CHEMICAL EDUCATION: LOOKING AHEAD

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I was given the task of speculating about what lies ahead in chemical education. During the course of preparing this talk I found my assignment to be much more difficult than I had expected--this in itself was a sobering realization which told me a great deal about how cautious I must be about making predictions.

I examined the current state of chemical education and also reviewed what has happened in the past 25 years. I am pleased with most of what has happened in chemical education and I am eager to hear what Elaine Ledbetter, Bill Kieffer, Tom Lippincott, and others have to say about our successes and failures. To me, having a clear understanding of the present and the past is a most important factor in bringing about changes and improvement. The other important factors include: making intelligent choices, having or creating the necessary resources, and developing strong determination to pursue our goals.

Ian Ross, the president of Bell Laboratories, spoke at the 1982 annual meeting of the American Association for the Advancement of Science and said, "These are exciting and challenging times for science and technology. Our society is poised, we are told, at the threshold of the Information Age, a time when the promise of technology has never been greater for raising productivity, improving the standard of living, and changing for the better the quality of life itself. American science and technology has led the way toward fulfillment of that promise. Now this preeminence is threatened by forces that may affect technological progress throughout the world. It is up to those of us in science, industry, and government to strengthen the institutions that have made us the leaders and restore our initiative".

I am personally convinced that we must make individual commitments to promote science and science education. We also need institutional commitments from different segments of our society to revitalize science education at all levels. Our ingenuity and wisdom will be seriously tested as we take on the challenges of the eighties.

According to legend, Destiny came down to a remote South Sea island one day in a cloud of doom and warned the inhabitants that a great tidal wave was coming. Then, as a test of the natives' ingenuity, Destiny asked three representative leaders what each would do about the inevitable inundation. The first respondent was a hedonist. He answered that he would gather together his fun-loving friends and have one last party to enjoy as much wine, women, and song as possible before dawn, when the great wave would end their pleasure forever. The second was a mystic. He said that he would seek out the most pious people he could find and make a pilgrimage to the sacred groves to pray for deliverance. The third respondent was a sage. She stoically explained that she would search the island over for the wisest men and women she could find, and together they would sit down and discover how to live underwater.

We in this society face tidal forces which could inundate us too. As in the case of Destiny's South Sea visitation, sages are once again required. In this instance, we need wisdom in addressing our political and socio-economic problems. And, we, as chemical educators, need self-renewal and determination in preparing our students to deal with perplexing issues such as energy conservation, the use of pesticides, nuclear fallout, food additives, and the effects of chemicals on health, particularly the effects of alcohol, tobacco, marijuana, and cocaine. Also, we need to train competent researchers and technologists to maintain our scientific pre-eminence and to expand our technological advances. New research and technological innovations will bring negative impacts, no matter how positive their overall consequences might be. The negative impacts may result from threats to our moral and ethical beliefs, from decisions to commit resources to substitute machines for teachers, or from bureaucratic incompetence.

We, as chemical educators, must be adaptable in pursuing our goals, but we should not compromise our purposes or the means of reaching them.

We must reassert the primacy of rational endeavor in the struggle to save and renew our commitment to teaching chemistry as a laboratory science. The pressure to eliminate laboratory experience for students at the precollege levels and at the introductory college level must be dealt with by convincing our colleagues and our administrators of the educational values of a meaningful laboratory experience. We must be convinced ourselves of these values; otherwise, how can we convince others?

The trend to eliminate laboratory work is based on economic reasons rather than pedagogic ones. We all know that the cost of chemicals and equipment as well as the availability of qualified instructors are very significant factors. That is why we should be deliberate and courageous. As we attempt to adjust and adapt, we must not compromise the integrity of our academic offerings. Several suggestions have been made to use computer and videodisc delivery systems as substitutes for laboratory work. I believe we should carefully examine these suggestions to determine their pedagogical value and not be simply lured by their novelty or by cost-savings which they may possibly provide. Fundamentally, my conviction about laboratory work is best stated in the words of the great master Leonardo, "There is no higher or lower knowledge, but one only flowing out of experimentation".

