubility of gases in water.
- Oxidation-reduction stoichiometry.

- Materials:

<i>Apparatus</i>	<i>Reagents</i>
- Graduated cylinder	- Manganese sulfate 2.15M
- Conical flask	- Concentrated sulfuric acid
- Small Beral pipette	- Alkali solution containing: 500mg NaOH/L, 135mg NaI/L, 10mg NaN ₃ /L
- Burette	- Starch indicator solution
	- Sodium thiosulfate, 0.025M, standardized

- Procedures:

The instructor gave a lesson on "Dissolved oxygen in water" including:

- (1) The determination of dissolved oxygen (DO) in water.
- (2) Some attention to laboratory procedures.

Students then moved to the chemistry laboratory. Each pair of students was provided a set of materials and a work area in the laboratory. They carried out the procedures of experiment. Detailed procedures of the experiment are shown in Appendix K. Water samples were collected from the Saigon River. All the water samples were supplied by the Department of Water Quality Control of Ho Chi Minh City.

After getting the water sample, students fixed the oxygen by reacting it quantitatively with a basic manganese sulfate solution. The oxidized manganese compound was mixed with sodium iodide and acidified forming an iodine solution. In the final step, the students titrated iodine with sodium thiosulfate. Students then made measurements on the water and performed stoichiometry calculations to show the concentration of O₂ in the water sample.

They then discussed the data with each other in groups and looked for what the oxygen concentration in the sample should be. Students were asked to repeat the titration procedure three times to test the measurements on the water.

Finally, each student was asked to write a laboratory report on his/her results and made a preliminary evaluation of water quality in the Saigon River. The laboratory report sheet is shown on Appendix L.

- **Questions:**

(1) How does a high BOD affect on water quality? Describe the way in which untreated sewage leads to a high BOD.

(2) Explain the water pollution in the Saigon River.

Activity 7 : Field-Trip

- **Learning outcomes:**

Students should be able to:

- observe an example of water pollution in Ho Chi Minh City.
- explain some environmental pollution problems and their local effects.
- analyze some of the biggest problems of water pollution in the big cities of Vietnam.
- understand primary, secondary and tertiary sewage treatment.
- identify and describe the chemical effects of a specific water pollutant on a living

organism.

- **Prerequisite:**

Students have learned the following topics in physical analysis: pH, temperature, turbidity, evaporation, freezing, demineralization by ion exchangers, distillation and chlorination.

- **Procedures:**

Visit the Saigon River at Nharong quay where sewage from Ho Chi Minh City is piped directly into the river. Students were asked to observe the environmental problems. Visit the Tanhoa Canal and Tanhoa Rice Mill Plant. Students were asked to report on their observations and develop conclusions for serious consequences to city's environment.

- **Homework:**

Write a report on the causes of water pollution in Ho Chi Minh City, and suggest some possible solutions to these problems.

- **Suggested questions:**

(1) Why are there increasing rates of water pollution in the Saigon River?

(2) Why does the Tanhoa Canal contain lots of black mud?

Activity 8 : Seminar / Workshop: environmental pollution in Vietnam

- **Learning outcomes:**

Students should be able to:

- apply their knowledge of general chemistry to explain aspects of air and water pollution related to chemical substances.

- suggest some general chemistry-related solutions to air and water pollution problems.

- **Prerequisite:**

Students should have mastered knowledge of chemical reactions, chemical kinetics, chemical equilibrium, acids and bases, the chemistry of dissolution, and gases and their properties.

- **Materials:**

- Videos available from the Ho Chi Minh City Television and Broadcasting Company.

(1) Mekong- Water problems; PAL, 1992, 47 min.; from Ho Chi Minh City Television Network Film.

This video deals with the problems of water quality in the Lower Mekong Basin, the role of water on the life of the surrounding people and its environment. The film also illustrates a national project financed by several other countries for improving and monitoring the water quality of the basin.

(2) Environment and quality of life in Indochina Asia (Vietnam, Kampuchea, Laos); PAL, 1994, 46 min.; from Ho Chi Minh City Television Network Film.

The video seeks to broaden our understanding of the problems of pollution in the countries of Indochina. It explains the causes of current pollution and outlines what must be done to help solve the problem through the joint social and political actions of these countries.

- Reading papers:

Air pollution in Vietnam. From Nguyen, Thi Tra Vinh (1994), pp. 1-21.

- Procedures:

- Phase 1: Seminar preparation

Students worked in groups, and each group was assigned one of the following topics:

(1) How are water and air essential to human life? What current problems are there with air and water pollution?

(2) Ho Chi Minh City and industrial pollution. The significance of the campaign "Greening and Sanitation" in Ho Chi Minh City, January, 1995 (relate with the observation of the Tanhoa Canal and Tanhoa Rice Mill Plant from the last activity).

(3) Water quality in the Mekong River.

(4) What are the national strategies for controlling environmental pollution? What can we, as chemistry students, contribute to the protection of the environment in our city? What can chemistry do?

Students should watch the videos and receive topics for preparing at home at least a week before running the seminar.

- Phase 2: Seminar

At the seminar, one member of each group gave a ten minute presentation. After all four groups had presented, a whole class discussion was aimed at understanding the details of the presentations. Class questions were answered by the members of the presentation groups. Class discussion also related to the following questions:

- **Questions:**

(1) Who is responsible for pollution?

(2) Consider the moral, economic, political and scientific questions raised by an article published in the Saigon Giai Phong newspaper May 1995:

A foreign chemical company persuaded the Department of Construction of Ho Chi Minh City to build a new \$300 million plant. It will employ over 1,000 Vietnamese people from nearby communities, giving them needed jobs and a good income. The living allowance of the people in these communities is very low. A group of citizens disagreed with the plan, claiming that it will pollute the nearby river, decrease the value of their houses, and ruin city tourism. The company informed them that its wastes would be adequately treated, but refused to submit its water treatment plans to inspection by Vietnamese experts of Ho Chi Minh City, because that disclosure would damage their competitive position.

Should the plant be built or not? What is the decision we should make and explain why?

(3) The Vietnamese government has suggested several policies to protect the environment:

(a) Cars and motorcycles should meet new emission standards.

(b) Ho Chi Minh City plan for the year of 2000 will require that "industrial zones should be moved away from the residential, entertaining and commercial areas."

(c) Houses built near sewers, canals or river systems must be relocated.

(d) Industrial plants which do not adequately treat their waste should be charged an extra tax.

Read and discuss some of these policies.

- Report:

Each student wrote a report on the consequences of environmental pollution in Vietnam. Students discussed some of the technological, economic and social solutions to this problem.

Times and places for the implementation of these activities are described in Table 5.

Self-evaluation of the environmental approach

The main purpose of this study is to examine the effectiveness of the environmental approach to the general chemistry course. Self-evaluation of this approach is based on the following criteria:

- (1) Have the goals of the environmental chemistry approach been fulfilled?
- (2) Are the resources required to implement this approach available?
- (3) Can the new approach be completed in the time available?
- (4) Will the new approach motivate students to study chemistry?

It is difficult for me to evaluate the effectiveness of my own study in an objective way. The best I can do is to analyze the approach according to these criteria and to see whether or not the approach satisfies them.

Goals

The goals of the environmental approach are:

- (1) to develop students' interest and motivation in studying chemistry.
- (2) to enhance student knowledge of environmental issues and solutions related to chemistry.
- (3) to improve students' understanding of the basic concepts and principles in the general chemistry course.

Table 5: A weekly schedule for the environmental chemistry approach

Week	Topics	Learning activities	Time (min)	Condition	Teaching strategies
1	Acid rain	1. The investigation of acid deposition and pH scale.	90	Classroom	The learning cycle model
		2. The erosion of carbonate stone by acid rain.	45	Classroom	The learning cycle model
		3. The effect of rain on the pH level of rivers.	45	Classroom	The learning cycle model
2	Air pollution	4. An investigation of air pollution.	90	Classroom	The learning cycle model
		5. View video.	90	Video lab	The learning cycle model
3	Water pollution	6. Lab work on pollution.	135	Chemistry lab	Group work
		7. Field-trip learning	45	Outdoor	Field trip
4	Environmental pollution	8. Environmental pollution in Vietnam seminar.	180	Classroom	Group work

Total : 720 min = 16 teaching hours

The educational development of Vietnam today aims:

to improve general knowledge, train manpower, and support bright and talented individuals, while broadening the scope of education and improving its overall quality and results. (Midwest Universities Consortium for International Activities, 1995)

A consideration of the three goals of this environmental chemistry approach shows that they are expected to provide students with a science education which contains a balance of scientific knowledge, personal development and social development. Generally, these goals fit with the goals of science education of the 1990's and the recommendations from the Ministry of Education and Training for improving the state of science education in Vietnam. The goals of the environmental approach can indeed be fulfilled by the learning activities. The learning activities of this approach could be evaluated by a following correlation matrix:

Table 6: Correlation matrix: Goals vs. Learning activities

Activity \ Goal	1	2	3	4	5	6	7	8
1		√	√	√	√	√	√	√
2		√	√	√	√	√	√	√
3	√		√	√		√		√

Activity 1

This activity showed the sulfur cycle that summarizes the chemical precursors of acid rain. Students who have little familiarity with reaction kinetics can understand that factors such as moisture and sunlight affect the rate of SO₂ oxidation in the atmosphere, and can see how oxides of sulfur can give rise to acid rain. This activity illustrated the real-

life significance of the pH scale with a demonstration of the pH change of dilute sulfuric acid in a litre of water. Students were asked to draw generalizations from their observations through demonstration; they learned directly chemistry by watching something happening before their eyes. Through this activity, students had the opportunity to improve their understanding of concepts and chemical principles such as the oxidation states of sulfur and the nature of the pH scale.

Activity 2

This activity used slides of the ancient historic monuments in Vietnam to motivate students to undertake the study of the chemistry of dissolution and metathesis reactions. These slides, consonant with the aesthetic values of our culture, allowed students to view the erosion phenomena brought about by acid rain on these historic monuments, and to see the effect of acid rain on natural materials. Group discussion of several of the strategies for controlling acid deposition considered to be most effective in our country developed students' skill in cooperative learning and provided students with the opportunity to see real-life applications of their own basic chemistry knowledge.

Activity 3

This activity required students to consider the current data on the pH values in the Saigon River from January to December. Students were provided with the opportunity to develop skills in interpreting data and graphs. It also gave students an understanding of the significance of the pH scale of solutions. The activity also developed students' skills in writing scientific reports. Students might become more interested in developing an appreciation for contemporary problems in Vietnam. They might come to enjoy group discussion and the presentation of their group's ideas on the environmental issues. Particularly, interesting discussions took place when the students tried to evaluate the quality of a water source for the Saigon River based on its pH values.

Activity 4

This activity involved an application of chemical principles to understand the background to air pollution. It was designed to provide students with the opportunity to relate chemistry to social issues. The real investigation of air pollution in Vietnam was required. Students analyzed and interpreted data on air pollutants by applying the concepts and principles of chemistry, knowledge of the chemical processes of the internal combustion engine, and carbon monoxide and nitrogen oxide reactions in the atmosphere. Students identified the chemical elements and compounds that damage our environment and raised some suggestions of our responsibilities as individuals to conserve our country's environment. The relationship between chemistry, technology and society became clear in this activity. It also used the data on estimated emissions of air pollutants in Vietnam to enable students to anticipate the air pollution in Vietnam in the year 2000. This activity was expected to make the class more interesting.

Activity 5

This video first showed the problems of air pollution in Vietnam. It vividly illustrated the causes of man-made pollution in the big cities of Vietnam and showed what is being done to help solve the problems through technological and legislative controls in Vietnam. Students were provided the opportunity to study real environmental problems and to investigate local, and national evidence in contemporary Vietnam. They might be interested in viewing the video and learn chemistry by direct experience.

Activity 6

This laboratory work provided direct experience with a determination of the dissolved oxygen in water that identified the pollution level of a water sample from the Saigon River. This activity motivated students to undertake the study of the solubility of gases in water and the oxidation-reduction stoichiometry. Students had the opportunity to

work with the local environmental materials using a general analytical procedure. It enabled students to develop skills and processes such as measuring, analyzing, hypothesizing, calculating and interpreting. It also gave them experience in writing a laboratory report.

Activity 7

These field trips to the Saigon River, Tanhoa Canal and Tanhoa Rice Mills Plant gave students the opportunity to observe environmental problems and develop conclusions about their serious consequences for the water source for Ho Chi Minh City, and allowed students to suggest some possible solutions to these problems. This activity also developed students' writing skills with a report on the causes of water pollution in Ho Chi Minh City.

Activity 8

The seminar/workshop on environmental pollution in Vietnam was an activity designed to develop students learn research skills. Students were expected to acquire skills in organizing group work, planning library readings, making observations of viewing videos, collecting, writing, and interpreting assigned problem sets. It also gave experience in preparing and presenting a report to others. Students had the opportunity to synthesize the aspects of environmental pollution related to chemical processes. The societal and philosophical aspects of chemistry and technology in Vietnam were emphasized in this seminar. Ho Chi Minh City and industrial pollution, water quality in the Mekong River, environment and quality of life in Indochina, national strategies for controlling environmental pollution, chemistry 's role in dealing with these problems, were dealt with in this activity. The national and global dimensions of chemistry, technology and society were highlighted. Students were led to appreciate the significance of the February 1995 campaign "Greening and Sanitation" in Ho Chi Minh City, and to enhance their perception of what they, as chemistry students, can contribute to the protection of the environment in our city. This activity aims to develop students' interest in chemistry as they see that

chemistry takes a significant part of our society development. Students might enjoy class debates and presentation on the environmental issues; they should also gain a basic knowledge of our environment and solutions to environmental problems related to chemistry.

The correlation matrix of goals vs. learning activity (Table 6) showed that the proposed learning activities address many of the goals 1, 2 and 3. The learning activities provided opportunities to increase students' interest and motivation in chemistry. They allowed students to experience chemistry education holistically in terms of its science-technology-society connections, and to gain basic knowledge on environmental issues and solutions related to chemistry. Generally, these activities fulfilled the main goals I have identified for the environmental approach in my study. They exemplified ways of providing students with a balanced and holistic science education. It is my belief that they can provide chemistry teachers with a basic environmental approach which could better motivate students in their study of chemistry.

Resources

The resources required to implement this approach included relevant journal articles, lab equipment, statistical data and video tapes of environmental pollution. Although the articles selected from the Journal of Chemical Education and the Western environmental chemistry textbooks may not be currently available in Vietnam now, instructors can replace them with the similar resources from Vietnamese libraries.

The equipment used for demonstrations and laboratory experiments was fairly simple and could be found in most of the general chemistry laboratories in Vietnam.

Community resources such as statistical data, video tapes showing environmental pollution in Vietnam, and articles from Vietnamese newspapers and journals were abundant and were readily available from the appropriate research institutes of Vietnam.

Time allocation

The general chemistry course in Ho Chi Minh City universities requires 90 hours of lecture time and 30 hours of tutorial time (see the General Chemistry Syllabus in Appendix B). This environmental chemistry program included eight learning activities designed to take 16 additional teaching hours, equal to 14% of the course time. A detailed schedule is shown in Table 5.

I believe that the program would not take valuable time away from the necessary lectures. The total time for this program was reasonable in proportion to the total time allotted for the course.

Motivation

Chemistry involves many abstract concepts and principles and complex chemical processes. Students often face difficulties in studying chemistry. My own experience in the classroom for the past twelve years clearly indicates that students do not generally enjoy chemistry. They usually consider traditional chemistry lectures to be dry, too difficult to comprehend, irrelevant and uninteresting. Vietnamese students generally show high interest in learning how the basic sciences can be related to social and technological applications. For this reason, I believe that the societal issues, technological applications, and local environmental applications presented in this environmental chemistry program would interest and motivate students to study chemistry.

The suggested teaching strategies in which students were required to develop their skills of active and dynamic interaction, cooperative learning and peer teaching, also provided students with an interest and motivation in their learning process.

Finally, it is my belief that this environmental chemistry approach, if properly implemented, could be successful. The results of the field-test that will be analyzed in the Chapter 5, can clarify the effectiveness of this environmental approach to the general chemistry course.

Chapter 5

The Results

This chapter reports the results of the study. The responses of students to the questionnaire on attitudes toward chemistry, the questionnaire on student feedback about the new approach, and the observation checklists will be presented first. Then, the findings of students' responses in the interview and on their essays will be reported.

Data resources

The purpose of the instruments was to examine the effectiveness of the environmental approach to the general chemistry course. The themes, which provided a framework for this investigation are summarized as follow:

1. Students' attitudes toward the program.
2. Students' awareness of environment.
3. Students' understanding of chemistry.
4. Students' perception on learning activities.
5. Students' views on the teaching strategies.
6. Resource validity.

Interview questions were organized into six groups. The first group of questions encouraged students to freely express themselves about their attitudes toward chemistry as well as their thoughts of taking the program. The questions were why they have chosen chemistry education, what chemistry means to them and how they felt about the teaching and learning approach. Probes were used to encourage students to desirable features of the general chemistry course, to what extent they felt interested or bored in this approach, and influences on their interests and motivation in chemistry.

