Chemistry in Sustainable Development and Global Environment

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Commentary

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by Peter Abeta Iyere

This piece was prompted by a call to all departments from the Chancellor of Chapman University to define their roles within a sustainable development and global environment. Because of the wide-ranging impact of the subject matter, we believe that our point of view will benefit the general public beyond Chapman University.

How, then, can any chemistry department help in this effort? Chemistry is a specific discipline in science that tries to understand and explain the makeup and changes of all things that have mass and occupy space. Over the years, chemistry has steadily advanced into the study of complete molecular structures in science and related areas. Surely, a subject as all-encompassing as chemistry can play a role in sustainability.

Learning from the Past

Many of the questions about the role of chemistry in sustainable development and global environment that face us today also faced our predecessors years ago. According to Charles Edward Munroe, who was president of the American Chemical Society (ACS) in 1898 and an internationally known explosives expert, one of the reasons for studying chemistry is "As a means for improving the condition of mankind by ameliorating his environment" *(1)*. Therefore, it is not surprising that during the Napoleonic Period, the president of the Royal Society, Sir Joseph Banks (1743–1820), organized, among others, a Society for Bettering the Conditions and Increasing the Comforts of the Poor that enlivened the "Royal Institute of Great Britain ... with the purpose of invigorating agriculture through the medium of a 'sensible chemistry' and disseminating through society knowledge of useful accomplishments" *(2)*. This was the first time in history that a political consortium aspired to improve its economic situation with the aid of chemistry. These events were motivated by the outstanding scientific accomplishment of one of the truly great men of chemistry, Joseph Priestley (1733–1804), who, among others, discovered oxygen *(2)*. This preceded a period of significant developments in chemistry including the presentation of the first lecture in Agricultural Chemistry before the Board of Agriculture (about 1802 or 1803) by Sir Humphrey Davy *(2)*. Thus chemistry has long been recognized as a capable contributor to sustainable development and as such our chancellor's call is an opportunity for us to reaffirm the need for a resurgent interest in the use of "sensible chemistry" in sustainable development locally and in the global context. The question is, why the urgency now?

The Time Is Now

According to Shah, "one billion children live in poverty (one in two children in the world), 640 million live without adequate shelter, 400 million have no access to safe water, 270 million have no access to health services, and 10.6 million died in 2003 before they reached the age of five (or roughly 29,000 children per day)" *(3)*. According to the United Nations, "Almost all of the deaths from hunger and diseases" in the world "can be stopped at about $195 billion a year" because the deaths "result from extreme poverty that keeps hungry people from buying enough food to nourish themselves, sick people from receiving basic medical treatment or taking simple preventive measures" *(4)*. Sustainability and globalization therefore encompass addressing world hunger and poverty as well. Thus, there is a great need to gear chemistry contribution to mitigation of these problems to the chemistry of the past. In those times, agriculture was invigorated through the use of sensible chemistry and the development of the connections between chemistry, other disciplines, the environment, and daily life in such a way that interdisciplinary thinking and the relation of chemical concepts to societal issues became a way of life.

Interdisciplinary Approach

Technological advances have not reached many developing countries. Even developed nations with access to advanced technologies now face a bleak future because raw materials are near depletion without any hope of replenishment. The above account is the basis of Chapman University's resurgent interest on interdisciplinary approaches to societal problems. Thus, the first issue to be addressed by chemistry departments is whether our current chronological approach to teaching chemistry is still best to educate our youths as we prepare them to become global citizens who will live "inquiring, ethical and productive lives" (this is also part of Chapman University's mission statement). Our idea is that chemistry should be presented as part of other disciplines rather than a separate entity. This can be achieved through discussion of chemical concepts interposed with biology, physics, health sciences, mathematics, arts, and societal problems. Consideration should also be given to interjecting globalization; incorporating cultural diversity and sustainable development into our curriculum to enable students to understand the significance of the global environment and sustainable development.

We recognize the difficulty of implementation of this concept because as stated by Moore "Cross-disciplinary teaching is something that neither chemists nor biologists can do alone, and it is perhaps the most difficult aspect of improving undergraduate education in the sciences" *(5)*. Nonetheless the National Research Council report on chemistry–biology connection encourages the initiation of "...collaborative, interdisciplinary efforts involving curriculum and pedagogy" *(5)*. Although some scientists have written insightful articles that emphasize the need

for implementation of interdisciplinary approaches to teaching *(5–10),* we are proposing the teaching of chemical concepts interposed with other disciplines, sustainable development, and globalization so that chemistry courses and laboratory experiments will not only result in factual learning but will mirror real-world situations that give students an "enduring sense of the power and beauty of creative inquiry" *(5).*

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Understanding Sustainability