I am often characterized as being an incurable optimist despite the fact that I see the world we live in to be mostly irrational, cruel, beleaguered economically, unstable politically, and full of anxiety. In this society, we often seem to be reckless, lacking purpose, wanting instant gratification and not very clear about our values. The syndrome of "looking out for number 1" is widespread and condoned. We live in a time when the characteristic values of our Western heritage are no longer adhered to or professed. Our behavior domestically and internationally is not always consistent with the fundamental premises upon which this nation was founded.

Can all this be the result of our educational system? How can we, as educated men and women, tolerate such societal deterioration? How can we, as educators, tolerate being a part of an educational system which does not appear to have clearly stated purposes?

Should we not step forward and state our individual purposes for teaching and more specifically for teaching chemistry? Should we not tell our students, at least, why we teach chemistry?

Should we not be aware of how our behavior both in the classroom and outside the classroom influences attitudes? Should we not tell the general public what the purposes of education are and why they should be supported?

Should we not educate our students and the public at large about chemicals, their properties, their usefulness, their benefits, and their potential hazards? Should we not be patient, intelligent, deliberate and vigorous in the pursuit of greater understanding of our chemical world?

The answer to most of these questions is: Yes! My answer is yes. What is yours?

The enormous ramifications of using chemicals to cope with energy, food, and industrial demands must be dealt with on sound scientific basis as well as ethical and moral grounds. Our tasks as chemists and chemical educators extend beyond research and transmitting knowledge. We should strive not only to train competent scientists and engineers, but also to inform and educate the general public in the best possible ways we know. Problems of population, food, fuel, pollution, etc. can be solved if we prepare our students and the public-at-large to live in a world full of chemicals whose properties and effects are understood. Our major concerns must include not only survival but the quality of life. As educators we must teach our students and the general public the difference between chemistry and chemical technology and emphasize that both can lead either to improving the quality of life or destroying it.

The burden of what I have enumerated so far is enormous, and I will not be surprised if some of us begin to experience moments of self-doubt and feelings of withdrawal as we think about the awesome responsibilities we have. My friends, the health and vitality of chemical education and the quality of life in our educational institutions, and eventually in society at large, is in our hands. Let us not surrender our mission of influencing attitudes and changing behavior. If we are not competent and sincere in renewing and pursuing our mission, we will cease to be educators.

Someone said that chemistry is man's quest to discover that the world makes sense. Chemistry <u>can</u> be fun when we deal with it phenomenologically. The thrill of discovery, the satisfaction of coming up with a coherent explanation, and the joy of learning are <u>results</u> of intense, hard, and often frustrating work. Our inquiries start at a very young age. Children ask questions, simple and simplistic questions. Why is the sky blue? Why is snow white? Why do soap bubbles float? Why do the leaves change color? Why does the firefly glow? What are explosions? Questions, questions, questions. But questioning is not enough. Children are often crushed by parents and teachers who ignore the question and seldom provide an answer.

The quest for an explanation causes us to develop an hypothesis that answers the question--but what do we do next? We do an experiment to test the hypothesis, and others do the same experiment and arrive at the same result. That is what science is, and that is how it differs from philosophy or theology since the philosopher or the theologian can hypothesize but cannot do experiments.

The fascination of students of all ages with phenomena is what we should capitalize on. Listen to the comments of fourth and fifth graders who came to a presentation given last June by my colleague Glen Dirreen as part of the University of Wisconsin College For Kids program.

"Last week my favorite thing was the chemistry exhibit. At the exhibit, he tickled a powder with a feather and it exploded. He also poured two mixtures into a container and it glowed in the dark. I liked it very much. That was neat".

"On the first week of "College For Kids", we took tours. My favorite one was chemistry. We saw balloons that gave off fireballs when ignited. We also saw liquid nitrogen that turned so cold it shattered when bounced."