The second set of questions asked students about how the environmental approach affected their learning chemistry and how useful this approach was. Probes in these groups

encouraged students to indicate whether or not the environmental approach affected their learning process, what the most important influences were, and their awareness of environmental issues and understanding of concepts and principles in chemistry.

The third group of questions asked students to talk about the learning activities and the teaching strategies used in the approach. Activities which illustrated environmental issues in teaching methods provided concrete examples to stimulate reaction and discussion. These groups of questions, therefore, sought understanding of students' perceptions about this new style of teaching in the chemistry class, about the differences between this class and others they attended, and how useful this class was. Questions also related to the organization of learning activities, the role of instructor, and time allocated for the approach.

Because the resources were selected from materials in Western countries and from the environmental data and facts in Vietnam, the final group of questions sought students' evaluation about those special resources.

All of the interview questions were minimally structured and designed to give the students considerable scope to say what was on their minds with minimal bias.

Verbatim accounts of conversations, transcripts and direct quotes from interviews and essays were used in the data analysis. The quotations were directly copied from students' essays and matched with students' responses from the interview. The degree to which I picked the same student answers is an approximate indication of the continuity between my reading of the essays and the student's comments during the student interview.

Questionnaire on the attitudes toward chemistry (QAC)

The responses of 35 students to the QAC instrument provided an indication of the students' attitudes toward chemistry. Each item was scored from 1 to 5 with a scale from "strongly disagree" to "strongly agree". The means, medians and standard deviations of item scores are shown in Table 7. The means of the eight items for the 35 students ranged

from 3.91 to 4.29, showing a high positive attitude (The minimum of the total scores of students is 24 and the maximum of the total scores is 40).

The results of the questionnaire on attitudes toward chemistry are cast in the form of box-and-whiskers plots (Figure 4). The + indicates the location of the median, the left side of the box indicates the 25th percentile, and the right side of the box the 75th percentile. The outliers are shown as * and the extreme outliers are shown as 0.

The boxplots also show that the distributions of the item scores are highly positive. These indicate that students' attitudes toward chemistry are positive. Especially, the score distributions of the items 3, 5 and 6 are highly centrally-focused. Their standard deviations are 0.78 for item 3; 0.56 for item 5; and 0.70 for item 6. These item scores are less spread out and therefore much less variability compared with the others. Hence, the students' responses to these items are rather homogeneous.

All of the eight items are statements presenting a favorable perspective toward chemistry. The histograms (Figures 5-12) show that strongest agreements occurred on 4 items for which the response pattern was over 80% for A (Agree) and SA (Strongly Agree), only from 0% to 2% for SD (Strongly Disagree) or D (Disagree), thus indicating a high favorable attitude toward chemistry. These included:

- Item 1: Chemistry is something that I enjoy very much.
- Item 3: The chemistry class is interesting.
- Item 5: Chemistry is helpful in understanding today's world.
- Item 6: Chemistry plays a significant part in our society's development.

The construct validity of the questionnaire was determined in the form of item-to-test correlation (Table 8). The results showed that four correlation coefficients were above the minimum acceptance level of 0.30. (Gable, 1986)

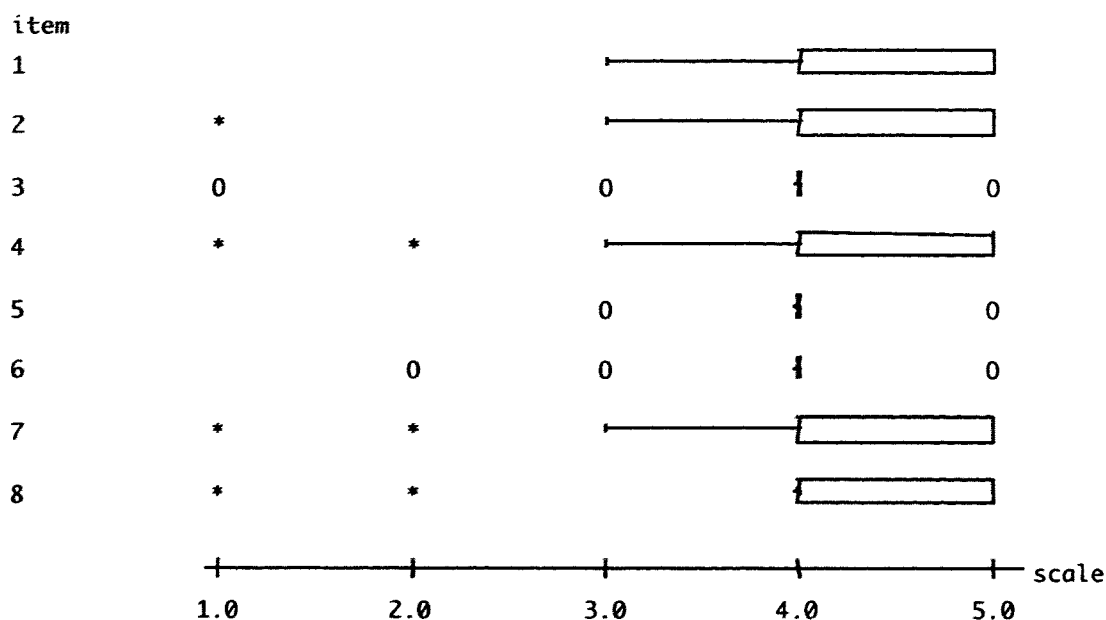
Table 7: Scores of questionnaire on the attitudes toward chemistry

Item	Mean (N=35)	Median	SD
1	4.20	4.00	0.58
2	4.29	4.00	0.86
3	3.91	4.00	0.78
4	4.09	4.00	1.01
5	4.08	4.00	0.56
6	3.91	4.00	0.70
7	4.17	4.00	1.04
8	4.26	4.00	0.95

Table 8: Alpha coefficients of questionnaire on students' attitudes toward chemistry

Item	1	2	3	4	5	6	7	8
α coefficient	0.218	0.424	0.569	0.145	0.008	0.564	0.377	0.201

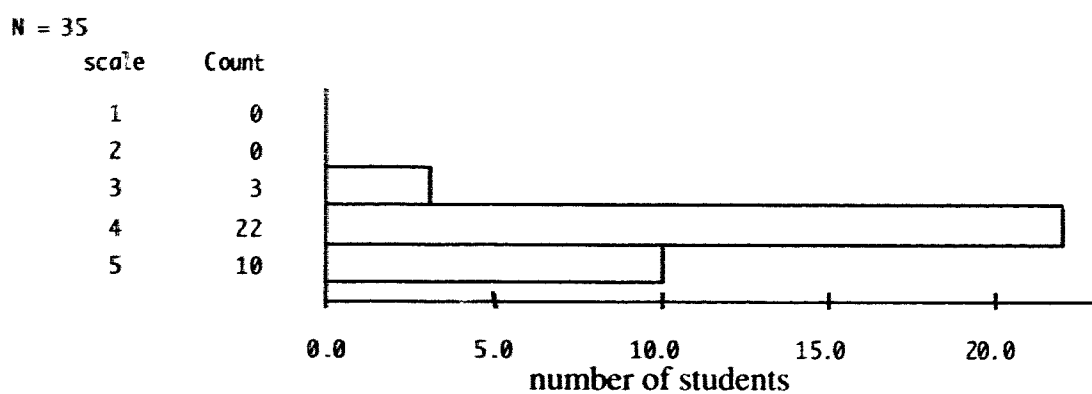
Figure 4: Boxplots of items of the QAC



Legend:

- + = refers to the median of the item score
- = the box spans the 25th to the 75th percentile
- * = outliers
- 0 = extreme outliers

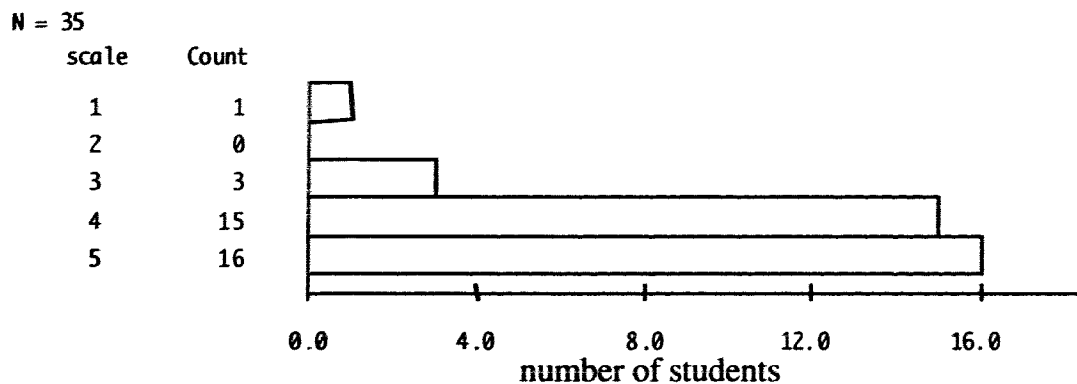
Figure 5: Histogram of item 1 of the QAC



Chemistry is something that I enjoy very much.

SD	D	U	A	SA
0%	0%	8.6%	62.8%	28.6%

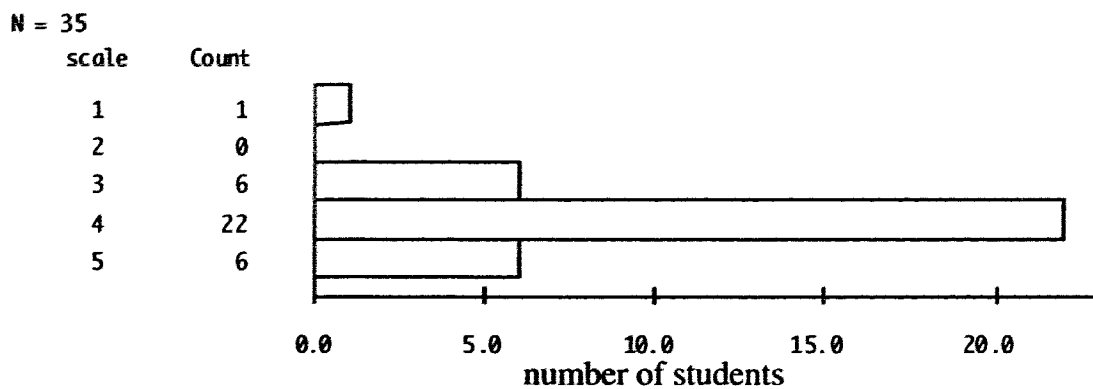
Figure 6: Histogram of item 2 of the QAC



I don't regret that I did choose chemistry.

SD	D	U	A	SA
2.8%	0%	8.7%	42.8%	45.7%

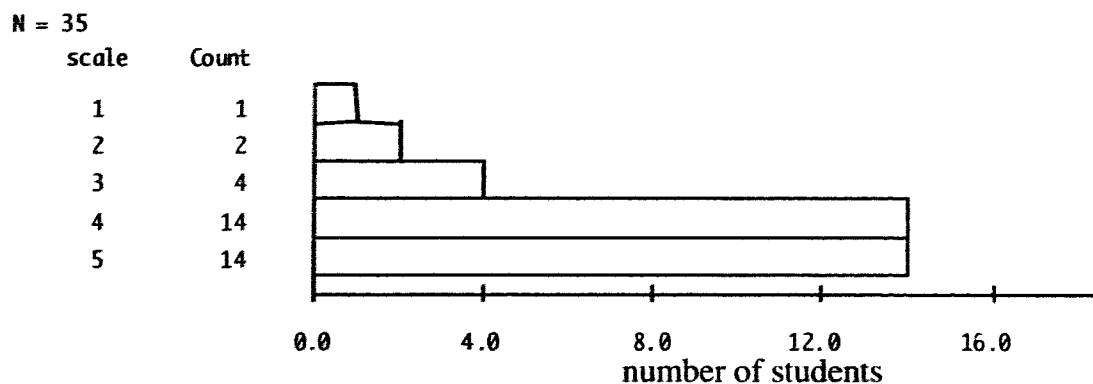
Figure 7: Histogram of item 3 of the QAC



The chemistry class is interesting.

SD	D	U	A	SA
2.8%	0%	17.2%	62.8%	17.2%

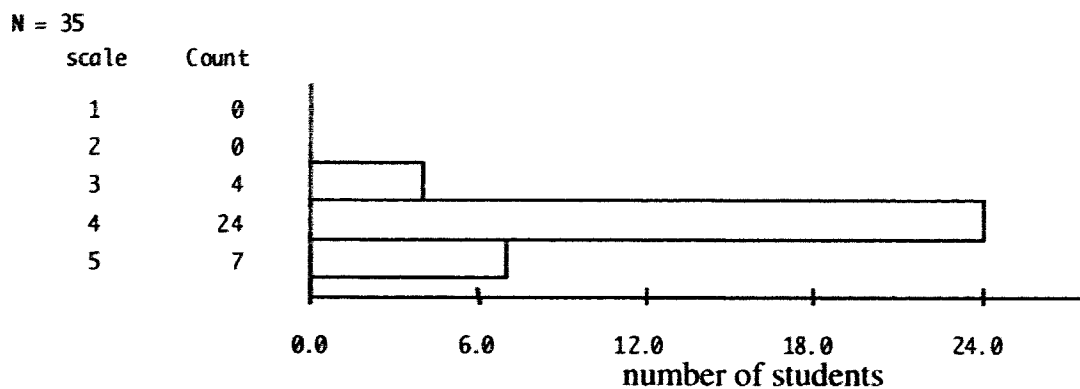
Figure 8: Histogram of item 4 of the QAC



Chemistry is useful for everyday life.

SD	D	U	A	SA
2.8%	5.7%	11.5%	40%	40%

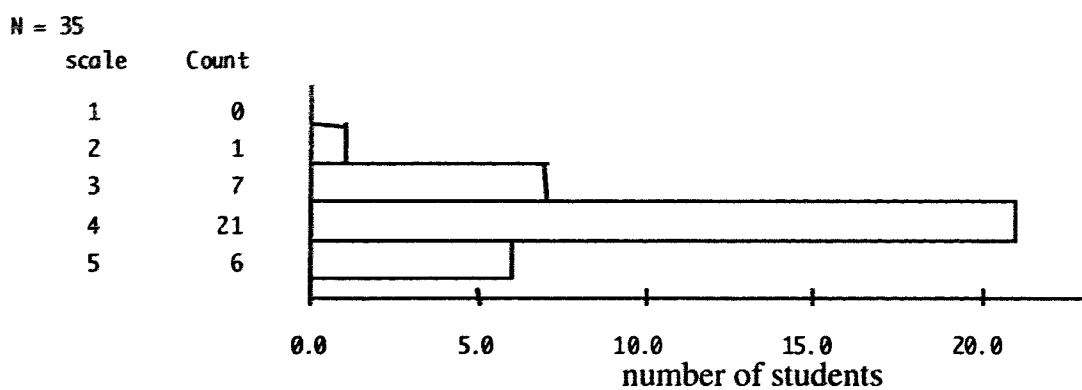
Figure 9: Histogram of item 5 of the QAC



Chemistry is helpful in understanding today's world.

SD	D	U	A	SA
0%	0%	11.4%	68.6%	20%

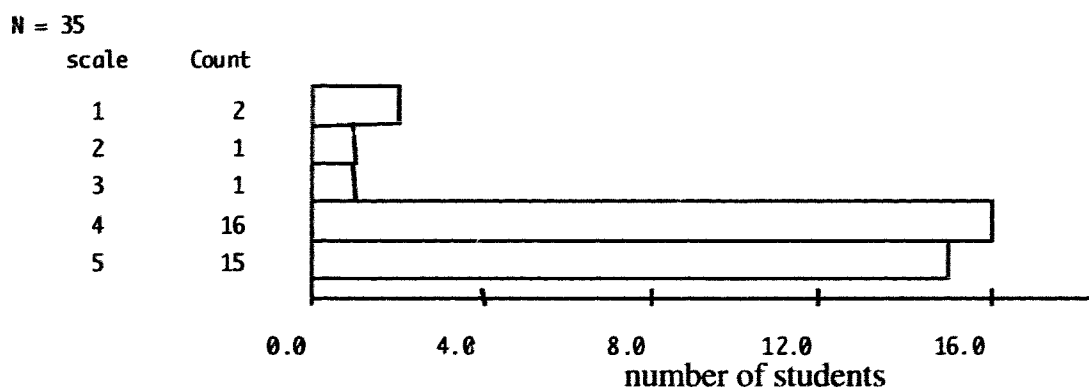
Figure 10: Histogram of item 6 of the QAC



Chemistry plays a significant part in our society's development.