Sustainable development is "a process of change during which societies and their citizens learn to deal with the tension between ecological sustainability and economic development while doing justice to interests at both the local and the global level"*(11).* This general definition can be interpreted differently depending on locality and geographic location. So, the type of sustainable development required in poorer communities in metropolitan areas in supposedly developed countries with access to clean drinking water and constant supply of electricity differ from that of poor villages in underdeveloped countries where there is no access to such basic necessities of life. In the latter, sustainable development implies combating shortage while in the former it implies the growth of renewable and environmentally friendly methods and sustained improvement of existing infrastructure. Therefore to make any meaningful contribution to these issues, a sustained effort should be made by chemists to determine the specific needs of any area of interest. In this paper, we try to answer this basic question: what is the role of the chemistry departments?

Recommendations for Chemistry Departments

To answer this question we will give wide-ranging recommendations that will hopefully lead to specific action steps that could be undertaken by each department. In general, chemistry departments can attempt to do the following:

- Change the current mode of education from discipline-based instruction to concept-application-based (CAB) instruction. This implies that the rate of chemical reaction, for example, should be taught with specific application (not just reference to) in biology, physics, biochemistry, microbiology, and daily living. Corresponding experiments should be designed to take place within and outside the laboratory with emphasis on practical applications. This is distinct from the development of courses that are team-taught because an instructor will teach the CAB course and either teach the corresponding laboratory also or coordinate teaching activities with the laboratory instructor.
- Determine ways to contribute to the development of cheap, environmentally friendly, and sustainable technologies for water purification, food production, and energy utilization in impoverished regions of the world through the involvement of their students in global studies (as required by our university's general education) and in travel courses that would take students to impoverished communities where they can acquire first-hand knowledge of the problems in the community and suggest ways in which chemistry (science) can be used to meet the basic needs of the people using readily available materials.
- Seek ways to replace environmentally malignant chemicals with benign ones.
- Organize outreach activities to educate the public on the responsible use of household and other chemicals and demonstrate that "chemistry is life".
- Employ and teach students best practices in the conduct of research within and outside the laboratory to maximize individual and public safety through the responsible use of resources.
- Make technological advances in chemistry available in developed countries accessible to chemistry departments in developing and underdeveloped countries through collaborations to promote sustainable growth in a global concept.

The key mission here is for chemistry departments to involve future chemists early in their career in the use of interdisciplinary approach and teamwork in sustainable development and global environment through awareness of chemical concepts in a broader framework that integrates other disciplines and combines daily living with global chemical issues. The above approach will require innovative learning environment and advances; some projects that can serve as a springboard for such innovation are already in place *(12).*

Globalization

A Sustainable Development Pact was signed recently by the presidents of six leading chemical societies (with over 300,000 members) with a pledge "to promote global sustainable development" through collaborative work to encourage sensible use of resources *(13).* They noted the essential role that chemistry plays in the development of solutions. The ACS president eloquently stated that the consequences of not tackling the universal energy, food, and water crisis will be grim if we do not develop ways "to support chemists in developing skills that will ensure the sustainability of our planet; develop roadmap and priorities for chemistry's contribution to sustainability and advocate for

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the resources needed to develop and deploy technologies globally; and convene academia, industry and government to better understand chemistry's contribution to sustainability and the need for action" *(13)*.

Implementation

Although quality articles have been written on sustainable development and globalization separately or in combination, what is left to be done is to establish a set of action-steps that will enable chemistry departments to implement curriculum changes that will incorporate sustainability concepts and initiate collaborative ties with other departments and disciplines to implement the concept of globalization. For a start, our chemistry department is spearheading the university's effort to establish an interdisciplinary degree program in environmental science and policy. This program, which brings together chemists, biologists, geologists, real estate and environmental policy professionals, etc., will be directed by an environmental chemist whose research is focused on environmental remediation. Furthermore the chemistry department has restructured its curriculum so that all majors in the department can satisfy their capstone requirement in a variety of ways. The unique aspect of this is that one of the ways of meeting the capstone requirement will be a travel course (under development) that will take seniors to impoverished communities of the state/nation and eventually the world. During the trips students will have the opportunity to observe and evaluate the various problems facing the community and determine ways in which chemistry/science can be used to ameliorate the suffering of the people using local materials. The project will culminate with a report and oral presentation to the full faculty and students of the department according to departmental guidelines. Thus, once the issues facing the community and possible solutions are identified, the reports will be presented to relevant authorities so that they become the focus of academia, government, and industry action and the source of their projects (we expect to publish details in this *Journal*). Participation of all chemistry departments in similar projects, we believe, will not only make chemistry more relevant to society globally but will give students the opportunity to study societal problems through a multidisciplinary approach and provide authorities basis for actions that will lead to sustainable development worldwide.

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