"My favorite thing was the chemistry demonstration. It was exciting to see him make things turn colors and blow up. I will always remember it. It was exciting!"

Listen to the questions of 8th graders who wrote me last spring after participating in the program I call "Chemistry Can Be Fun" which I have put together for junior high school students in the Madison area:

"Why did the yellow balloon explode louder than the blue balloon?" "Why does a mixture of oxygen and hydrogen gases explode more loudly than just hydrogen?"

"Why did the colors of the liquid in the beaker keep changing from orange to blue, to colorless?"

"How long will the light stick keep glowing?"

"How do you turn it off?"

Should we not encourage these youngsters to pursue careers in science and technology? Should we not, at the very least, expose them to the process of science?

In less than a year the Chicago Museum of Science and Industry will open a permanent exhibit on "Everyday Chemistry". One of the features of the exhibit will be a dozen chemical reactions and demonstrations, controlled by microprocessors, but set in operation by the visitors. In developing these demonstrations, my associate Rodney Schreiner and I have aimed at enabling the visitors to see color changes and chemiluminescence, identify organic compounds by smell, and feel the heat released from reactions. About 4 million people visit this museum every year. If only 1% of this total visit the chemistry exhibit, then 40,000 people will get a brief exposure to chemistry. That is more people than any of us will have in our classes in a lifetime!

Shouldn't those of you who live near museums try to contact the museum personnel and offer to help in setting up chemistry exhibits?

One of the biggest tidal forces we face now is a shortage of qualified teachers of chemistry at the pre-college levels. A recent study at the University of North Carolina revealed that every year incoming teachers are less academically able than their predecessors while the most able teachers strike out in search of better jobs. Nearly 70% of high school and elementary school teachers who expected to be teaching at age 30 scored below the mean verbal SAT score of their peers who did not go into teaching. This is attributed to the inability of the teaching profession to compete with other white-collar professions. Low salary and low prestige contribute to the problem. The more able teachers leave the profession for higher paying and more prestigious jobs. Those who remain tend to become stale and lose interest in the subject matter they teach. In science education, the problem has reached the crisis stage. Chemistry and mathematics teachers are in short supply in most states. Fewer graduates are going into teaching science and mathematics. School systems are busy reassigning biology and earth science teachers who have some background in chemistry to teach chemistry. Many of these teachers have not been in a chemistry classroom in 5, 10 or 20 years. One teacher from Ohio who came to me for help has not had chemistry in 24 years! These are well-meaning teachers. They will do the best they can, but will that be good enough?

The efforts of the American Chemical Society and its different organs in attempting to reach both the pre-college teacher and the pre-college student are laudable. The Division of Chemical Education, the Society Committee on Education, and the Education Division work diligently and in harmony to promote teacher renewal activities and develop curricular material. These efforts include: the secondary school section in the Journal of Chemical Education, the publication Chemunity which is available free to interested high school teachers, the proposed replacement for SciQuest which is currently being put together so that it will be placed in the hands of students as soon as possible, the material in the "Combating the Hydra" packet, the Expert Demonstrator Training Activity, the high school chemistry programming at national and regional meetings, the new interdisciplinary science course for 10th grade students, "Chemistry in the Community" which is now being developed under the direction of Tom Lippincott and is supported by staff from Sylvia Ware's office in Washington, the proposals of the Task Force of Fostering High School Student Achievement, and many more.

How many of you pre-college teachers are actively participating in any of these activities? If you are not, why aren't you? Do you not judge them to be worthwhile? Perhaps you are working on something worthwhile and I simply don't know about it.

Other organizations such as the National Science Teachers Association and the American Association for the Advancement of Science are equally alarmed about the precollege science education tidal wave. The AAAS Board of Directors recently adopted a resolution urging, "that all public and private schools in the United States provide, within a balanced curriculum, a strong and uninterrupted program of science education which shall include regular instruction in science for all pupils from kindergarten through twelfth grade."