SD	D	U	A	SA
0%	2.8%	20%	60%	17.2%

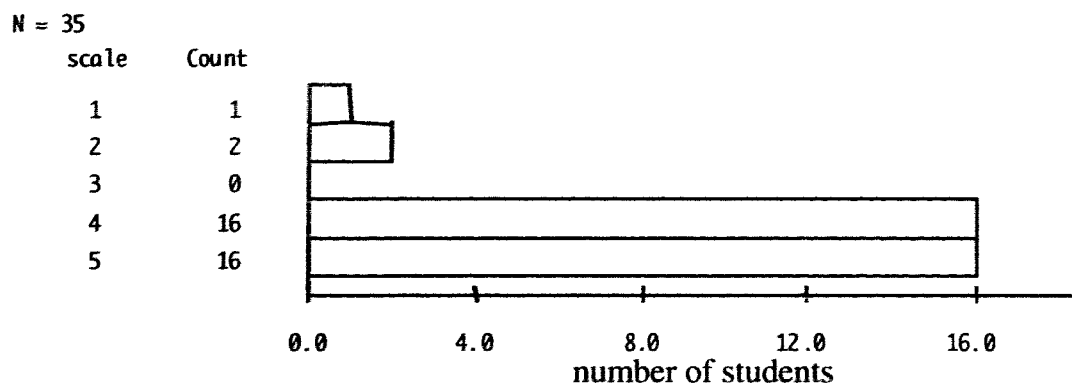
Figure 11: Histogram of item 7 of the QAC



Most chemistry knowledge is relevant.

SD	D	U	A	SA
5.9%	2.8%	2.8%	45.7%	42.8%

Figure 12: Histogram of item 8 of the QAC



There should be other study materials or sources available besides the lecture notes.

SD	D	U	A	SA
2.8%	5.8%	0%	45.7%	45.7%

Questionnaire on student feedback (QSF)

Student feedback about the environmental approach was obtained through a questionnaire administered at the end of the program. Each item was scored from 1 to 5 respectively, with the scale from "not at all" to "very much". The means, medians and standard deviations of item scores are shown in Table 9. The means of the seven items for the 25 students ranged from 3.24 to 4.16, showing a highly positive response.

The seven items are the favorable statements about the environmental approach to the general chemistry course. The histograms (Figures 14-20) show that strongest agreement occurred on all the items except item 7. In these the response patterns were over 50% for scale 5 (very much) and scale 4 (a lot), thus indicating a supportive perspective on the new approach.

The boxplots (Figure 13) also show that the distributions of the scores are highly positive for item 5, and highly centrally focused for item 6. The standard deviation of the item 6 is 0.702, which is much less variability and, therefore very homogeneous. These data suggest that students' ideas about the new approach are positive for the items 5 and 6.

These included:

- Item 5: I'd like to learn more about environmental issues from radio, TV, newspapers and magazines.
- Item 6: Studying environmental topics stimulates me and furthers my interest in chemistry.

Item 6 is the one in which students had strongest agreement and its score distribution is extremely dense. This result suggests that the environmental approach interested and motivated students to study chemistry.

The scores of the items 2 and 4 are much spread out, hence the students' responses to these items are heterogeneous. These included:

- Item 2: I want to devote myself to the activities of environmental conservation.
- Item 4: I am interested in the campaign for environmental conservation in our city.

These data suggest that the teaching approach used in this study might not have strong effects on improving students' attitudes toward social issues related to the environment.

The construct validity of the questionnaire was also determined in the form of item-to-test correlation (Table 10). The results showed that seven correlation coefficients were above the minimum acceptance level of 0.30. The rather small correlation coefficient of item 4 corresponded to its large standard deviation, compared with the other items (Table 10).

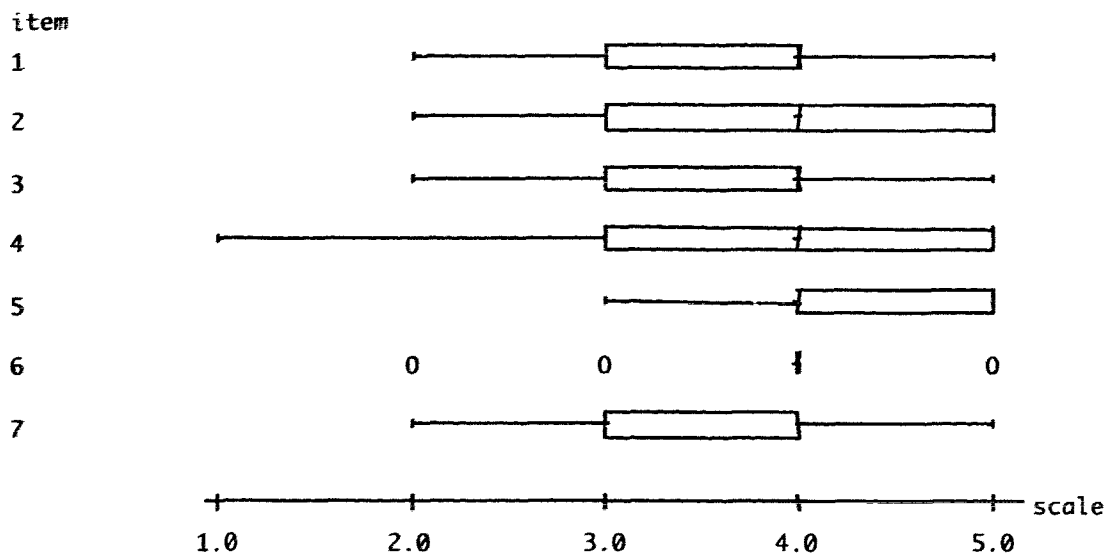
Table 9: Scores on questionnaire on student feedback

Item	Mean (N=25)	Median	SD
1	3.48	4.00	0.963
2	3.92	4.00	0.997
3	3.84	4.00	0.850
4	3.72	4.00	1.137
5	4.16	4.00	0.746
6	3.92	4.00	0.702
7	3.24	3.00	0.831

Table 10: Alpha coefficients of questionnaire on student feedback

Item	1	2	3	4	5	6	7
α coefficient	0.449	0.692	0.573	0.194	0.572	0.372	0.456

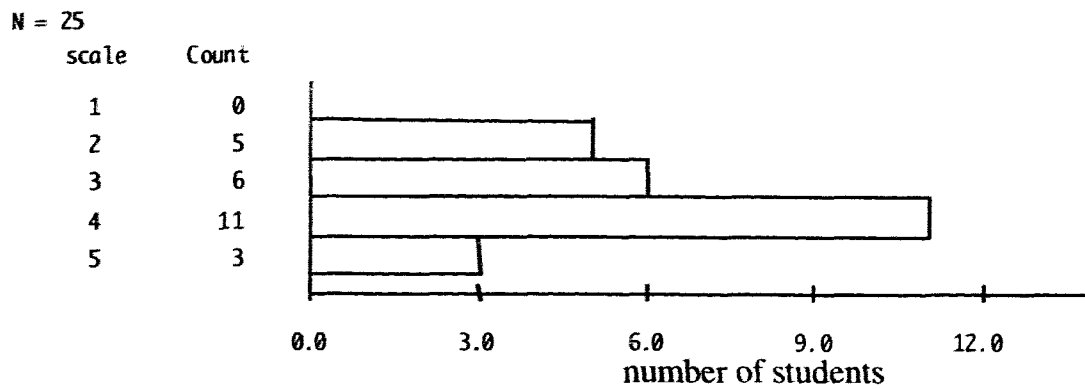
Figure 13: Boxplots of items on the QSF



Legend:

- + = refers to the median of item score
- = the box spans the 25th to the 75th percentile
- 0 = extreme outliers

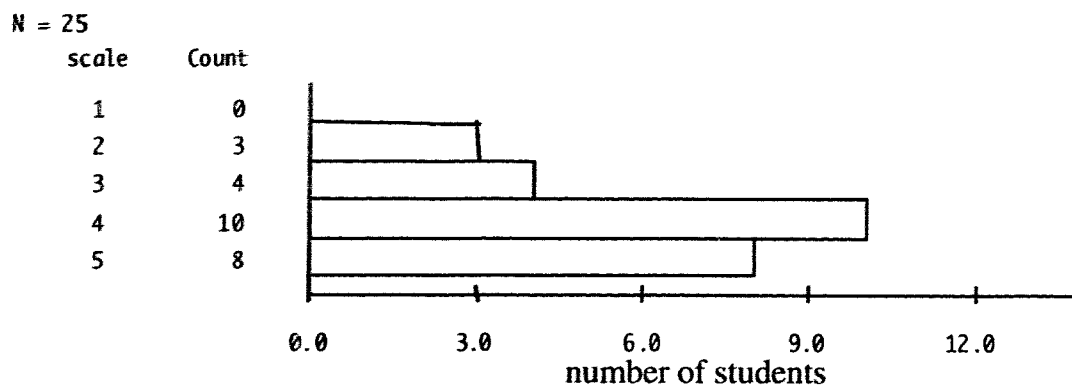
Figure 14: Histogram of item 1 of the QSF



My perception of global environmental problems has improved.

Not at all	1	2	3	4	5	Very much
0%	20%	24%	44%	12%		

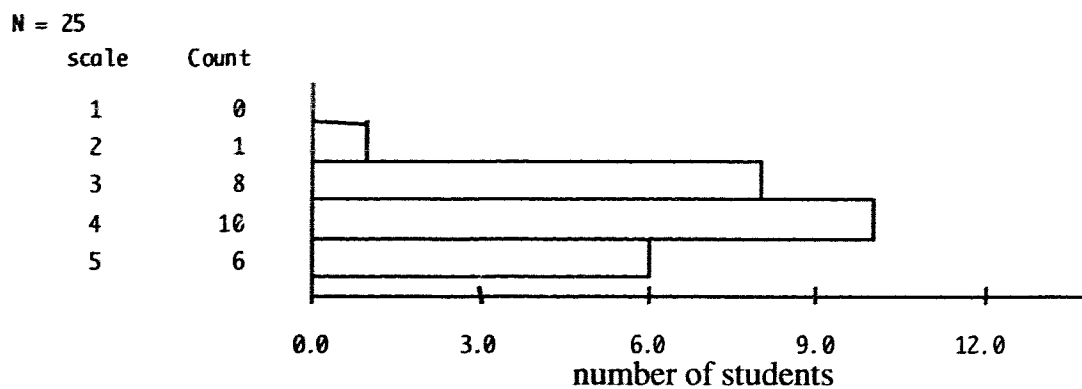
Figure 15: Histogram of item 2 of the QSF



I want to devote myself to activities promoting environmental conservation.

Not at all	1	2	3	4	5	Very much
0%	12%	16%	40%	32%		

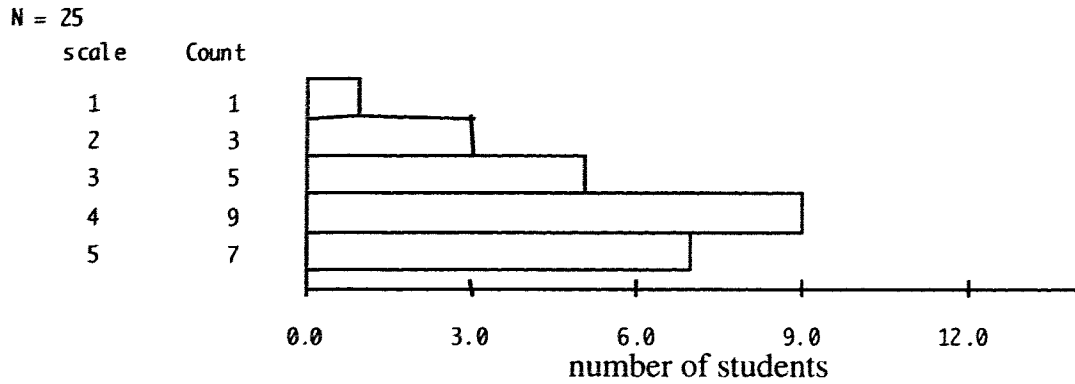
Figure 16: Histogram of item 3 of the QSF



Environmental topics help me understand the application of chemistry
in daily life.

Not at all	1	2	3	4	5	Very much
0%	4%	32%	40%	24%		

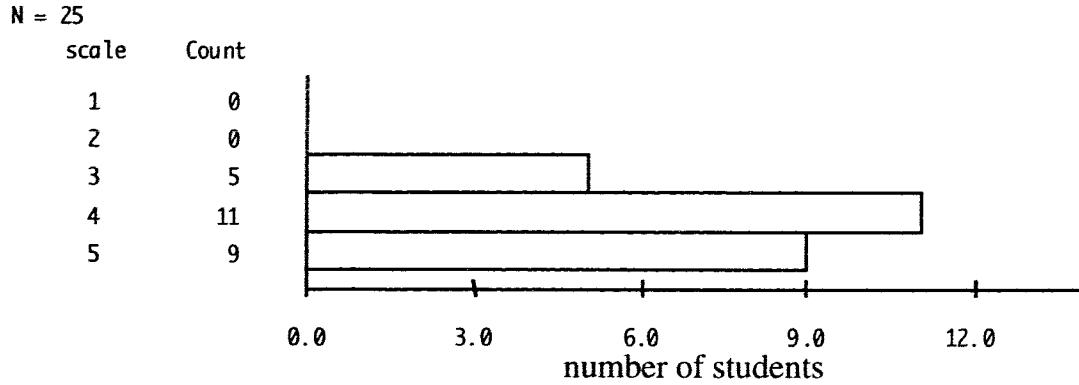
Figure 17: Histogram of item 4 of the QSF



I am interested in the campaign for environmental conservation in our city.

Not at all	1	2	3	4	5	Very much
	4%	12%	20%	36%	28%	

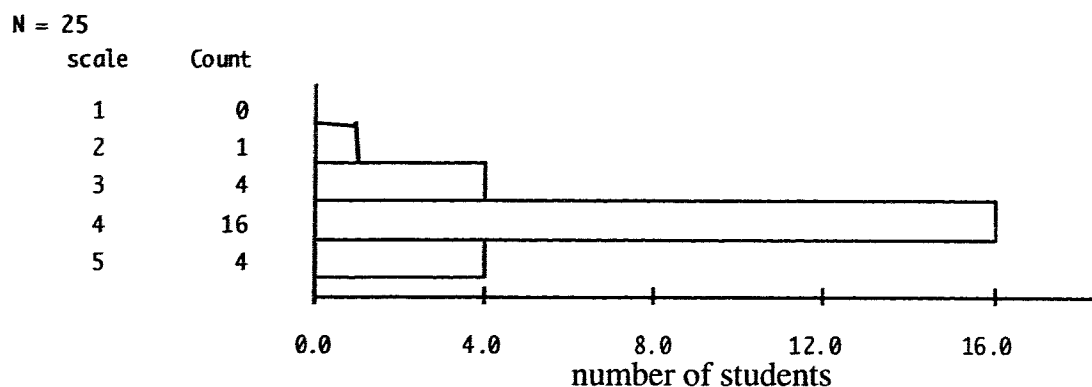
Figure 18: Histogram of item 5 of the QSF



I'd like to learn more about environmental issues from radio, TV, newspapers, and magazines.

Not at all	1	2	3	4	5	Very much
	0%	0%	20%	44%	36%	

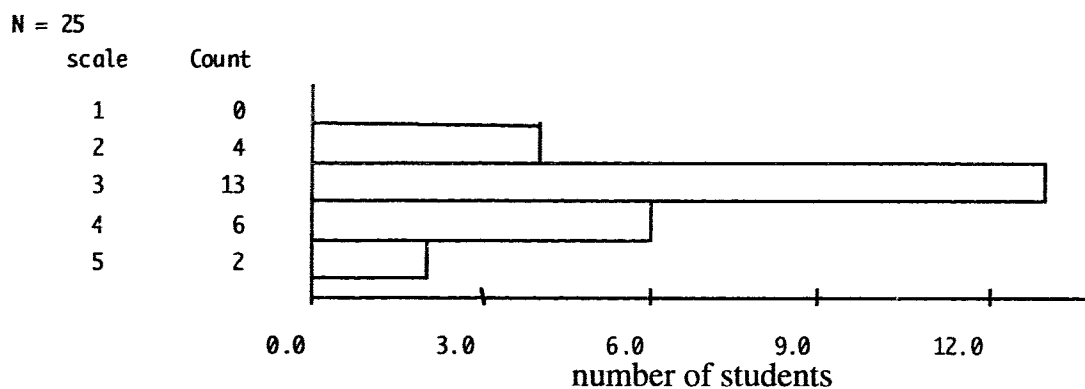
Figure 19: Histogram of item 6 of the QSF



Studying environmental topics stimulates me and furthers my interest in chemistry.

Not at all	1	2	3	4	5	Very much
0%	4%	16%	64%	16%		

Figure 20: Histogram of item 7 of the QSF



Studying environmental topics helps to promote my understanding of the basic concepts, principles and the processes of chemical science.

Not at all	1	2	3	4	5	Very much
0%	16%	52%	24%	8%		

Observation checklist

Observation checklist was administered to the six students of the target group. This checklist was done by the researcher during the group discussion of each lesson in order to

evaluate students' skills through the discussion processes. This instrument was a classroom observation form that the researcher used to explore the interaction among students and their changing communication skills and team work through the new teaching and learning style. This checklist contained eight items which were to be ranked on a five point scale in which the scores were marked 1 for the response "not at all", 2 for "a little", 3 for "average", 4 for "a lot" and 5 for "very much". Data for this instrument included six observation checklist sheets for six students in each week (or four checklist sheets in four successive weeks for each student). The rating scale that was chosen for the observation checklist provided an indication of the students' changing communication skills through the new teaching and learning style. Table 11 shows mean scores of items vs. week. The mean scores of all eight items increased from week 1 to week 4. The mean scores are low for the items 3, 5, 7 and 8 that referred to the advanced communication skills. Students usually experience poor self-esteem when they take part in group discussion. However, the scores of these items increased quickly in the final two weeks of the study. This suggests there was an increase in students' communication skills as a result of the new approach period. Table 12 shows that the total scores on observation checklist for each student clearly increased from week 1 to week 4. The graph of the total scores of each student vs. week is shown on Figure 21.

