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ABCS OF TEACHING ANALYTICAL SCIENCE

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Sharing instrumentation globally

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Advances in computer technology have made the world shrink in many ways. Industry routinely makes use of the ability to control instruments remotely from one laboratory to another. On the other hand few students are exposed to remote use of instrumentation and even fewer academic laboratories have worked to share instrumentation globally. The Great Lakes International Instrumentation Collaboratory (GLI^{2}C) was established in 2004 in response to the paucity of such collaborations (Fig. 1).

The GLI^{2}C Cyber Chemistry Collaboration is based on five elements: shared teaching curriculum involving student-derived environmental samples mounted in GIS format for cross comparison of landscape-driven changes in environmental chemistry; shared expensive capital resources of major instrumentation and maintenance; faculty research resulting from access to major instrumentation; insertion of access of major instrumentation into the chemistry curriculum; and workshops to develop technical skills among chemistry faculty necessary to initiate and/or join in cyber-chemistry infrastructure.

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This project is designed to initiate and strengthen ties of US chemists with analytical and environmental scientists in Africa. One, of several, desired end outcomes is shared class content in environmental sciences. Such a shared class necessarily will require web content that is specific to the class and accessible to all members of the learning community. Benefits to such a class are envisioned as advancing an understanding of global needs in measurement sciences and a greater depth of cultural understanding between participants in the classes. In order to prepare for this sustained effort several basic needs must first be met: adequate course content, collaborations, basic shared instrumentation, basic Internet connectivity and a built-in plan for understanding cross-institutional and cross-cultural learning (Fig. 2).

The GLI^{2}C (Fig. 3) core group consists of Loyola University Chicago Department of Chemistry (US Ph.D. chemistry department, Alanah Fitch), University of Dar Es Salaam Department of Chemistry (Tanzania Ph.D. chemistry department, Michael Kishimba), Egerton University Department of Chemistry (Kenya, M.S./Ph.D. chemistry department, Ward Mavura), and Kenya Methodist University Department of Applied Biology (Kenya, no chemistry department, Alice Muriithi). The collaboration has placed on line two instruments, demonstrated real-time connectivity of the instruments intercontinentally, and prepared a set of 20 content modules centered around pesticide use in east Africa and Illinois.

A planning session was undertaken at Dar Es Salaam in November 2004. At that meeting the exact type of experiments and curricular focus were selected based upon the shared expertise of Ward Mavura and Michael Kishimba in the area of tropical toxicology: specifically organochlorine pesticides [1–9]. Michael Kishimba serves as executive secretary of the African Network for the Chemical Analysis of Pesticides (ANCAP), which has close links with the tropical subgroup of the international Society for Environmental Toxicology and Chemistry

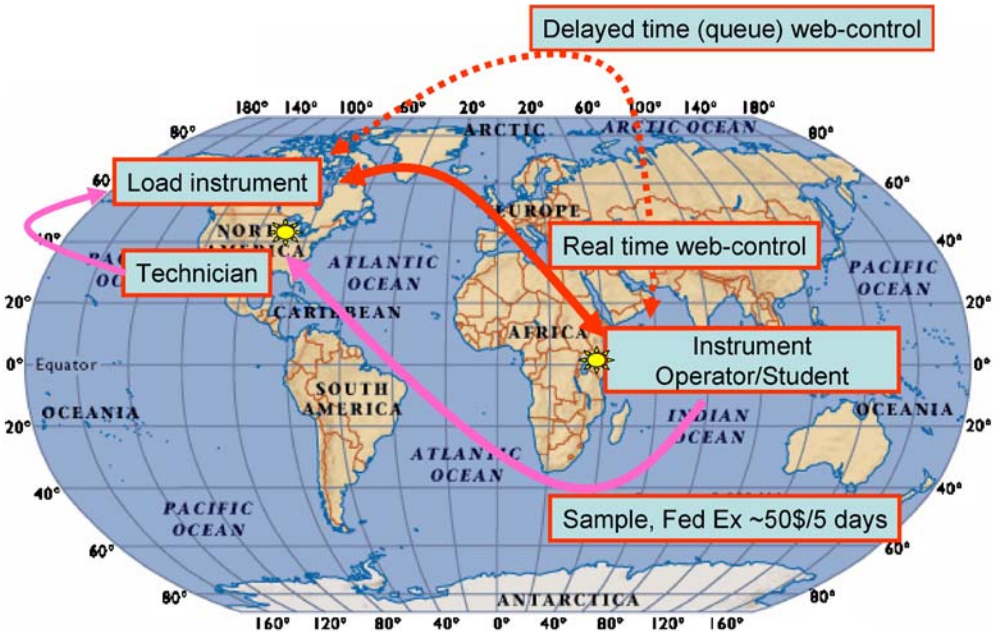

Figure 1 Meeting the future needs of globalization. Concept Great Lakes International Instrumentation Collaboratory (*GLI*^{2}*C*). Samples are acquired and prepared in east Africa, and sent to Loyola University Chicago, where a technician loads samples onto instruments. Instruments are operated in real time via the web or delayed time (queue) with web control. Data are delivered directly from instrument to operator in east Africa

(SETAC), with which they will organize, in the fall of 2006, an "International conference on the use of pesticides in developing countries: environmental fate, effects and public health implications."