The resolutions of the 6th IUPAC Conference on Chemical Education also address similar concerns, and later on this week we will hear about them from Marge Gardner and others.

In late 1981, the Commission on Human Resources of the National Research Council issued a report entitled "Science for Nonspecialists: The College Years". In transmitting this report to the National Science Foundation, the executive director of the Commission on Human Resources wrote, "This report concerns a vital area of education in U.S. colleges which has not received the emphasis it deserves. Although curriculum committees have long worried about appropriate breadth and balance in the humanities and social sciences for those studying science or engineering, little attention has been paid to the converse case. All too frequently, graduates in the non-science areas leading to professional work in law, business, journalism, and so on have had little or no contact with science. We believe this is a serious problem that deserves early and continued attention by U.S. educators and those who support their efforts."

The study which led to the report showed that:

* The historical evolution of college science education has benefitted the science major immensely but has left the non-specialist largely unattended.
* Colleges and universities in general have lowered their science requirements over recent years to the alarming point where the average non-specialist student devotes only about 7 percent (135 contact hours) of a college course load to work in the sciences.
* Within such subminimal requirements, these students are often allowed to choose willy-nilly from an ever growing cafeteria offering "topics courses" that rarely fit into a well-conceived, comprehensive pattern of education.
* In many cases, those topics courses, which were designed as a response to the student concern for relevancy in the 1960's, have outgrown their relevancy.

* In all too many other cases, those topics courses, as they reach for relevancy, fail to provide students with an understanding of the basic principles of science.
* When students do opt for more traditional introductory science courses, learning often suffers because so many students come to college ill-prepared in secondary-school science and mathematics.
* These students often are subjected to inadequate teaching that stresses dull lecturing more often than exciting laboratory experiments and demonstrations.

The concern, the report goes to say, rests upon three major contentions: First, enlightened non-specialists are essential to help implement the pluralistic function of democratic decision making about pressing matters of science and technology. Second, knowledgeable non-specialists must serve as opinion leaders in the American political structure to help the public at large understand the complexities as well as the risks and benefits of science and technology. Third, well-prepared non-science specialists can lead the way in their professions more effectively if they have a command of science and technology.

The Report calls for colleges and universities to ensure that undergraduate education for non-specialists is an "enabling" process embracing the following goals:

* College science education should enable non-specialists to overcome fears that might prevent them from launching a lifetime learning experience about science and technology.
* College science education should enable non-specialists to develop their capacity to engage in critical thinking.
* College science education should enable non-specialists to gain the scientific and technical knowledge needed in their professions.
* College science education should enable non-specialists to gain the scientific and technical knowledge needed to fulfill civic responsibilities in an increasingly technological society.

Are those of us at colleges and universities willing to pursue these noble goals? Are we as individuals willing to take action or are we going to let someone else worry about them?

And what about the undergraduate education of chemistry majors? Four years ago at the 5th biennial conference on chemical education we heard that too much of the chemist's education concentrates on things of interest to Ph.D.s and that perhaps the teaching of undergraduate chemistry should be placed in the broader context of engineering, business, and economics, especially since most of the chemistry graduates go to industry rather than graduate school. We were urged to have our students be able to communicate well, to be safety conscious, and to have a positive attitude toward continuing education. We were told that poor communication skills limit the effectiveness of many new employees. We were urged to encourage our students to take courses in technical journalism rather than rely on the typical courses in literature or creative writing.

To what extent are we now implementing these suggestions? How important are these recommendations now?

As an incurable optimist I wish to share with you some additional concerns about the immediate future of chemical education.

Ten years ago at the Second Biennial Conference on Chemical Education I was among the youngest participants. Tonight, as I scan the over 500 participants in this Conference, I find myself still among the youngest group. Why aren't there more chemical educators in the 25-40 age group? In the interest of time, I shall list these concerns and ask that you think about them with the hope that you will eventually act on some, if not all of them.