Table 11: Mean scores and standard deviations of items vs. week

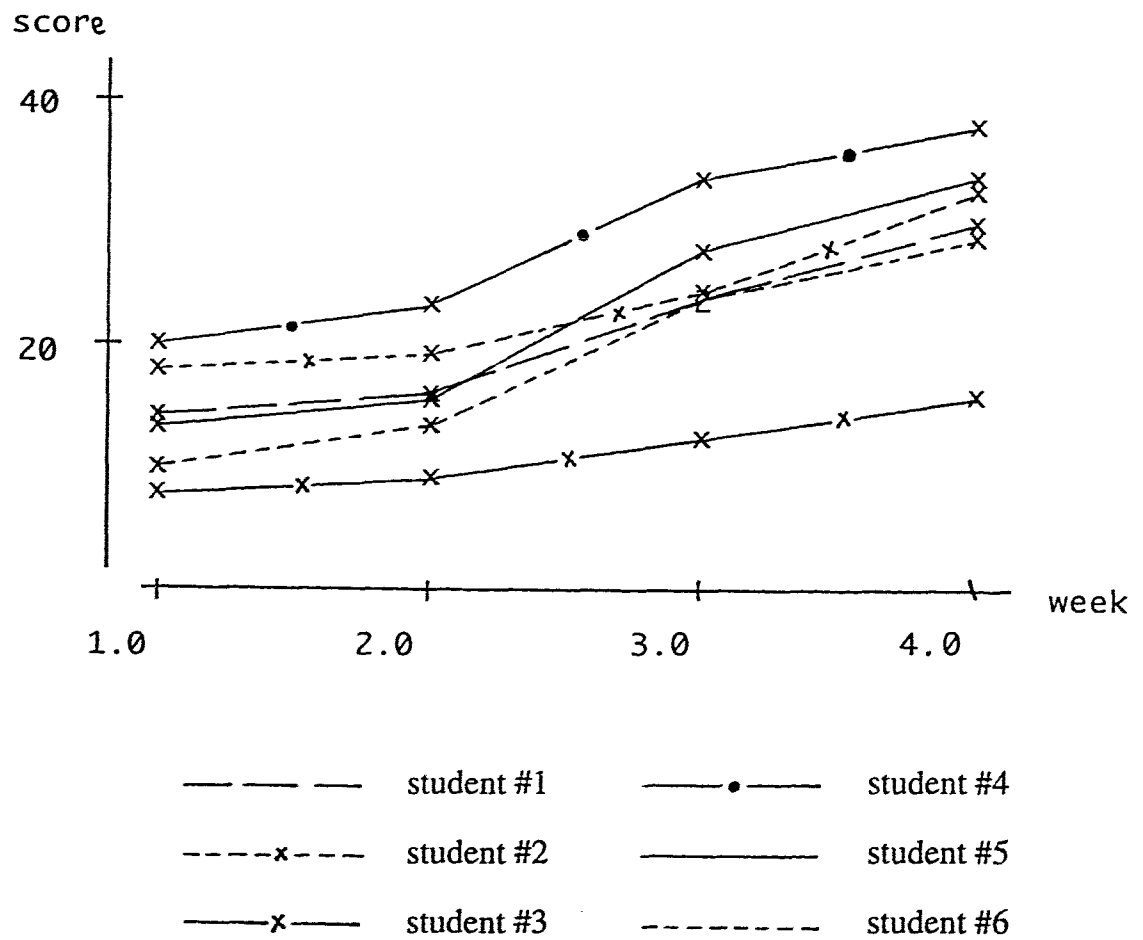
	Item 1		Item 2		Item 3		Item 4	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Week 1	3.167	0.753	2.000	0.894	1.500	0.548	2.000	0.894
Week 2	3.333	0.516	2.667	1.033	1.667	0.816	2.333	0.816
Week 3	3.833	0.753	3.833	0.983	2.167	0.753	3.167	0.753
Week 4	4.167	0.753	4.500	1.225	3.000	1.265	4.333	0.816

	Item 5		Item 6		Item 7		Item 8	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Week 1	1.333	0.816	2.000	0.632	1.333	0.516	1.500	0.548
Week 2	1.667	0.816	2.167	0.983	1.333	0.516	1.667	0.516
Week 3	2.500	1.049	4.000	1.095	2.500	1.049	2.667	1.033
Week 4	3.000	1.095	4.333	0.816	3.000	1.265	3.667	1.033

Table 12: Total scores on observation checklist of each student vs. week

Week	Std 1	Std 2	Std 3	Std 4	Std 5	Std 6	Mean
1	15	19	9	21	14	11	14.83
2	17	20	10	24	16	14	16.83
3	24	25	13	34	28	24	24.67
4	30	33	16	38	34	29	30.17

Figure 21: Student # vs. total score for week



The student interview

Six students in the target group were interviewed to investigate the effectiveness of the environmental approach in the general chemistry course. Among the six students interviewed, three were male and three were female. The students' ideas were codified into six groups: students' attitudes toward the program, students' awareness of environment, students' understanding of chemistry knowledge, students' perception on learning activities, students' view about the teaching strategies, and resource validity.

Students' attitudes toward the program

When asked how they felt about this environmental approach, comments from students reflected two themes in their attitudes: enjoyment of the new approach and motivation in study chemistry. All of students interviewed responded that they liked this program very much, the environmental approach interested and motivated them in studying chemistry. Four of them said that this approach removed some boring elements of general chemistry. Responding to the question why they had chosen chemistry education, several students said that it is easier for them to pass the university-entrance examination than the others. One student said:

I don't think that I will teach chemistry in the future although I am majoring in chemistry education, therefore I don't make all efforts in studying it. I just want to do enough to pass the course.

Only one student said that chemistry has been something that he liked since he was in high school. However, all of the students felt that they were not satisfied with the traditional class. One student commented:

I have been much interested in chemistry since I was in high school. I think learning a subject in university must be different from learning it at high school. However, in chemistry, for a long time I was provided with pure scientific knowledge only. I took notes in class, then studied these notes at home. How boring it was!

For these students, general chemistry course deals with a large amount of abstract

concepts, principles and complex chemical processes. To the students, this course was "information and hard questions". When asked what things in general chemistry course they liked to study, they said that they were enthusiastic about experiments, that they like to find out things they do not know by doing experiments. Therefore, in this environmental approach, students felt interested in the issues related to "real life" problems that they experienced by directly watching demonstrations. These things increased their interest in the study of chemistry.

I now like to study chemistry much more because beside the basic chemistry knowledge, I have also been equipped with the understanding of the environment and learned its direct applications to the real world. For example, when I study about the pH scale, I know what happens to the pH in acid rain. It was helpful!

I have put more time to study this approach, I begin to really like chemistry. I want to study and understand its application in our daily life, not just to take note and memorize because it would be too boring.

All students had strong feelings about the value of the environmental chemistry approach. Most students felt that chemistry in high school (as well as university) becomes difficult and boring when it emphasizes note-taking, reading and memorization. Students valued this new approach because they felt they would learn more about real-life applications of their own chemistry lessons through interesting learning activities.

Students' awareness of environment

When asked to talk about how the environmental approach affected students' learning in general chemistry, nearly all students stated that the environmental approach was useful. They identified several affects: the enrichment of their awareness of environmental issues and the promotion of their understanding of basic knowledge in chemistry. They implied that the approach influenced positively their learning processes. The most influence was that the environmental approach enriched their awareness of the environmental crisis and their responsibility to act to help avert this. One of the students' ideas was:

The environmental approach to general chemistry course helped me to aware the environmental effects of chemical processes and products; and to be able to explain to other people a number of environmental issues.

Environmental issues are among today's most important global problems, particularly since they are accelerating and becoming more and more serious in Vietnam nowadays. This approach developed students' appreciation of contemporary problems in chemistry. Most students felt happy and satisfied as they could use the knowledge of general chemistry to explain the causes of simple environmental problems. One student expressed this view as follow:

Formerly, I could not explain any environmental issue mentioned in the newspaper or on television by my chemical knowledge although I am a student of chemistry. Now, I am more self-confident since I can explain some popular and simple environmental issues, especially those from Ho Chi Minh City.

Another told that:

Some of my sisters and brothers who have accidentally read my report on the environmental pollution in Vietnam, told me that I was lucky when I was taught in a new way: theory is linked to the real-life application. That is really interesting. At their time, they could learn only the theory. It was boring because with their knowledge of chemistry, they could not explain even the phenomena that happened in their daily life.

According to this comment, the students' awareness of the environmental issues through this approach was well achieved.

Students' understanding of chemistry knowledge

Another influence of the environmental approach to students' learning process was the promotion of their understanding on the chemical concepts and principles. Most of students said that the environmental approach in this course provided them with an opportunity to reinforce the concepts, chemical reactions and processes that used to be quite vague to them. One student said:

The environmental approach provided me with the opportunity to understand and memorize the abstract concepts such as pH scale as well as the chemical processes such as the erosion of calcium carbonate by acid sulfuric, the oxidation reactions, that I have learned from chemistry lecture.

I get some advance in my learning by watching something happening before my eyes, by exploring the real-environmental problems in our daily life.

Another student identified the significant effect of this approach on his learning process as follow:

After the four weeks of this new approach, I have got an ability to explain some simple environmental issues by my own chemistry knowledge. For example, I can explain that carbon monoxide and hydrocarbon from automobiles are the main pollutants causing air pollution in Ho Chi Minh City nowadays. Through technological controls, we can solve this problem by the device of the exhaust manifold thermal reactor. The principle is the increase in reaction rate with increased temperature. If the temperature in the manifold is raised sufficiently, the carbon monoxide from the engine will be oxidized to carbon dioxide before it is released to the atmosphere. The manifold thermal reactor is insulated to reduce heat losses and sustain the required temperature. Exhaust gases from the engine are mixed with air to provide the necessary oxygen for oxidation.

This student analyzed well the main pollutants of air in Vietnam and applied thoroughly knowledge of general chemistry (thermochemistry, the chemical reaction of carbon dioxide, the oxidation states of carbon) to explain a technological control of air pollution. The environmental approach significantly effected students' awareness of environment and their understanding of chemistry knowledge.

Students' perception on learning activities

When asked what they thought about the leaning activities, six students commented that those learning activities were very interesting and helpful. One student said:

I appreciate the learning activities that you had given out in class, they help me know how to apply my knowledge in chemistry to our daily lives, especially I have more knowledge about environment surrounding me. That is very useful.

The students have been more interested in a “real-life” applications of their own chemistry lessons, they also wanted to investigate contemporary environmental problems that relate chemistry to social values and political action in our country . One student expressed it:

I like watching the slides showing beautiful landscapes of Vietnam, or the harmful effects of acid rain on the historical structures made of limestone.

I'm afraid that someday these ancient structures will be destroyed, which will be a pity for us all.

Another said:

I like the most the field-trip learning at Saigon River, Tanhoa Canal. It is a wonderful opportunity to discover that chemistry is everywhere!

These comments indicate that students enjoyed those activities that make connection between chemistry course and their lives. All students argued that through this field-trip learning, they observed water pollution in our city and identified the chemical effects of a specific water pollutant on living organisms. The field-trip brought light to the societal needs for the increased role of chemistry in facing with new challenges brought on by the growth of our city.

When asked to talk about which activities they felt helpful to develop skills required by a university science student, nearly all students stated that the laboratory work on pollution and the seminar/ workshop were most helpful:

Well, I appreciate the seminar on environmental pollution in Vietnam. It provided me with the opportunity to develop many abilities and skills such as library reading, writing and presenting problem sets. I feel very enthusiastic! But I think that activities such as seminars, oral reports and presentations should be more than just once!

This view indicates that students feel research skills should be developed in the university science classroom.

Students' views on the teaching strategies

The majority of the students interviewed appeared to feel positively about the style of teaching used in this approach.

Comments from students reflected four activities: discussion, demonstration, viewing videos and doing group work. All six students reported that the instructor had prepared well for demonstration experiments and student discussions. They found that this style of teaching was different from other chemistry classes they had attended. The new teaching method focused on discussion and active learning rather than the note-taking,

memorization and assignment solving of traditional methods. Students were more likely to be interested in instructional techniques such as demonstration and group discussion:

I have more interest in this new teaching method with demonstrations. It makes it is easy for me to comprehend abstract concepts and the nature of chemical processes.

Six students were enthusiastic about demonstrations. For these students, demonstration was a key to exploring chemical changes. Students liked experimental demonstrations because they liked to be active. They enjoyed action better than words. They said that demonstrations helped them promote their understanding of the abstract concepts in chemistry by watching something happen before their eyes.

In this teaching style, group discussion was a new activity for chemistry students in Vietnam. Therefore, students had strong opinions about this teaching technique. When asked how useful this teaching strategy was, most of students said they thought that within the university environment, they should be provided with the opportunity to learn dynamically. Group discussion helped them to enrich their knowledge from the ideas of the others in group.

Well, it 's really good because I have the opportunity to talk about my own ideas, to ask questions during the discussion, and through it, I comprehend all of the issues thoroughly.

Students felt that group discussions were not only fun but also effective in terms of learning. Discussions helped them share ideas with others. It also helped students to develop their cognitive thinking ability because it provided them with the opportunity to think and express the ideas. Presentation skills were also developed through discussion. This skill required students to think before they could formulate answers. One student said:

Until recently, I was familiar with a way of teaching in which the teacher talks and the students listen. Even if we are vague about some ideas, we don't think of asking the teachers, partly because of our shyness, partly for lack of opportunities to raise questions. With the new method, I was quite at a loss at first, but after several group discussions, I had the opportunity to raise questions. Thanks to the different opinions suggested by my friends in the group, I have a clearer view and better understanding of the matter.

This view illustrates some problems that Vietnamese students have had because of

their traditionally passive mode of learning. They may be embarrassed and reluctant, at least at first, to take part in group discussion. Students echoed this view:

I remember saying nothing in the first discussion because I didn't know how to express my opinions properly.

During the first discussion, no one in my group was bold enough to speak on behalf of the group. Finally, I was appointed representative. I was quite embarrassed, but then gradually I felt more self confident.

These students perceived that discussion and presentation were useful to develop the thinking, speaking and expressive skills they needed as student teachers. One student said that:

Through this teaching method, I gained some understanding about the new teaching strategies which I hope to develop further in the future when I graduate and become a high school teacher.

Although the students appreciated the new teaching method, they also expressed dissatisfaction in their comments about the organizations of learning activities, the role of instructor and time allotted to the approach. Some students said:

I felt it was difficult to take part in group discussion because the instructor didn't give enough help.

There should be more discussion on difficult points in class.

The instructor should be available more frequently to give help on points of difficulty.

There is too much reading involved.

There is too much work to do.

We need to have more opportunities for field trips.

Since Vietnamese students are most familiar with passive learning, they had many difficulties taking part in group discussions and other learning activities that were included in the approach. We also recognized that the instructor in this approach did not always perform well, for example, the instructor did not enhance the classroom atmosphere and concentrated efforts on behaving as a facilitator to keep student thinking and discussion on track.

Resource validity

Equipment and resources for science teaching are lacking all over Vietnam. This approach provided students with articles selected from Western materials. The researcher of this study received grateful comments from all of the students for providing a new supply of articles from Canada and North America. Students reported:

I used to read materials about chemistry in the libraries, but these materials are quite old. The readings that you gave us were very good, they were very up-to-date and useful to us, they were easy to read and to understand, and I could read the original materials written in English as well as those translated into Vietnamese.

Essay analysis

Unlike the interview which focused on six students in the target group, the essay was administered to 48 students at the end of the course. However, the researcher received only 30 essays of a total of 48, leaving 18 who did not submit their essays. These 30 essays were analyzed to examine the students' feelings, thoughts and comments about the class. Of the 30 students who submitted essays, 13 were male and 17 female. The essay data were categorized into seven themes and their factors as follows:

- Theme 1: Students' attitudes toward the program.
- Theme 2: Students' awareness of environmental issues.
- Theme 3: Students' understanding of chemistry knowledge.
- Theme 4: Students' perception of learning activities.
- Theme 5: Students' view about the teaching strategies.
- Theme 6: Resource validity.
- Theme 7: Other student comments.

The distribution of students' ideas about the environmental approach is given in **Appendix M**.

According to the *students' attitudes toward the program*, we found that

most students had strong feelings about the environmental approach. 87% students enjoyed the approach, 70% students stated that the program increased their interests and motivation in chemistry. Most students said that the environmental approach removed some boring elements of general chemistry, they felt regret at finishing the program, and some of them felt it was a honor to be exposed to the program.

Most of the students enjoyed the environmental approach because environmental issues are among today's most important global problems and Vietnam is facing a great deal of environmental pollution. This approach developed an appreciation for contemporary problems in chemistry. One male student wrote:

Although environmental pollution issues are not compulsory topics in the general chemistry syllabus, they are of great practical value and are considered an important social problem. For this reason, when I had an opportunity to study them, and especially when I could use my knowledge of general chemistry to explain the causes of environmental pollution, I had the feeling that chemistry was not as dry and tedious as I previously thought it was.

Vấn đề ô nhiễm môi trường cũng vậy, tuy là không phải là kiến thức bắt buộc trong học phần hóa đại cương nhưng nó lại rất dễ kết nối thực tế, vậy mà hàng ngày ta đều bắt gặp nó, từ vấn đề mà ta nhìn thấy khi đứng ngoài trời, từ vấn đề mà ta nhìn thấy khi đứng ngoài trời. Vì vậy khi được học về vấn đề này và nhất là khi áp dụng kiến thức nguồn gốc của nó ô nhiễm (điều chỉ là một phần nhỏ) bằng kiến thức của môn hóa đại cương thì em cảm thấy môn học này không còn khô khan như lúc đầu em vẫn nghĩ.

100% of students reported that this approach was quite different from what they had met in their previous chemistry learning, so the new class was interesting to them. Most of students said that the program motivated them to study chemistry, and the environmental approach removed some boring elements of general chemistry. They found that the class was not rigid or made up of dry lectures. It was enjoyable, comfortable and engaging.

Some students wrote:

I attended this course with great interest of the past four weeks. Nobody was sleepy or negligent of his study in the class. This was quite different from what we had done before.

Trong 4 tuần học Hóa Đại Cương, môn học này được hướng dẫn khá thú vị. So với trước đó thì không dẫn đến tình trạng buồn ngủ hay làm việc riêng.

The new approach interests me. I feel quite comfortable, not tense or anxious as before.

Phương pháp mới này dù sao cũng đem lại sự say mê học hỏi hơn, cảm thấy nhẹ nhõm chứ không nặng nề.

The new approach interested and surprised us. Almost all the students participated the class meetings with pleasure because the learning was lots of fun and we could discuss many interesting things.

Phương pháp này rất làm chúng em hứng thú khi học môn này! Một điều thích thú đến những ngày của tôi em! Hầu như ai cũng tham dự buổi học này vì khi học rất vui và thực tiễn triết luận vẫn để mà có thể học hỏi rất tốt ở nhau. Mọi người một ý và ý chính của cô hướng dẫn làm chúng em vô cùng hứng thú khi học.

I like learning without taking lots of notes, and I like speaking up freely in the discussions on matters which are simple but closely linked to our daily lives, and which I couldn't explain with my own knowledge about chemistry. Today, quite a lot of matters have been solved fully and openly, and I'm not required to learn by heart what is explained and included in the course book.

Đôi thích khi đi học ít & có thể tự do phát biểu như thế này. Những vấn đề đơn giản & gắn liền với đời sống không ngay mà trước đây tôi ở giữa để đi để giải quyết thật đầy đủ & thoải mái ở trước tôi giải thích kiến thức trên SGK như bình thường.

Students enjoyed the new approach, at the end of the program, they said that they felt regret at finishing the program:

The four week course came to an end, leaving me with a feeling of regret. I wish to learn more like that not only the general chemistry course.

Chấm dứt việc học này qua thật là có sự tiếc nuối, mong muốn được học như vậy không chỉ riêng ở môn Hóa Đại Cương.

Right at this moment, I wish the program would continue. I can't imagine that next week we will no longer enjoy the lively atmosphere of our class.

Ngay lúc này tôi em muốn môn học được tiếp tục. Đến ngày chấm dứt môn học mà tôi em không ngờ! Khi có vô lớp nữa ai cũng ở! Lớn vì quá bất ngờ!

How time flies by! Four weeks went by quick as a wink! I hope I will have another opportunity to learn chemistry in this way again.

Ước tiếng của em ngay lúc này là: Học mà thời gian học 4 tuần trôi qua mau quá. Chỉ chỉ mà những năm sau này, việc áp dụng phương pháp học này.

Although only two students of the 30 expressed that they felt it an honor to be exposed to the program, I believe that the students generally appreciated the program. One student wrote:

First of all, I must admit that I am very proud, for I had the honor of being one of the first students to work with this new approach. We are really lucky to be given a chance to enrich our knowledge in so short a time and under such difficult study conditions.

Trước hết em rất lấy làm vui mừng vì là một trong những học viên đầu tiên được tiếp cận với phương pháp mới này. Bởi vì thời gian ít lâu nhưng trong điều kiện học tập khó khăn hiện nay, em đã được tạo điều kiện để trao đổi kiến thức như vậy thì thật là may mắn trước hết là cho bản thân em, các bạn em & sau đó là xã nhiều thế hệ đi sau nữa.

Through this approach, they realized that environmental chemistry is more complicated than "pure" chemistry because it deals with different aspects of our environment. Therefore, environmental chemistry should be taught in better conditions of teaching and learning. In the context of the poor conditions in university science teaching of Vietnam nowadays, they valued hands-on environmental chemistry topics that made them think and learn general chemistry enjoyably.

On the theme of *students' awareness of the environment*, the essay data showed that 77% of students understood environmental issues and the relationship between chemistry and everyday life. They could explain the causes and consequences of environmental pollution, and felt a sense of responsibility towards environmental

conservation.

Our university science program has been usually focused on "pure" traditional science. Very little or none of the social and technological implications of science are presented in the science curriculum. STS issues are rarely seen in chemistry university curricula in our country. Although students were provided with the first opportunity to study contemporary problems in chemistry and their real life application, most students reported that through this approach they understood environmental issues and the relationship between chemistry and everyday life. One student wrote:

Environmental issues have been reported and discussed extensively on radio and TV, in newspapers and magazines, so they are quite familiar to me. However, it is the environmental topics which were recently introduced in the general chemistry course that have really given me a lot more awareness of the relationship between chemistry and environment.

Tôi nhận môi trường vấn đề của thời đại này một cách đáng tài tâm
 nhận bài báo này nó không xa lạ với em
 Tuy nhiên tôi học qua các bài học về môi trường trong
 chương trình hóa đại chúng vẫn chưa hiểu đó là một môi
 trường như mong muốn trên thực tế bây giờ thời đại của mình
 tôi với vấn đề này.

This comment reflects a belief that through this program, students had opportunities to understand environmental issues and the real-life applications of chemistry more than through newspaper, and television coverage. Some students said that the awareness of the environment stimulated by this approach helped them develop their explanation skills about the causes and consequences of environmental pollution. One student said:

Due to my knowledge of these environmental issues, I can explain to everyone around me the causes and consequences of environmental pollution and its influences on human life. I can also inspire a wish in them to protect the environment.

Bằng những hiểu biết của mình về vấn đề này em có thể lý giải cho
 những người xung quanh hiểu được nguyên nhân gây ô nhiễm môi trường
 ảnh hưởng của nó tới sức khỏe và khả năng sống thọ của con người
 giải báo về môi trường.

The Spring 1995 "Campaign for Sanitation and Greens" in Ho Chi Minh City was a program for rubbish reduction and the planting of trees to increase oxygen. After studying with this new approach, students felt that their awareness of the environment was adequate to allow them to discuss a contemporary environmental problem using their own chemistry knowledge. As one might also predict, the more awareness the students had of environmental issues, the more confident they felt in expressing their ideas and the more likely they were to talk about their ideas with each other.

Through this program, some students felt a sense of responsibility towards environmental conservation. One student said that the understanding of the harmful effects of environmental pollution had changed her view of the environment and aroused her sense of responsibility towards environmental conservation. This illustrates that the program may contribute to the challenge of linking education to environmental protection.

Exploring the theme of *students' understanding of chemistry knowledge*, we found that 70% of students reported that the program helped them to reinforce their understanding of concepts and principles in chemistry. Only a few students felt that the program did not promote such understanding.

This environmental chemistry program was designed to enrich the existing general chemistry course, which aims to help students promote their understanding of the basic concepts and principles in chemistry. We tried to promote an appreciation of contemporary problems in chemistry and the real life application of general chemistry in combating environmental pollution. We hoped that, through this environmental chemistry program, students would reinforce their basic chemistry knowledge in general chemistry. We found that most students stated that the program helped them reinforce the understanding of concepts and principles that were formerly considered abstract and difficult to comprehend. One student said:

I feel more interested in general chemistry after learning more about environmental issues in this program. It is clear that the program helps to reinforce those concepts about chemical reactions in nature that used to be quite vague to me.

Sau khi học bài học về ô nhiễm môi trường, em cảm thấy
 thích học môn này nhiều hơn. môn học học rõ ràng, các kiến thức về
 môi trường giúp em rất nhiều trong ý thức sinh hoạt hàng ngày.
 Trước kia, nó còn vụng vơ chút nhưng (chưa hiểu về những phản
 ứng hóa học trong tự nhiên, mà trước đây em còn mù mờ).

Most students agreed that the program was helpful for their understanding of chemistry. However, one student with negative attitudes towards the program felt that the program did not promote anything:

For the past four weeks, the program seemed quite vague to me. There was too much to study, but all topics have not been explained in detail by the instructor, so they were not embedded in my mind. I felt that they were quite vague and actually, I could not understand them clearly.

Qua 4 tuần học, vẫn qua như học thế thì với em
 vẫn còn mơ hồ, có thể là quá nhiều vấn đề nhưng giải
 thích chưa rõ để thì không thể cập nhật, các kiến thức
 vẫn đi đó chỗ kia ăn sâu vào đầu em, nó chỉ là nhồi
 nhét vào đầu, không thể hiểu sâu về nó được.

This complaint reflected his strong feelings about the traditional lecture-based style of teaching in which the instructor usually answers students' questions about the lecture material and assigned problems, and gives students the correct answers. With this style, learning was static. The environmental approach was based on a more active and dynamic interaction with student. This student was uninterested in the new approach. He felt that there was too much work for him to do himself, and that the instructor did not give enough help, so he could not cope with the topics in the program. In this instance, we found that the instructor's techniques could be improved. It could be argued that this was the first time the instructor as researcher changed her teaching of chemistry, taking a new approach

that was seen as more complicated than "pure" chemistry.

Looking at the *students' perception of learning activities*, we found that the students commented that demonstration activities related well with the study of contemporary problems. Most students reported that the video helped them realize the relationship between chemistry and real environmental problems. They appreciated the seminar/ workshop.

Students were very interested in the video and the demonstration activities. Most students were enthusiastic about the videos of real environment pollution with local, national and global evidence in Vietnam and Indochina. They reported that the video helped them see the relationship between chemistry and the real environmental problems. One student said:

Learning with video illustrations is very interesting and beneficial. It not only entertains me but also provides me with extensive knowledge and understanding of current issues in the world.

Việc xem video mình học rất hay & bổ ích. Nó tuy giống giải trí nhưng lại bao hàm nhiều kiến thức. hàng ngày, năm để các hiện tượng hóa học xảy ra trong đời sống hàng ngày...

Another said:

Studying with video tape helps me recognize the relationship between chemistry and our daily lives, a relationship which seemed to be too abstract up to now.

Em được học = Video. Cảm thấy rất gần gũi học rất liên quan đến đời sống hằng ngày diễn ra. mà từ học đến giờ em luôn cảm thấy thú vị.

While investigating the *students' views of the teaching strategies*, we found that students had strong ideas about what they experienced in the new teaching method. Most students had good comments about demonstration, and group discussion. They stated that the new style of teaching was helpful, they were happy to have less note-taking in the new class.

Concerning the teaching strategy of demonstration, nine students reported that demonstrations helped them to understand and memorize chemical concepts and principles. Four students said that demonstrations helped them learn chemistry by direct experience and six students stated that demonstrations increased their interest in chemistry lessons.

One student expressed a wish for demonstrations in other chemistry courses. One student wrote:

I wish we had demonstrations in other chemistry courses, not just "dry" lectures because it would be useful for us to apply the demonstration strategy when we become chemistry teachers in the future.

mong muốn tất cả các thầy, cô khác đều cho tôi em tiếp xúc nhiều hơn với thực tế (thí nghiệm) chỉ học lý thuyết không thì viết chán lắm thời khi đi tạo 1 giờ giờ, thầy giáo đưa học chưa học thêm nữa, chỉ đi về với đề tiếp xúc để học ngày nay vì dù muốn học mà không bài cho học sinh -

Most students reported that group discussions helped them understand concepts and principles in chemistry. Some students stated that discussion provided them with the opportunity to express their own ideas, replaced formal lectures with a more active and dynamic classroom environment, and helped them to share their ideas.

Most students identified some differences between the new teaching method and the conventional method. One wrote:

I can point out big differences between the new method of teaching and learning and the old one:

- For the new method, we do not have to take a lot of notes because we receive the materials beforehand and read them before class.

- Class contacts are no longer dry or dull with pure lectures. There are experiments that illustrate ideas, then discussions with lots of opinions from our friends that help us come to convincing conclusions.

Si khác biệt giữa những giờ học mới này với những giờ học trước đây
 - Bài viết không ghi chép nhiều do ai tài liệu - bạn khác trước.
 - Giờ học không bị nhàm chán như "khô khan" như phía ngoài giảng lý thuyết "suy nghĩ"

mở, có thí nghiệm, kiểm chứng. Sau giờ học được thảo luận những vấn đề, chưa hiểu rõ càng lắng nghe ý kiến của các bạn và tự đúc kết cuối cùng.

Students had some general comments about the teaching strategies in this approach.

73% of students argued that the new style of teaching was helpful because it developed their cognitive skills and critical thinking abilities; it provided understanding that they felt would be useful in their future careers. Students expressed the wish that other chemistry courses would be taught in the same style. One student reported:

With the new teaching method, we did not have to take a lot of notes, but the method required me to think critically and actively. This helped me to comprehend the lessons much better.

Trước kết (pp mới) nó ko đòi hỏi phải chép bài nhiều nhưng ngược lại nó đòi hỏi em phải tư duy, lập luận nhiều hơn. Điều đó giúp em nắm bắt được vấn đề sâu hơn, vững chắc hơn.

I like to study with this new method. After graduating, I will apply this technique to teach my high school students.

Em thích học phương pháp này (nếu sau này ra trường, em sẽ cố gắng học tập theo phương pháp này để hướng dẫn cho học trò của mình,

After four weeks, I realize that I am a "university" student, but to be a university student is no joke!

Sau 4 tuần học với cô, em cảm nhận được 1 điều duy nhất là: "Là 1 sinh viên Đại Học thực sự, mang đúng nghĩa của cụm từ Đại Học, thật không dễ".

Students had strong feelings about the teaching strategies:

Group discussions after the demonstrations have encouraged me to further study chemical processes.

Sở với kiểu dạy, những giờ học như này có thêm phần thí nghiệm thực tế, việc hỏi thảo luận để rút ra ý kiến đúng, hay nhất. Đây là dạng cơ bản dạy bị nghiên cứu từ môi trường vì cái quá trình học hỏi, là từ em rút ra kinh nghiệm.

Most students had some suggestions about the new method. They suggested that

the instructor should supply more correct solutions to assigned problem sets. Most of them

preferred that the instructor give more help in group discussion. A few students

commented that some learning activities were not well planned. These were the weakest

features of the instructor's work in her first time teaching with this new method.

On the *resource validity*, we found that 60% of students stated that the

supplemental resources were helpful, they were relevant and interesting. They reported that

the strongest feature of this approach was the supplemental resources. A few students

suggested that more references from the city libraries should be presented to students.

Students were provided with resources including articles, equipment, statistical data and

video tapes. Except for the equipment were supplied by the general chemistry laboratory of

the university, most of resources were provided by the instructor. Articles used in this

approach were selected from Canadian and American materials. Most students appreciated

them. They reported:

The new class is different from the old one in which we used to listen to

instructor's presentation and take notes with no articles supplied.

gō hōc mē nōy xēt thēe eāch hōc nōi fīndc dōy : sōi vī tū

hūc dōn nōy cōc en eāc' thūc hōc thēe dōc nōy vā chip qōc

eāch fūngū dōt cūa thōy cō mē thōy cōl mōyng tū hōcīn thōm rīcō,

Students realized that materials are poorly organized in our country, and they are

happy to have instructors taking responsibility for the supply and organization of science

materials.

The essay data exposed *students' other comments*. Some students commented

that it is difficult to study with this approach. They said that this approach required them to

spend more time studying but that this was quite useful. A few students complained that

there was far too much work to do.

The environmental approach demanded that students do more work than before

because they had to read articles at home before class. Sometimes they had to do library

research, view videos, or work in groups at home to prepare for the learning activities in the next class. During the class period, students had to observe, discover, and test chemical processes in order to create their knowledge. Perhaps this approach demanded more student study time. For this reason, some students felt that it was difficult to study with this approach because it was unfamiliar for them. However, most of the students stated that although this approach required more study time, they found it quite useful.

I had to spend a lot of time in learning this program. However, I did not feel regret because I found it quite useful.

Với phương pháp mới này, so với trước kia thì chúng em vẫn
thời gian hơn nhưng lại lý thú và bổ ích. nên chúng em vẫn
thích dành nhiều thời gian cho nó.

Very few students complained that there was too much work to do:

There are too many lessons, too many things to read and to study. If all my other courses were taught in the same way as this approach, I would surely be unable to keep up.