I believe that we, as chemical educators, have a moral responsibility and a professional obligation to:

1. improve the communication skills of our students. Thus, the skill to listen, the skill to communicate orally, and the skill to write must receive our attention in the context of teaching chemistry. I urge that we collaborate with our composition and English department colleagues in reinforcing the significance of clearly conveying observations and descriptions of chemical systems.

2. increase the number of qualified women in all areas of chemistry. We should provide good role models for our students.
3. expand our efforts to reach minority students and encourage them to pursue scientific careers as well as become qualified teachers of chemistry. I believe we should support special tutorial programs in chemistry for minority students at the pre-college and at the college levels. In this regard, should we not begin serious efforts to provide chemistry instruction in Spanish to the ever increasing number of youngsters in this country who, in theory, are being raised as bilingual, but in practice speak Spanish better than they speak English.
4. enable physically handicapped students to have the same opportunities as other students to learn science and to pursue careers in science.
5. educate foreign students in the chemical sciences and encourage their return to their home lands. The current practice in some graduate departments of relying heavily on foreign students as teaching assistants should be carefully evaluated. Perhaps the structure of supporting graduate research should be re-examined.
6. include in our pre-college and introductory college courses the topics of polymers and nuclear chemistry.
7. insist on having our students develop and use reasoning skills as they learn chemistry and as they apply quantitative thinking in their daily lives. In this connection, I hasten to point out the contributions of Dudley

Herron. The significance of what he has helped us learn about critical thinking will affect how we teach.

We have many other moral responsibilities, and I am in no way suggesting that we ignore any of them.

I would be amiss in my task tonight if I did not comment about the use of educational technology in chemistry. Clearly, the use of computers in chemical education is no longer just a fad. Significant contributions continue to be made by an increasing number of chemistry teachers. The low cost of computing has provided access virtually to any precollege student. In many cases, students are teaching their chemistry instructors about computers. And in some cases, teachers feel threatened and worry about being replaced by a computer. This fear is not unfounded. Recently, one of the vice presidents of Control Data Corporation tried to explain to me how their new PLATO college program for engineering students would save instructor salary costs and laboratory costs in chemistry and physics. I was appalled that he was suggesting the complete replacement of instructors by a computer, and I told him so. I told him a few other things too!

The state of the art in computer technology is such that it enables us to be creative and most effective in using computers as <u>aids</u> rather than <u>substitutes</u> for the teacher. Stan Smith, John Moore, and so many others in attendance at this Conference continue to show us how this can be done. I am <u>convinced</u> that computers will be most successful as teaching aids if they are used for simulating the behavior of chemical systems and for interfacing with instruments. Fundamentally, my conviction stems from the belief that components of educational technology should be enslaved as teaching aids to do what cannot be done otherwise.

A most exciting technological innovation which will undoubtedly be exploited by chemical educators is the interactive videodisc. The successful coupling of the computer to the laser-vision disc enables us to personalize learning by simply having the student touch a pressure-sensitive screen and avoid using the computer keyboard which some people find intimidating. We should exploit the capabilities of this innovation as a teaching aid--we should resist using it as a toy or a gimmick.

Lately, we have witnessed the wide appeal of arcade video games among youngsters and adults alike. Unfortunately, these games emphasize destruction, war, and empty triumph. The addiction to Pac-Man, Asteroids and other games is not healthy. The potential loss of individuality from constantly playing such games is deplorable. Yet, people find them fascinating and that is what we as chemical educators should capitalize on. We should exploit this attraction that people have to videogames and develop our own chemistry games for teaching purposes. This is an area which warrants our attention. Playing and programming computer games in chemistry will sharpen the thought processes and develop critical thinking among students.

Another aspect of educational technology which is bound to have an impact on chemical education is cable television. We must explore the capabilities of cable TV as a delivery system of instructional material to schools and to individual homes.

Chemistry programs similar to the old Mr. Wizard series should be produced and made available to viewers of all ages. The state of the art in television production is sufficiently advanced and relatively inexpensive to enable us to display chemical phenomena and reveal intricate details about chemical systems undergoing change. We are yet to exploit the slow motion capability and the playback capability in observing, for example, fast reactions.

In using technology in education we should be always mindful of its potential dehumanizing effect. My idea of individualizing instruction is not to isolate the student in a carrel equipped with a TV screen, a computer, an audiocassette player, and several workbooks. Students learn with the help of inanimate resources, but they learn well from each other and with each other. Students should always interact with a human teacher.

I am disturbed that in using computers we tend to be poor communicators. When we describe or refer to instructions from a computer we say, "it tells you to do this, or it asks you to do that! and we have to tell it to do something". The impersonal it bothers me.

At this time I would like to take a few moments to announce that a most exciting development in chemical education is about to be realized. For about 10 years, many others and I have felt the need for a national research and development center in chemical education. The idea was presented in 1977 by Jerry Bell to the Manufacturing Chemists Association and again in 1982 by Truman Schwartz to the Chemical Manufacturing Association. Both Jerry and Truman have worked closely with me in preparing a draft proposal aimed at establishing a multimillion dollar endowed National Institute for Chemical Education (ICE). The aim of ICE is to revitalize the teaching of the chemical sciences at all educational levels by engaging the cooperation of academic and industrial chemists. Funds for the planning phase of ICE are being sought from industry and elsewhere. The response so far has not been overwhelming, but contributions are beginning to come in. The current state of the economy has caused several potential donors to defer making a commitment. I hope that within a year ICE will be in operation.

ICE will serve chemical educators in the chemical sciences (chemistry, chemical engineering, biochemistry, etc.) at all educational levels by

(a) strengthening the links between the chemical sciences and other disciplines and technologies, and by applying new techniques and methods, such as computer science, to chemistry and chemical education;

(b) fostering continuing education and professional growth in the chemical sciences;

(c) sponsoring the development and dissemination of creative ideas and practical methods for conveying chemical knowledge and information; and

(d) providing a national center for identifying and addressing critical issues in chemical education.

Much of the creative work at ICE will be conducted by resident Fellows: college or university professors, high school teachers, and industrial chemists. Six to eight Fellows usually will be in residence, and most residencies will be for 3-12 months. Fellows' projects will be in any area of chemical education or training, including interdisciplinary projects. Most projects will result in the development of an instructional product or technique such as a new course syllabus and material, a series of videotape modules for self-instruction, a correlated set of laboratory experiments, a series of lecture demonstrations, computer programs for simulation or drill exercises, new teacher training programs for teaching assistants, etc. The opportunities for interaction among Fellows will be a valuable feature of ICE.

The primary form of dissemination of the ideas and techniques developed by the Fellows will be continuing education workshops for pre-college and college teachers. Fellows will develop most of these 1-4 week workshops during their residencies, and Fellows will usually conduct at least one such workshop.

The Institute will provide facilities, technical support, and staff assistance to produce and disseminate materials developed by the Fellows. ICE will provide the necessary organization for follow-up activities by Fellows and workshop participants. All ICE projects will be thoroughly evaluated.

Why is ICE needed? In the past, National Science Foundation institutes, workshops, and other programs have been the primary resource for promoting chemistry teachers' continuing professional education and for developing and disseminating new instructional methods. With the demise of NSF's educational programs, an independently-financed organization such as ICE, functioning on the basis of cooperation between education and industry, is urgently needed. To my knowledge the only national teacher renewal activity scheduled for 1982 was the Dreyfus Summer Institute for High School Chemistry Teachers, which accommodated only 50 teachers. When fully operational, we anticipate that ICE will annually sponsor 25 one to four week long workshops with approximately 50-60 participants each, thus directly benefiting almost 1500 chemistry teachers each year.

Through the Fellows' projects the Institute will develop more effective means of teaching the chemical sciences, including the synthesis, characterization, properties, and uses of chemicals. All chemists need to convey such information, often to different audiences with varying degrees of chemical understanding. ICE will spearhead the development and implementation of teaching and training methods to improve such communication.