Cảm thấy số ví phải học nhiều lắm nhiều

Vi không phải chỉ học 1 môn học mà còn học rất nhiều môn quá như
môn nào cũng học theo cách học đó thì có lẽ em sẽ không học
nổi.

Finally, we found students' very enthusiastic about the new approach:

After four weeks of studying, this new approach has provided me with many new things, including teaching methods, the learning style, and supplemental resources. Everything was very enriched and useful. This new style of teaching and learning startled us at the beginning, but after about two weeks, we got used to it and became excited about our studies.

qua 4 tuần học môn học mới chúng em được cung cấp nhiều
mọi đã đến với em những điều hoàn toàn mới lạ. từ phương pháp giảng
bài. sự tiếp thu và phương pháp học tập. trong phương pháp học môn học
vừa qua, nói về tài liệu cho chúng em học. thậm chí rất phong
phú và bổ ích cho việc học. phương pháp mới giảng dạy này lúc đầu
chúng em còn ngỡ ngàng qua 4 tuần học thì đã dần quen và rất
hứng thú như học.

Most students felt that they were embarrassed at the first stage but they quickly became attracted to the new approach after the first few weeks. One female student said:

At first, I was rather embarrassed and reluctant to take part in group discussions, but later I became acquainted with these activities and then became really interested in them.

*Chưa đầu em cảm thấy bị ngại ở
đầu buổi với những giờ học tập nhưng sau đó quen dần và cảm
thấy thích học như lúc đầu.*

This view generally showed that students were flexible enough to try the new approach. After working hard with unfamiliar teaching and learning styles, students developed their communications and team work skills.

Instructors' perceptions of the environmental approach

After examining students' perceptions of the environmental approach, the study strove to come to an understanding of how this approach was valued by Vietnamese instructors who have taught the general chemistry course. Four chemistry instructors in Ho Chi Minh City University were interviewed (instructors from The School for Education, The Polytechnic, The School for Agriculture and The School for Science).

The instructors received questions related to comments on the suggested environmental approach. The questions sought to give the instructors the opportunity to respond freely about their thoughts on the environmental approach to chemistry classes; how they felt the general chemistry curriculum should be conducted; and how they felt the general chemistry course should perform.

When asked what they thought about introducing environmental issues into the general chemistry course at the general higher education phase, three of the four instructors identified that it was really needed, for environmental pollution and environmental conservation were important social problems.

One said that in the discussions on the syllabuses for the General Higher Education

phase in Ho Chi Mine City, pollution is always mentioned. At present, our students study basic theories of general chemistry only, so it is necessary to include the environmental issues in the general chemistry syllabus, or to consider it as a separate approach for environmental chemistry in which there are several topics concerning environmental pollution. Another argued that environmental chemistry is a new area, that it is very important and modern. Therefore, it needs to be taught to the chemistry students but we should consider when and where it should be included in chemistry curriculum.

In discussing how knowledge of environmental issues should be introduced (i.e. in which part of the curriculum, how much time should be spent on it. etc.), two of the four suggested that it was best introduced at the end of the general chemistry course, while another said that it should be included as part of any relevant topic of the course. One who did not agree with including the environmental topics in the general chemistry course, felt that the better solution was a separate course in environmental chemistry for third or fourth-year students. When considering the environmental topics introduced in this program, all of instructors stated that environmental pollution included many very broad topics that could not all be brought into the program. The choice of which should be taught should be based on the characteristics of the course as well as the fundamental matters closely connected to be content of the general chemistry curriculum concerning three aspects: water, air and soil. The content of the environmental topics as presented in this program is reasonable. However, they suggested that the issue of soil pollution should be included in the program. One said:

With respect to content, it is necessary to introduce the issue of pollution in the earth's crust into the program because extensive deforestation, mineral resources exploitation, and sewage disposal from the factories are contributing to the loss of ecological equilibrium and to the contamination of the earth.

When asked to talk about the teaching strategies that were used in the suggested environmental approach, all of instructors identified that the teaching method used with this environmental approach was based upon the learning cycle of Demonstration- Exploration-

Discussion. Although they had seen this method before, it is still a new teaching style that has not been used widely in teaching chemistry in Vietnam. Sometimes they had brought an experimental demonstration or series of demonstrations to their class just to give students simple observations of chemical reactions. However, the learning process has not been that of going from demonstration to exploration to discussion. Some of them said that although they did not participate in the new class regularly except as observers, they had the opportunity to understand this teaching method through discussions with the researcher. They thought that this teaching model might be suitable to deliver chemistry, particularly environmental chemistry. One instructor said:

It is impossible to use the conventional method in teaching the environmental approach because the environmental chemistry is an issue relating to real-life. Students need to study from reality like the learning activities that were designed in this study.

They appreciated the learning activities that were implemented in this approach. Nearly all instructors commented that the activities such as the environmental chemistry experiment of "Dissolved oxygen measurements" with water samples from the Saigon River, or the examination of current data on Ph values in the Saigon River, or the visit to the Saigon River and Tanhoa canal, or viewing slides and videos are very lively, creative and progressive. They felt that these activities surely motivated the students. One of the four instructors who observed the new class reported:

During the past four weeks in the experimental class, I have seen that the students were enthusiastic, hard-working and very interested. The classroom environment fostered the active participation and creativity of the students.

This observer said that these learning activities were interesting because they related to real-life activities and the environment while relying on a basic understanding of the course.

When asked to talk about how the environmental approach affected the students' learning process in chemistry, the instructors agreed that this approach had a good effect on students' knowledge. Certainly, it enhanced students' awareness of environmental crises.

It also enhanced students' understanding of the concepts and principles in general chemistry and their ability to apply this knowledge to explain aspects of environmental issues in real-life. The instructors spoke about the benefits that our students may gain through this environmental chemistry program. Most of them said that the environmental program as a part of the general chemistry curriculum may benefit students in general higher education phases. Most important was the link between teaching and learning science and real life, which would help students to orientate themselves in their future jobs. As one instructor said:

The great benefit to the students from the program is to provide them with the sense of responsibility as a member in the society whose future activities must be linked with that responsibility, with general guidelines and measures in the struggle for preserving the environment as well as treating environmental pollution.

When considering whether or not the resources required to implement the environmental approach were available in the Vietnamese context, all of the instructors felt expressed that in Vietnam, the issue of the environment was a new area in education. Consequently, data were not sufficient and must be collected from scattered sources. However, the equipment used in this approach could be found in most of our general chemistry laboratories. They valued the supplemental resources supplied in this teaching experiment. The articles collected from Canada and North America were very up-to-date and helpful. The videos of environmental pollution were well-selected and excellent. One of them felt that in Vietnam, it is quite advantageous for us to teach environmental issues at the present time because the Vietnamese reality is raising urgent issues such as the water supply, industrial pollution in big cities, the purity of drinking water, and the treatment of discharged water or sewage. He said there are abundant sources which could be very useful for the teaching of these issues. However, there may be difficulties in funding field trial.

When asked whether the suggested environmental approach was consistent with the spirit of the recent education reform in our country, whether it achieves the aims and

objectives of our university chemistry curriculum, nearly all of them answered "yes" because the Ministry advocates the establishment of a curriculum that is state of the art, practical and suitable for Vietnamese context. Hence, the introduction of environmental pollution into the general chemistry curriculum at the general higher education phase is not in opposition to the policy of the Ministry. They stated:

This is completely in agreement with the spirit of the education reform in the university, and with the aims and objectives of the general chemistry curriculum.

Finally, they welcomed the content as well as the new teaching style in this approach but they stated that this approach still has some limitations that need to be addressed. It was felt that the program was successfully implemented in the School for Education in a small pilot program consisting of classes of less than 50 students. In the School for Science with its pilot program consisting of classes of more than 150 students, they thought that it would be impossible to implement this approach because it would be hard to organize the teaching and learning process. It would be necessary to modify this design some what to present environmental chemistry students in large classes. They also realized that this new approach stimulated them to rethink the way the curriculum is delivered, and what, how and why we should teach chemistry at this level.

Meaningful support of this study indicated in a letter we received from one of the four instructors who observed in this approach. The letter commented on the strongest and weakest features of the new approach and gave suggestions. This letter is given in Appendix N.

Chapter 6

Conclusions, Discussion and Limitations of the Study

This chapter presents a summary of the results and the conclusions of the study. Then, the analysis of the findings is reviewed and followed up by two matters for further attention. The first deals with students' views after taking the environmental approach as well as some indication of their changing attitudes toward and knowledge of the new program. Secondly, instructors' comments on the suggested approach are reported. A discussion follows in which an attempt is made to answer the research questions asked in Chapter 1. The chapter ends with the limitations and recommendations of this study.

Conclusions and Discussion

The study began with a look into some of the problems of the university science curriculum of Vietnam, which is in urgent need of innovation. The researcher suggested an environmental approach infused into the general chemistry course. With this approach, students can learn chemistry by direct experience of the real-life application of their own chemistry knowledge, and not just listen to lectures in pure chemistry as they used to. The environmental topics that illustrate the concepts and principles in chemistry were learned by the students through a new teaching model—the learning cycle: Demonstration-Exploration-Discussion, in which students were placed at the center of the learning process. For the purposes of this study, several environmental issues dealing with the content of the general chemistry curriculum were chosen, and eight learning activities with appropriate teaching strategies were designed. The suggested environmental approach was then implemented in a classroom of university students in Vietnam. This study gathered data on the effectiveness of the environmental approach to this course. The analysis presented in Chapter 5 has led to several conclusions.

The first objective of the study was to determine whether or not the suggested

environmental approach in the general chemistry curriculum affected the students' attitudes and their learning process. The answer to this question was based on the analysis of student interviews and essays, combined with the questionnaire on attitudes, and on feedback instruments. The findings from student interviews are in accordance with those from students' essays. They showed that more than two-thirds of students in the sample responded that the environmental approach interested and motivated them to study general chemistry. This approach enhanced students' learning processes. The greatest influence was that the approach enriched students' awareness of environmental crisis and contributed to their feeling responsible to take action to help avert this crisis. Furthermore, students had the opportunity to reinforce the concepts and principles of chemistry. Positive results of the questionnaire on student attitudes showed that students were interested and motivated toward chemistry. In particular, there were two items for which the response pattern was 91.4% for A (Agree) and SA (Strongly agree) combined. These items were:

- Item 1: Chemistry is something that I enjoy very much.
- Item 3: The chemistry class is interesting.

Results of the questionnaire on student feedback also showed that students' views about the new approach were highly positive for item 6: "Studying environmental topics stimulates me and furthers my interest in chemistry".

These results agreed with the findings from the interviews and essays, and all supported the above conclusion. This is not surprising because our university science program has usually been focused on "pure" science. Most students feel that general chemistry in university becomes difficult and boring when it emphasizes note-taking, reading and memorization. Students enjoyed this new approach because they felt that they could learn more about the real-life applications of their chemistry lessons. Students reported that this approach was quite different from what they had previously met in their chemistry learning and the program motivated them to study chemistry. In addition, the new teaching method and the learning activities increased students' interests and

motivation. It is clear that with the traditional teaching method, students were passive, but with the new teaching method, they were placed at the center of the learning process; they felt their learning was active and dynamic. The learning activities were not only lively and active, but they also related to the real environmental issues.

Although the data analysis from the instruments indicated highly positive attitudes in terms of students' interest and motivation toward chemistry, it would be difficult to attribute the development of students' interests and motivation completely to the new approach. The factors that affected on students' changing attitudes included the content of environmental topics, the new teaching method, the learning activities and the social impacts of environmental pollution as well. At the present time, Vietnam is facing many urgent environmental issues. Environmental pollution is often mentioned in newspapers, TV, and radio. Therefore, during the implementation of this teaching approach, television programs and information in newspapers about the environment may have affected students' attitudes. One of the objectives of this study was striving to stimulate students to study chemistry. There is the question whether the treatment was enough to maintain and develop students' interests and motivation, not only in this general chemistry course, but also in further chemistry courses. Although the data presented in Chapter 5 show clearly that the new approach interested and motivated the students, they might lose their interest and motivation in other chemistry courses if the courses are taught with the old curriculum and traditional style of teaching.

Students' responses also indicated an increased awareness of environmental issues through this approach because the program brought the authenticity of the real world, with its problems and issues into the classroom. In this program, students were guided to explore the societal and environmental issues involved in significant environmental pollution in contemporary Vietnam. Students were provided with the opportunity to investigate the erosion of carbonate stone by acid rain by watching slides of the corrosion of historic monuments in Vietnam. The visit to the Saigon River provided students with the opportunity to observe some

cases of water pollution in Ho Chi Minh City. Viewing videos provided an opportunity for students to understand the problems of pollution in the countries of Indochina. It is evident that the content and the learning activities of this suggested program guided students in their understanding of environmental issues. The result of the questionnaire on students' attitudes also showed that the item in which the strongest agreement occurred (with the response pattern of over 88% for A (Agree) and SA (Strongly agree) combined) was:

- Item 5: Chemistry is helpful in understanding today's world.

In the questionnaire on student feedback, the item for which students' responses were very homogeneous and positive was:

- Item 5: I'd like to learn more about environmental issues from radio, TV, newspapers and magazines.

These responses supported the hypothesis that the new approach enriched students' awareness of environmental issues, because the more students became aware of the environmental issues, the more they were interested in learning about and understanding those issues from newspapers, TV, and radio.

The finding that this program helped students to reinforce their understanding of concepts, and principles in chemistry could be explained by the fact that the program crossed several traditional chapter headings and unified the content of the general chemistry curriculum around the environmental issues. The chemical reactions of hydrogen sulfide, sulfur dioxide, Le Chatelier's principle, the acidic properties and solubility of gases in water, etc. were covered. The environmental issues in the program furthered students' ability to apply the concepts and principles learned in the classroom to actual life. In addition, the implementation of the new teaching method contributed well to students' understanding of chemistry knowledge.

Although the findings from the instruments showed positive results in terms of students' awareness of environmental issues and students' understanding of concepts and principles, these results were obtained only through students' self-evaluation. We have

not had any achievement tests to measure students' changing knowledge. However, in the final examinations that I constructed and administered to the students at the end of the teaching experiment, most of students performed well. The final examination took the form of essay questions. Students' answers to the questions showed that they gave good explanations of the causes and consequences of environmental pollution and skillfully applied the principles and processes of chemistry to explain technological methods of control for environmental problems. For my experience of teaching the general chemistry course for twelve years, I found that students' scientific arguments and their ability to express their ideas on the final exam were better than those of students in previous general chemistry classes. According to the Observation Checklists used to evaluate students' skills through group discussions, there was an increase of students' skills in each week of the teaching experiment. Especially, the score for item 6 (students relating discussion to the environmental problems in Vietnam) increased quickly in the last two weeks. In addition, during the new approach, four reports were assigned to the students and were marked (see learning activity design in Chapter 4). I found that there was an evident development of students' ability in writing and explaining environmental issues. So even though there were not any rigorous measurements of students' understanding of knowledge, the environmental approach at least partly affected students' awareness of the environment and their understanding of basic knowledge in chemistry.

The second objective was to investigate which teaching method could be used effectively to deliver environmental issues in the general chemistry course. The teaching method used in this approach was based upon the learning cycle Demonstration-Exploration-Discussion. The data from the interviews and essays on student views about the environmental approach reflected the effectiveness of this teaching method. The findings showed that the new style of teaching chemistry was different from other classes at the university. This new approach was distinctive in that it used more involving modes of teaching to encourage students to analyze and make hypotheses in the Demonstration step.

Not only was an experimental demonstration used, but also concrete models and examples were presented—for example, video, slides, and field trips to polluted places served as simple observations to develop students' process of fact finding in the Exploration step. This teaching model was positively valued by the students because it developed their cognitive skills and critical thinking ability. It helped students create and expand their own chemistry knowledge through dynamic and active learning. The data from the Observation Checklists indicated that the total scores for each student in the target group clearly increased from week 1 to week 4, and the scores for these items increased quickly in the last two weeks. This reflects that the new teaching model focusing on group discussion was useful to develop students' communication and team work skills, even though they had felt this would be difficult at the beginning of the teaching experiment.

The teaching method also was accepted by our colleagues. Although the method is still a new teaching style that may have not been used before in teaching chemistry in Vietnam, our colleagues appreciated this teaching model and stated that it could be suitable to deliver chemistry and environmental chemistry as well. It could be explained that the classroom environment fostered the active participation and creativity of the students. It is clear that demonstration was a key to explore chemical changes. The process of the learning cycle helped students to promote their understanding of abstract concepts in chemistry by direct experience and cooperative learning. A disadvantage in the implementation of the three steps in the learning cycle is that Vietnamese students have been familiar with passive learning, and had some difficulties taking part in group discussion. Therefore, the discussion step took more time than expected. The role of instructor as facilitator and guide would help the learning cycle proceed successfully. In the exploration step, students could repeat the demonstration to test their hypotheses.

The new teaching method is also limited by the fact that it can only be used effectively with small classes. It would be difficult to apply the learning cycle with big classes of more than 100 students. With a large class, it would be hard to organize group

works, demonstrations and discussions. Existing classroom and laboratory facilities would not allow some activities that are important to all three steps of the learning cycle.