The Institute's workshops will enable teachers of chemistry at all levels to broaden and update their knowledge of the chemical sciences and related topics. They will provide hands-on experience with the most current methods and equipment. They will promote the personal and professional growth of the participants, will thus enhance the quality of instruction in the chemical sciences, and in turn will stimulate further professional activity.

The workshops will also enable chemists with different perspectives to work closely together: chemists from education and industry, from different levels of education, and from different disciplines. The need for such cross-fertilization is widely cited. For example, the 1980 report from ACS on "The Cross-Fertilization of Chemistry and Chemical Engineering Curricula" strongly recommended efforts to integrate the two disciplines and urged that "topics requisite to success in industry" be included in the curriculum.

The American Chemical Society offers programs in chemical education (in particular, the ACS Short Courses) for professional chemists. The ACS programs focus on short workshops (2-5 days) and transportable, primarily self-study, audio and audio-visual courses. ICE will complement the ACS activities by supporting extended research and development in chemical education through its resident Fellows; by offering longer workshops (1-4 weeks) for chemistry teachers; by providing for cross-fertilization among chemists with different perspectives; and by developing, testing, and disseminating new methods and materials in chemical education. ICE will not compete with existing programs but will cooperate fully with all related organizations such as ACS, the American Institute for Chemical Engineers, NSTA, AAAS, etc.

I am quite excited about ICE and, in due time, we will seek your cooperation in launching its activities. At the ACS Kansas City Meeting we shall seek endorsements for the concept of ICE from the Executive Committee of the Division of Chemical Education, from the Society Committee on Education and from the Board of Directors. The Chancellor and other administrators at the University of Wisconsin have given unqualified support to the concept of ICE and to housing it in Madison.

Throughout this talk I have asked that we become more involved in endeavors which lead to dealing with the incoming tidal waves. I realize that most of what I have suggested requires groups and institutions mounting collective efforts to enhance the quality of chemical education and to save us from the need to figure out how we can survive under water. However, I believe each one of us can individually engage in personal initiatives aimed at improving our teaching of chemistry and our role as chemical educators. I know of your commitment to chemical education which is manifested this week in your willingness to share with others and to learn from others. As you firm up your commitment this week and until the 1984 biennial conference at the University of Connecticut, I ask each one of you to please consider the following 8 personal challenges:

1. Increase and improve your own knowledge of chemistry. Make sure you know more chemistry than what is in the books that your students use.
2. Examine your course material and your teaching strategies. If feasible, make appropriate changes.
3. Collaborate with colleagues who teach English and those who teach math to improve your students' ability to communicate well and to handle numbers.
4. Learn how to use a computer and how to use computers in your teaching. Enslave the computer as an aid in your teaching.
5. Establish professional contact with another chemistry teacher. If you teach at the college level, contact a pre-college chemistry teacher in your

area. If you teach at the pre-college level, contact a college teacher in your area and develop an arrangement whereby both can meet at least twice a year to discuss matters related to teaching chemistry. If you are an industrial chemist, contact both a college and a pre-college teacher in your area and arrange to talk to their students about a career in chemistry.

6. Spur your local ACS section to conduct programs in chemical education. Be specific in what you suggest and help implement the project.

7. Make a presentation to junior high school students in your area. Emphasize the process of science, the benefits of chemistry, and the safe handling of chemicals.

8. Every month during the two coming academic years, do at least one more lecture demonstration than you have been doing. Display chemical phenomena and illustrate principles. Use each demonstration as a vehicle to teach and not as a magic trick.

My friends, tidal waves come and go. They cause enormous destruction and sometimes irreparable damage. But the human spirit endures. I trust that my remarks have not been misunderstood. In my judgment, the immediate future for the chemical education community is exciting and can be rewarding. Charles Dickens' ambivalent characterization, "It was the best of times, it was the worst of times", emphasizes that all times are a mixed bag. Can you think of a better time to be alive? Can you think of a better time to be a chemical educator?