The third objective of the study was to examine how the chosen environmental issues are suitable for the general chemistry curriculum in the Vietnamese context. The results from the self- evaluation of the environmental approach that were discussed in Chapter 4 showed that these environmental topics were closely related to the content of the current general chemistry course. They were selected and analyzed to a level appropriate with the students' understanding and current curriculum. The suggested environmental approach was consistent with the spirit of the recent education reforms in our country and it achieves the aims and objectives of our university chemistry curriculum. The resources required to implement these topics were readily available in the Vietnamese context. Finally the suggested approach fit reasonably into the time frame of the course. These results were strongly supported by the data from the instructor interview.

Although most instructors found the content of the environmental topics helpful because it provided students with the opportunity to understand the concepts and principles of chemistry, these topics did not include the entire curriculum content of the general chemistry course. In focusing on certain concepts and chemical reactions, the environmental topics did not cover all of the basic knowledge in the course.

Although the supplemental resources in this suggested approach were seen as meaningful, relevant materials and appropriate references on global environmental issues are lacking in Vietnamese universities, and specialized journals on the environment are rather difficult to find. This suggested approach used only the resources that could be collected in Vietnam, since papers from journals or textbooks in Western countries may be not available in Vietnam.

Although the suggested approach fit reasonably into the time frame of the course, the time required of students to work at home was unbalanced. Some learning activities required students to spend a great deal of time preparing at home. I felt that classroom time

and homework time should be more balanced.

The reliability of the instrument design is considered as follows:

In this study, the researcher was also the instructor who taught the suggested environmental approach, so the relationship between the researcher and the participants might have effects on students' response to the interview and their essays. In addition, the interview and essay data were coded by the researcher. Some bias could not be avoided.

The low alpha coefficients of the questionnaire on students' attitudes toward chemistry showed that some of the items may be criticized as not being representative of what was being tested, or may have ambiguous scoring procedures. The questionnaire on students' feedback about the new approach gave better indications for reliability.

Another risk in the internal validity of this study is the attrition of the sample size. This study received only 35 answer sheets to the questionnaire on the attitudes, 25 answer sheets to the questionnaire on student feedback and 30 essays from a total of 48 students in the sample, leaving a number of students who did not take the tests, or did not go to submit their essays. This may have had a limiting effect on the conclusions which can be drawn from the results. However, it may be pointed out that the conclusions are coordinated with the results of different instruments.

Recommendations

This study was implemented for a class in the Department of Chemistry at the School of Education in Ho Chi Minh City University. Because the students were majoring in chemistry, they might have had better backgrounds and more interest in Chemistry than non-chemistry majors who have to take the general chemistry course. Similarly, the subjects' orientation to teaching careers also made them more interested in the new teaching strategies which they would expect to implement in their future jobs. Therefore, further studies or implementations of the suggested program for other kinds of students should re-examine the results gained from this study.

The environmental approach suggested for the general chemistry course in this study may be seen as a sketch for two orientations in environmental education for university chemistry students in Vietnam:

(1) Environmental chemistry as a part of the general chemistry course.

The environmental topics should include not only Air Pollution, Water Pollution and Acid Deposition like those in this approach, but also Ozone Holes, Nuclear Energy, and Soil Ecosystems that would help students to gain understanding of further concepts in the general chemistry course such as bond energy, gas behavior, and reaction kinetics. The laboratory learning activity of "dissolved oxygen in water" could be replaced by analysis of phosphate in detergent, or analyzing sea water for its cation concentration. All of these experiments are appropriate to a general chemistry laboratory in our university context.

(2) Environmental chemistry as an elective course.

University chemistry in Vietnam could also include an environmental chemistry course for third or fourth-year chemistry students. It would be helpful to develop the approach described in this study in designing an environmental chemistry elective course or specialized credit course. The environmental topics, learning activities and teaching strategies designed in this study could be used and developed for the course.

Environmental topics for the course should cover chemistry of the atmospheric environment, chemistry of the aqueous environment, analytical environmental chemistry, carbon chemistry, nuclear radio-chemistry, nuclear energy, mineral resources and pollution. However, not all of these topics would be introduced every year. The selection could be based on students' interests, current new topics and contemporary problems.

In my experience, resource materials on environmental issues suitable for chemistry instructors can be found in recent editions of Vietnamese periodicals shown in Chapter 3. These references have useful data and suggest good homework problems. In addition, the resource materials on environmental issues that come from Western countries could provide updated resources. They could be found in:

- Journal of Chemical Education; Published by the Division of Chemical Education of the American chemical Society; Subscription and Book Order Department 1991.

- Journal of Environmental Education; published in association with the North American Association for Environmental Education; Heldref Publications, 4000 Albemarle St., N. W., Washington, D.C. 20016.

It was evident from this approach that field- trip learning interested students and helped them to study environmental chemistry by direct experience. In Ho Chi Minh City, the places which field trips could visit are the Saigon River, Dongnai River, Mekong Delta, Tanhoa Canal, Logom Canal, Nhieuloc Canal, Hatien Cement Manufacturer, Dongnai paper Manufacturer.

Further studies in designing general chemistry curriculum for Vietnamese universities should also exploit other approaches related to the STS theme and other teaching strategies that can get students actively involved in their learning process. This study could contribute as a pilot project for such broader studies.

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Appendices

Appendix A:

COURSE OUTLINES OF CHEM 317, CHEM 371, CHEM 372

(From Department of Chemistry, Simon Fraser University)

DEPARTMENT OF CHEMISTRY

DAY, SPRING 1996

**CHEM 317-2 Analytical Environmental
Chemistry**

**Instructor: Dr. L.K.Peterson
Office: C-8070**

General Course Description: (from calendar)

Principles and applications of the methodologies of analytical chemistry employed in the determination of substances in air, water, and soil, with particular emphasis upon sampling and sample preparation.

0 lecture hours/week; 0 tutorial hour/week; 4 lab hours

Prerequisite: CHEM 316 and 371. CHEM 372 should be taken concurrently.

Textbook: Willard, Merritt, Dean & Settle, "Instrumental Methods of Analysis".
7th Edition. 1988. Wadsworth. ISBN 0-534-08142-8. Required.

<u># of Lectures</u>	<u>Topic</u>	<u>Chapter</u>
	The Atmosphere: Origins and effects of undesirable components (particulates; "smog" gases; organic pollutants).	
	Aquatic Environments: Inorganic and organic components of freshwaters and marine waters.	
	Soil Environments: Origins and effects of undesirable inorganic and organic components.	
	Lab Assignments: A selection from the following list: Determination of atmospheric particulates; Determination of "smog" gases and other gaseous pollutants; Determination of inorganics and organics in soils; Determination of inorganics and organics in water samples.	
<u>Evaluation:</u>	Mid-term Exam	50%
	Final Exam	50%

DEPARTMENT OF CHEMISTRY

DAY, SPRING 1996

CHEM 371-3 Chemistry of the Aqueous Environment

**Instructor: Dr. S. K. Lower
Office: C-9016C**

General Course Description: (from calendar)

An introduction to chemical processes in the aqueous environment. Quantitative treatment of the variables determining the composition of natural systems. Chemistry of aqueous toxic agents, wastewater treatment, and related matters.

3 lecture hours/week; 1 tutorial hour/week; 0 lab hours

Prerequisite: CHEM 150 (or 251) and CHEM 261.

Textbook: Chemistry 371 Syllabus.

<u># of Lectures</u>	<u>Topic</u>	<u>Chapter</u>
4	Survey of Environmental Geochemistry	1-4
2	Thermodynamics Review	5-6
5	Acid-base chemistry of the aquatic environment	7-8
3	Solids, colloids and complexes	9-11
4	Redox chemistry of the aquatic environment	12
2	Interphase Transfer	13-14
2	Geochemical element cycles	15
4	Water supply, waste water treatment, water pollution	16-18
4	Toxic substances in environment, Industrial pollution	19-23

<u>Evaluation:</u>	Problem Assignments	20%
	Midterm Exam	20%
	Final Exam	40%
	Term Paper	20%

DEPARTMENT OF CHEMISTRY

DAY, FALL 1995

**CHEM 372-3 Chemistry of the
Atmospheric Environment**

**Instructor: Dr. T. N. Bell
Office: C-9043**

General Course Description: (from calendar)

Quantitative treatment of chemical and physical processes in the atmospheric environment. Chemistry of air pollution. Environmental radioactivity, its detection and effects. Specific case studies.

3 lecture hours/week; 1 tutorial hour/week; 0 lab hours

Prerequisite: CHEM 150 (or 251) and CHEM 261.

Textbook: Nigel J. Bunce, "Environmental Chemistry", Paperback. 4th Edition or latest edition. Wuerz Publishing Ltd. ISBN 0-920063-46-2. Recommended.

Topic

Review of the relevant principles of photochemistry and chemical kinetics.

Profile of the atmosphere: Regions and main differences resulting from composition, temperature pressure and radiation.

Atmospheric chemical composition: natural and man made sources. Properties of atmospheric constituents.

Measuring techniques in atmospheric chemistry/

Chemistry of the troposphere. Pollution, smog, acid rain.

The possible influences of atmospheric processes on climate change.

Chemistry of the stratosphere. The ozone problem.

Environmental radioactivity. Natural and man-made nuclides in the environment. Detection systems, effects of radiation and health physics.

Guest lectures on aspects of the atmosphere.

Class presentations on assigned topics.

<u>Evaluation:</u>	1 Midterm	20%
	1 Term Paper/Oral Presentation	20%
	Final Exam	60%

Appendix B:

Ho Chi Minh City University

GENERAL CHEMISTRY SYLLABUS

Department of Chemistry

6 Credits

(3 lecture hours / 1 tutorial hour)

Topics	Teaching hours
<p>1. The basic concepts and laws in chemistry.</p> <ul style="list-style-type: none"> • The concepts: <ul style="list-style-type: none"> - Atom, molecule. - Element, compound, mixture. - Atomic mass, molecular mass, mole. - The ideal gas, the Ideal Gas Law. • The laws of chemical combination: <ul style="list-style-type: none"> - The law of Conservation of Mass - The law of Constant Composition - The law of Multiple Proportions • Some chemical reactions: <ul style="list-style-type: none"> - Formation and Decomposition reaction. - Displacement reactions. - Combustion reactions. 	6
<p>2. Atomic structure</p> <ul style="list-style-type: none"> •The Quantum Theory and the Hydrogen atom. •-Electron atoms. •The Periodic Table. 	14

3. Structure of compounds <ul style="list-style-type: none">• The chemical bond• Chemical Bonding theory• Liquids, Solids, and Intermolecular forces	26
4. Thermochemistry <ul style="list-style-type: none">• Heats of reaction• Standard Enthalpy changes• Hess's law	10
5. Chemical kinetics <ul style="list-style-type: none">• Reaction rates and the factors that influence them• Rate laws• Reaction mechanisms	8
6. Chemical equilibrium <ul style="list-style-type: none">• Reaction quotients and equilibrium constants• Equilibrium involving solvents• Le Chatelier's principle	6
7. Solutions <ul style="list-style-type: none">• Gas solubility and pressure• Ideal solutions and real solutions• Colligative properties• Solubility and pH.	6
8. Acids and Bases <ul style="list-style-type: none">• Brønsted-Lowry acids and bases.• Acidic, basic and neutral solutions.• Acid-Base Equilibria in aqueous solution.	6

<p>9. Oxidation-Reduction reactions</p> <ul style="list-style-type: none">• Oxidation number.• Writing and balancing redox equations.• Galvanic cells.• Electrical work and free energy.• Standard electrode potentials.• EMF and concentration.	8
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Total : 90 lecture hours

Appendix C:

THE RESOURCES AVAILABLE IN VIETNAM FOR ENVIRONMENTAL TOPICS

(unpublished materials)

1. Vietnamese Environmental Board (1993). Standards on pollution control in Vietnam. Environmental quality standard division. Hanoi, Vietnam.
2. Ministry of Water Conservancy of Vietnam (1985). Water quality of Dong Nai river and coastal area. The Sub-Institute of Investigation and Planning for Hydraulic Work for South Vietnam. Ho Chi Minh City, Vietnam.
3. Mekong Secretariat (Nov. 1988). Water quality monitoring network in the Lower Mekong basin. Final report (1.3.04/83/SWE). Ho Chi Minh City, Vietnam.
4. Huynh, Ngoc Phien (July, 1990). Simulation of acid water in the Plain of Reeds. Mission report AIT.
5. Huynh, Ngoc Phien (1991). A statistical analysis of the water quality data in the Lower Mekong Basin. AIT.
6. Le, Xuan Quang (Oct, 1991). A first approach for a modeling acidic water propagation.
7. Ambassador City Jomtien, Chon Buri, Thailand (Dec, 1990). The greening of Thai industry: producing more and polluting less. Research report No.5 for the 1990 TDRI Year-End Conference.
8. Hungspreug, N. (1991). Strategy for water pollution control in the Lower Mekong Basin. Draft report, prepared for the Mekong Secretariat.
9. Tridech, S. & Tridech, P. (1992). Water quality of the Mekong river: Its use and sources of pollution. Prepared for the Mekong Secretariat by Dr. Saksit Tridech, water pollution specialist and Dr. Piyathida Tridech. Public health specialist.
10. Nguyen, Thanh Tin & Pham, Gia Hien (Dec, 1994). Report on water quality in 1994, Saigon environment plan. Ho Chi Minh City Water Quality Laboratory. Institute of Investigation and Planning for Hydraulic Work of the South Vietnam.

Appendix D:

Simon Fraser University
 Graduate Program Office
 Burnaby, B.C. V5A 1S6
 Canada

Ministry of Education and Training
 Ho Chi Minh City University of Education
 280 An Duong Vuong St.
 District 5, HCM City, Viet Nam
 Fax: 84-8-398946

ACKNOWLEDGMENT LETTER

August 26, 1995

According to the proposed research of Ms. Vo Thi Hong Tinh, we allow Ms. Tinh to teach a pilot course on Environmental Chemistry for the class HH during the period April 15, 1995 to May 30, 1995 (involved 24 periods). Ms. Tinh is also permitted to administer the tests on Attitude Toward Chemistry to the first year students at the Department of Chemistry.

Vice-Rector
 HCMCity University of Education 

BS. NGUYEN TONG KHAM

Appendix E:

OBSERVATION CHECKLIST FOR INSTRUCTOR

Criteria for each student in group discussion, focus on chosen group

Student code number:

Lesson no:

Rating scale:

- 1 Not at all
- 2 A little
- 3 Average
- 4 A lot
- 5 Very much

- | | | | | | |
|--|---|---|---|---|---|
| 1. Listens while others speak. | 1 | 2 | 3 | 4 | 5 |
| 2. Appears to be interested in and willing to hear others. | 1 | 2 | 3 | 4 | 5 |
| 3. Interjects ideas appropriately. | 1 | 2 | 3 | 4 | 5 |
| 4. Takes part in and contributes to discussion. | 1 | 2 | 3 | 4 | 5 |
| 5. Considers viewpoints of others. | 1 | 2 | 3 | 4 | 5 |
| 6. Relates discussion to the environmental problems
in Vietnam. | 1 | 2 | 3 | 4 | 5 |
| 7. Refers to but does not repeat the ideas of others. | 1 | 2 | 3 | 4 | 5 |
| 8. Speaks clearly; expresses ideas clearly. | 1 | 2 | 3 | 4 | 5 |

Appendix F:

STUDENT QUESTIONNAIRE ON
ATTITUDES TOWARD CHEMISTRY

To the student:

The results of this questionnaire will remain strictly confidential. Reporting will involve the total results only. No individual students, or instructor will be identified, or identifiable, in any of the written reports.

Age: Student code no:

(If you are in chosen group)

The following items relate to your thoughts and experiences in the chemistry course. Please choose the circle which is most representative of your attitudes toward the course.

	SA	A	U	D	SD
	Strongly Agree	Agree	Undecided	Disagree	Strong Disagree
Items					SD D U A SA
1. Chemistry is something that I enjoy very much.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2. I don't regret that I did choose chemistry.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3. The chemistry class is interesting.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4. Chemistry is useful for everyday life.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
5. Chemistry is helpful in understanding today's world	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
6. Chemistry plays significant part in our society's development.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
7. Most chemistry knowledge is relevant.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
8. There should be other study materials or sources available besides the lecture notes.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Appendix G

FEEDBACK QUESTIONNAIRE FROM STUDENTS

Age:

Student code no:

(If you are in chosen group)

The following items relate to what you have learned through a new style of teaching in this course. The answers are arranged or graded on the following rating scale:

1	2	3	4	5
not at all	a little	average	a lot	very much

Please circle the number for each item which is most representative of your ideas.

Items

After finishing the classes:

- | | | | | | |
|---|---|---|---|---|---|
| 1. My perception of global environmental problems has improved. | 1 | 2 | 3 | 4 | 5 |
| 2. I want to devote myself to activities promoting environmental conservation. | 1 | 2 | 3 | 4 | 5 |
| 3. Environmental topics help me understand the application of chemistry in daily life. | 1 | 2 | 3 | 4 | 5 |
| 4. I am interested in the campaign for environmental conservation in our city. | 1 | 2 | 3 | 4 | 5 |
| 5. I'd like to learn more about environmental issues from radio, T.V., newspapers and magazines. | 1 | 2 | 3 | 4 | 5 |
| 6. Studying environmental topics stimulates me and furthers my interest in chemistry. | 1 | 2 | 3 | 4 | 5 |
| 7. Studying environmental topics helps to promote my understanding of the basic concepts, principles and the processes of chemical science. | 1 | 2 | 3 | 4 | 5 |

Appendix H:**INTERVIEW QUESTIONS**

The questions asked of **the students** were:

1. How do you feel about the new teaching and learning approach?
2. What are your perceptions of the environmental approach to chemistry class?
3. Are resources adequate?
4. Were there any differences between this class and others you have attended?
5. Did the environmental approach affect your learning process in this course? What had the most influence?
6. Do you think that the environmental approach required you to spend too much time studying? Is there too much work to do? Is it boring? Please explain.
7. How useful was the environmental approach?

Appendix I:

INTERVIEW QUESTIONS

The questions asked of the **instructors** were:

1. How long have you been teaching?
2. Have you ever presented any environmental issues to your students in chemistry class?
3. What do you think about the suggested environmental approach to chemistry class?

Probe:

- Are there many environmental problems related to Vietnamese society nowadays?
 - Do you think environmental issues should be presented to students at the general higher education level in our university?
4. What is the importance of the environmental approach in the general chemistry class?
 5. Which knowledge of environmental issues, if any, should be integrated into the general chemistry curriculum?
 6. How should this knowledge be introduced?

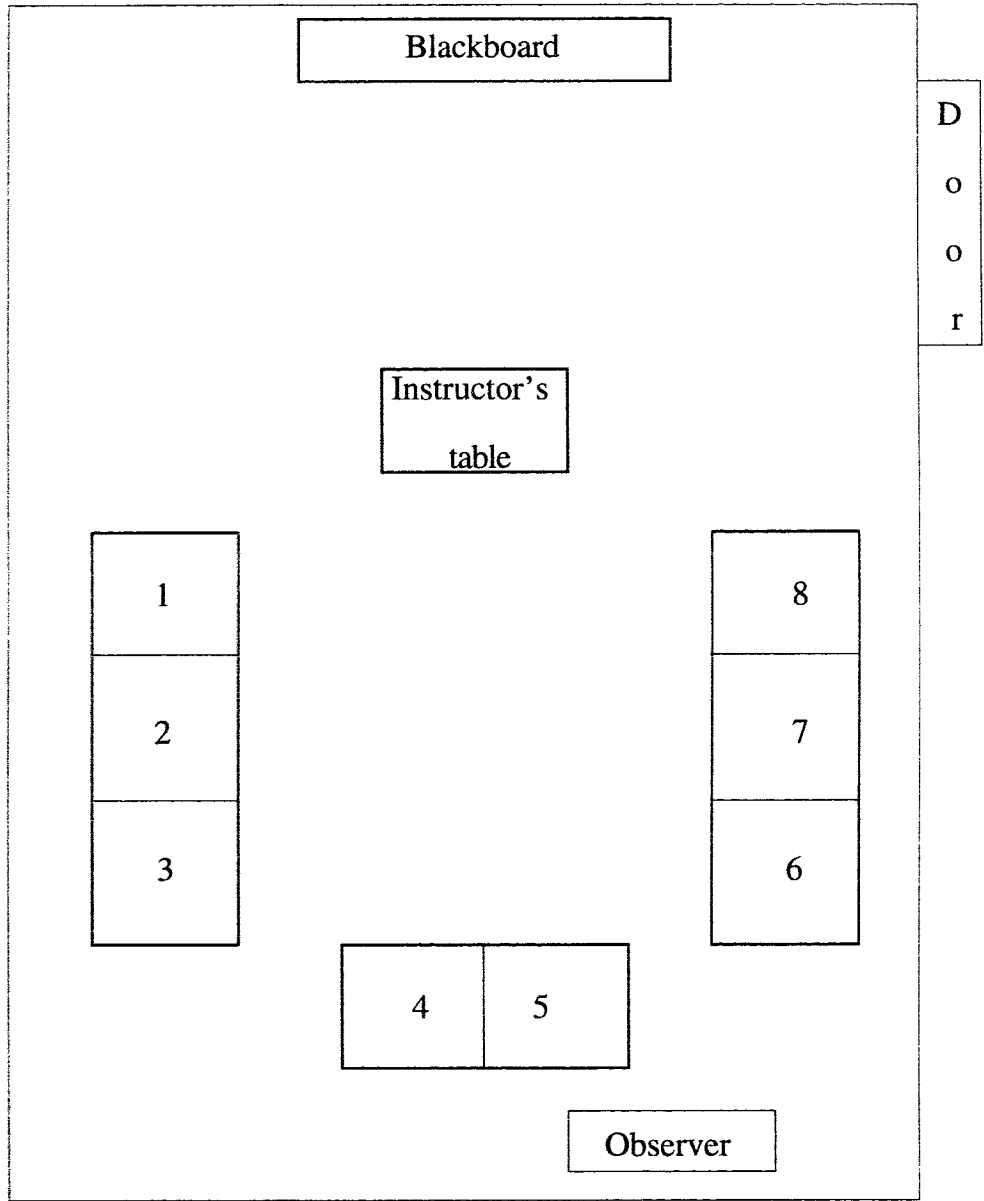
Probe:

- In what part of the curriculum?
 - How much time to be spent on it?
7. Is this approach consistent with the spirit of the recent education reform in our country; and does it achieve the aims and objectives of the university chemistry curriculum determined by the Ministry of Education and Training?
 8. What is your opinion of the benefits our students may have from this approach?
 9. In your opinion, how and to what extent does the environmental approach in the general chemistry curriculum affect the students' learning process?
 10. Are the resources and data about Viet Nam which can be found in Ho Chi Minh City sufficient for teaching and learning environmental issues? What are the difficulties and how could solved they be?

11. What are your opinions of the teaching strategies that I used in the environmental approach for teaching chemistry?

Appendix J:

THE MAP OF THE CLASS



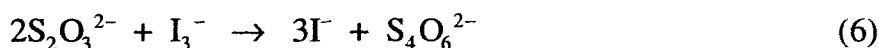
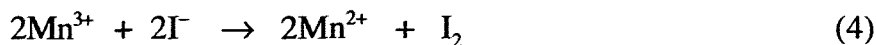
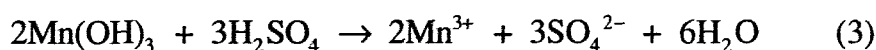
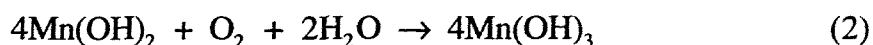
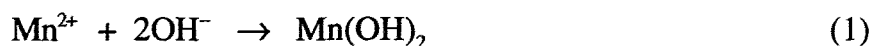
Appendix K:

EXPERIMENT: DISSOLVED OXYGEN IN WATER

This experiment is taken from Stagg (1972) and Crosson & Gibb (1992)

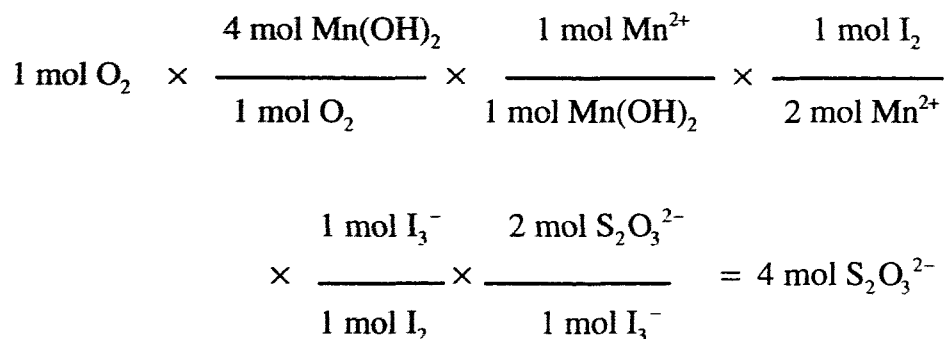
Introduction: Determining dissolved oxygen (Crosson & Gibb, 1992)

DO in a water sample is determined by a sequence of reactions. In alkaline solution, manganese (II) hydroxide is precipitated (eq1) and oxidized (eq2) by the dissolved O₂ to Mn(OH)₃. This is converted by the addition of sulfuric acid (eq3) to manganese (III) (as sulfate), which immediately oxidizes (eq4) iodide ion (previously added as KI) to iodine. The liberated I₂ in the form (eq5) of soluble I₃⁻ is determined by titration with sodium thiosulfate solution of known concentration, using starch indicator (eq6).



Starch reacts with the iodine to produce an intensely blue complex. Upon reduction of iodine to iodide, the blue disappears, indicating the endpoint.

The amount of DO in the water sample is reported in parts per million (ppm). As the balanced equations show, for each mole of oxygen in the sample, 4 mol Na₂S₂O₃ is required.



The 1976 EPA Quality Criteria for Water recommends a minimum concentration for DO of 5,0 mg/L (which is 5 ppm when the density of sample is 1g/mL) to maintain good fish population. DO values decrease with rising temperature. They also depend on the atmospheric pressure and the chemical content and depth of the water. At constant temperature, the DO decreases as the chloride ion concentration increases.

Purpose: to determine dissolved oxygen in water.

Materials:

Apparatus	Reagents
- Graduated cylinder	- Manganese sulfate 2,15M
- Conical flask	- Concentrated sulfuric acid
- Small Beral pipette	- Alkali solution containing: 500 NaOH/L,
- Burette	135mg NaI/L, 10mg NaN ₃ /L
	- Starch indicator solution
	- Sodium thiosulfate 0.025M, standardized (the thiosulfate may be standardized by the usual method)

Procedures:

The analysis is carried out as follows. After collecting the sample add 2 ml of manganese sulfate and 2 ml of alkali solution, in that order, and stopper the bottle. Since both the manganese sulfate and alkali solutions are more dense than the water sample they will sink, displacing some of the sample into the cup at the top of the bottle. This portion of

the sample (4ml) will be lost when the stopper is replaced. Mix thoroughly by inverting. In the laboratory add 2 ml of concentrated sulfuric acid, stopper, and mix. Measure out 203 ml of the solution with a graduated cylinder into a conical flask and titrate with standard thiosulfate to a pale straw color. Add 3 ml of starch indicator solution and continue titrating until the blue color disappears.

Calculation of the equivalent of dissolved oxygen in the aliquot is straight forward, however correction must be made for the amount of original sample displaced by the manganese and alkali solutions. The usual BOD bottle has a capacity of 300 ml. Thus the amount of sample taken for analysis is $203 \times (300 - 4) / 300 = 200$ ml of original sample.

Dissolved oxygen is usually reported as milligrams oxygen/L Report the DO in the sample.

Appendix L:

Experiment: Dissolved oxygen in water

Name:

REPORT SHEET

Date:

Group:

Data and observations:

Sample #:

	Trial 1	Trial 2	Trial 3
Temperature			
Volume of water sample used (ml)			
Initial reading of $\text{Na}_2\text{S}_2\text{O}_3$			
Final reading of $\text{Na}_2\text{S}_2\text{O}_3$ (ml)			
Volume of $\text{Na}_2\text{S}_2\text{O}_3$ used (ml)			

Results:Moles $\text{Na}_2\text{S}_2\text{O}_3$:

DO (mg/L) :

Questions and calculations:

- (1) Write the net ionic equation for the reaction that occurred.
- (2) Calculate the concentration of O_2 in the water sample in parts per million (ppm) (the number of milligram of O_2 per litre).

Conclusions:

- (1) What should the oxygen concentration in the sample be?
- (2) Comparing the DO and BOD of the water sample to their measurements of reference solution from city data (data from Ho Chi Minh City Water Quality Laboratory) , make a preliminary evaluation of water quality in the Saigon River.

Appendix M: DISTRIBUTION OF STUDENTS' IDEAS ABOUT THE ENVIRONMENTAL APPROACH

	Themes	Factors	Number of students' ideas	Percentage
T1	Students' attitudes toward the program.	<ol style="list-style-type: none"> 1. Students enjoyed the environmental approach. 2. The program increased students' interests and motivation in chemistry. 3. The environmental approach removed some boring elements of general chemistry. <ul style="list-style-type: none"> - the new class is enjoyable, comfortable, and engaging. - The class is not rigid with dry lectures. 4. Students regretted finishing the program. 5. Students felt a honor to be exposed to the program. 	<p>26</p> <p>21</p> <p>19</p> <p>13</p> <p>2</p>	<p>87</p> <p>70</p> <p>63</p> <p>43</p> <p>7</p>
T2	Students' awareness of the environment.	<ol style="list-style-type: none"> 1. Students understood environmental issues and the relationship between chemistry and everyday life. 2. Students could explain the causes and consequences of environmental pollution. 3. Students felt a sense of responsibility towards environmental conservation. 	<p>23</p> <p>7</p> <p>6</p>	<p>77</p> <p>23</p> <p>20</p>
T3	Students' understanding of chemistry knowledge.	<ol style="list-style-type: none"> 1. The program helped students to reinforce their understanding of concepts, principles in chemistry. 2. Students felt the program did not promote such understanding. 	<p>21</p> <p>1</p>	<p>70</p> <p>3</p>

T4	Students' perception of learning activities.	<ol style="list-style-type: none"> 1. Video helped to realize the relationship between chemistry and the real environmental problems. 2. Demonstration activities related well with the contemporary problems. 	15	50
T5	Students' views of the teaching strategies.	<ol style="list-style-type: none"> 1. Demonstration: <ul style="list-style-type: none"> - helped to understand and memorize the chemical concepts and principles. - helped students to learn chemistry by direct experience. - increased students' interests in chemistry lessons. - students wish for demonstrations in other chemistry courses. 2. Discussion: <ul style="list-style-type: none"> - helped to understand concepts and principles in chemistry. - provided students with the opportunity to express their own ideas. - replaced formal lectures with a more active and dynamic classroom environment. - helped students to share their ideas. 3. Not too much note-taking style in the new class. 4. The new style of teaching was helpful: <ul style="list-style-type: none"> - it developed students' cognitive skills and critical thinking abilities. - it provided understanding that they felt would be useful in their future career. - students wish other chemistry courses would be taught in the same way like this style. 5. Students' suggestions about the new teaching method. 	20 9 4 6 1 22 12 3 5 2 13 22 9 6 7 17	67 30 13 20 3 73 40 10 17 7 43 73 30 20 23 57

		<ul style="list-style-type: none"> - There should be more correct solutions to assigned problem sets. - The instructor should give more help on group's discussion. - Some learning activities were not well planned. 	5	17
T6	Resource validity	<ol style="list-style-type: none"> 1. Supplemental resources were helpful, relevant and interesting. 2. The strongest feature of this approach was supplemental resources. 	18 8	60 27
T7	Other students' comments	<ol style="list-style-type: none"> 1. It is difficult to study in this approach. 2. This approach required to spend more time studying that this was quite useful. 3. There was far too much work to do. 	5 14 2	17 47 7

Appendix N:

LETTER OF RECOMMENDATIONS

HO CHI MINH CITY UNIVERSITY
POLYTECHNIC INSTITUTE268 Ly Thuong Kiet Steet
District 10, Ho Chi Minh City

August 26, 1995

Ms. Vo Thi Hong Tinh
Instructor
Department of Chemistry
Ho Chi Minh City University of Education**Re: Some remarks on the suggested environmental approach to the
general chemistry course.**

Dear Ms. Tinh,

I basically agree and support for the idea of introducing environmental issues into the general chemistry curriculum for students at the general higher education phase for the following reasons:

- It is consistent with the aims and objectives of the general chemistry curriculum at this stage in world development and in Vietnam.
- The content and the suggested method of teaching as presented in the environmental approach are logical and complementary to each other, which ensure the success for the intended aims and objectives.
- This environmental approach is completely applicable under the existing condition of expenditure, equipment for teaching and experiments in Vietnamese colleges and universities.
- The suggested method of teaching is very lively, creative and up-to-date. It will surely motivate students since it links their study at school with real life, improves their study, and imbues them with a sense of responsibility for the present society as well as for its future.

In addition, I wish to suggest some more ideas as follows:

- About the content: it is necessary to introduce the issue of pollution in the earth's crust into the program because extensive deforestation, mineral resource exploitation, dumping of sewage disposal from factories. etc. are contributing to the loss of ecological equilibrium and to global contamination.
- In terms of the method of teaching, there should be more activities, like field trips to seriously contaminated areas, to further subsequent discussions and lively reports and at the same time, to create a deep impression on the students.
- About the experiments: the sea water analysis should be replaced with other sources of contaminated water in order to help students learn more from real life.

- With reference to time allotment the program should take up about 8 - 10 % of the general chemistry curriculum, and should be introduced at the beginning (or at least before the end) of the course so that there will be enough time for students to go on a field trip, and references collect before writing their reports or participating in discussions.

I hope this suggested environmental approach will soon be widely accepted and implemented in the universities of Vietnam.

Yours very truly,

Dr. Nguyen Dinh Soa
Associate Professor
Head of the Inorganic Chemistry Department
Polytechnic Institute, Ho Chi Minh City University