The preparation of water samples for pesticide analysis by gas chromatography (GC) is imminently compatible with stability, sample size, and instrument solvent requirements for analysis by GC–mass spectrometry (MS). In addition, the method has a demonstrated ease of use (minimal glassware requirements).

Samples are prepared by extraction into dichloromethane, which is then dried, evaporated and replaced with stabler, chlorine-free cyclohexane. The final sample size is small enough to ensure low shipping charges.

Figure 2 Our logo

Solvents in the shipped samples are allowed under the CDC and EPA import requirements, are compatible with the injection system of the gas chromatograph/mass spectrometer, and may be stored for up to 2 months prior to use.

The planning meeting of November was followed by a training session on the instrument in February in Chicago with piggy-back attendance of the PittCon and the ASDLib editors meeting. On the basis of the training meeting the skills required to take a sample from the environment into the laboratory and back again to a displayed set of data were identified. A stand alone module was developed to meet each particular skill set and then, at a third meeting in April, modules were evaluated and grouped according to specific curricular needs of the participants. For example, Kenya Methodist University intends to use the pesticide analysis modules in a course entitled "Crop protection", where the specific skills required are a good understanding of pesticide use and toxicology and the ability to analyze data from submitted samples. The universities of Egerton and Dar Es Salaam intend to use the GC-MS capacity for the teaching of a course in "environmental chemistry" and for research at the postgraduate level (M.S. and Ph.D.). Loyola University Chicago intends to use the modules in the teaching of "instrumentation." Each of these particular curricular needs requires the faculty to pick and choose particular skill modules that are or can be grouped under disciplinary content as shown in Fig. 4.

The need for research on pesticide persistence is acute in tropical regions because of the high requirement for pesticides owing to favorable conditions for pest population growth (tropical climate) and lack of research into the half life of pesticides in the tropical environment. Many of the

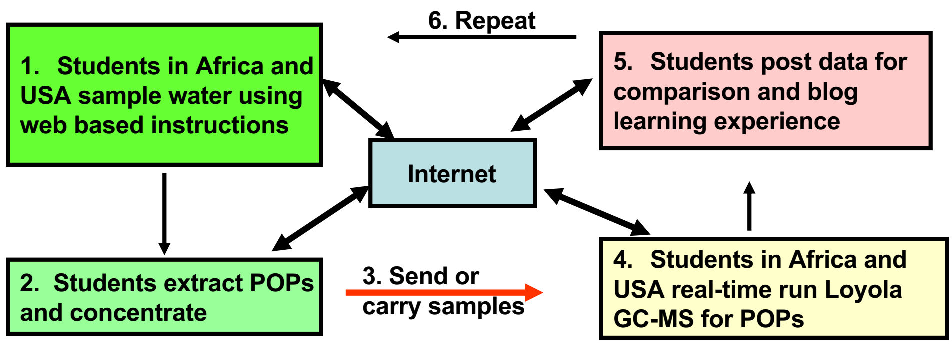

Figure 3 The sequence of work envisioned

pesticides required for domestic crop and export crop use are the same as those required for large dispersion for public health use, and the risk assessment debate over their use centers primarily upon data acquired for use of the chemicals in temperate regions where the half lives are apparently an order of magnitude or more greater than in tropical regions. The regional need for greater pesticide measurement capacity is larger in east Africa. In particular, the greatest export portion of the Kenyan economy is currently horticultural, which must comply with European Union pesticide residue regulations.

Work from the core participants will be presented at the ACS Atlanta meetings next spring where the results from the first set of samples which arrived this fall will be discussed. In addition, a workshop is planned to precede by a day the ANCAP-SETAC conference. A total of 60 younger scientists in training will be invited to participate in the workshop, which will feature real-time on-line use of GC-MS and the curriculum that has been developed.

Future developments depend upon addition of new instrumentation to the GLI^{2}C and on the interests of the researchers and new members. One area of interest is in total and speciated lead, as lead continues to be a very real issue in inner-city Chicago from paint hazards, and in Africa through the use of leaded gasolines. The persistence and form of the distributed lead is expected to be very different between the temperate and tropical locations owing to differences in temperate and tropical soils and the extent of iron-containing minerals.

For further information on this collaboratory project, preliminary modules and their content can be found at the web site http://www.luc.edu/chemistry/faculty/fitch/GLIC/index.html.

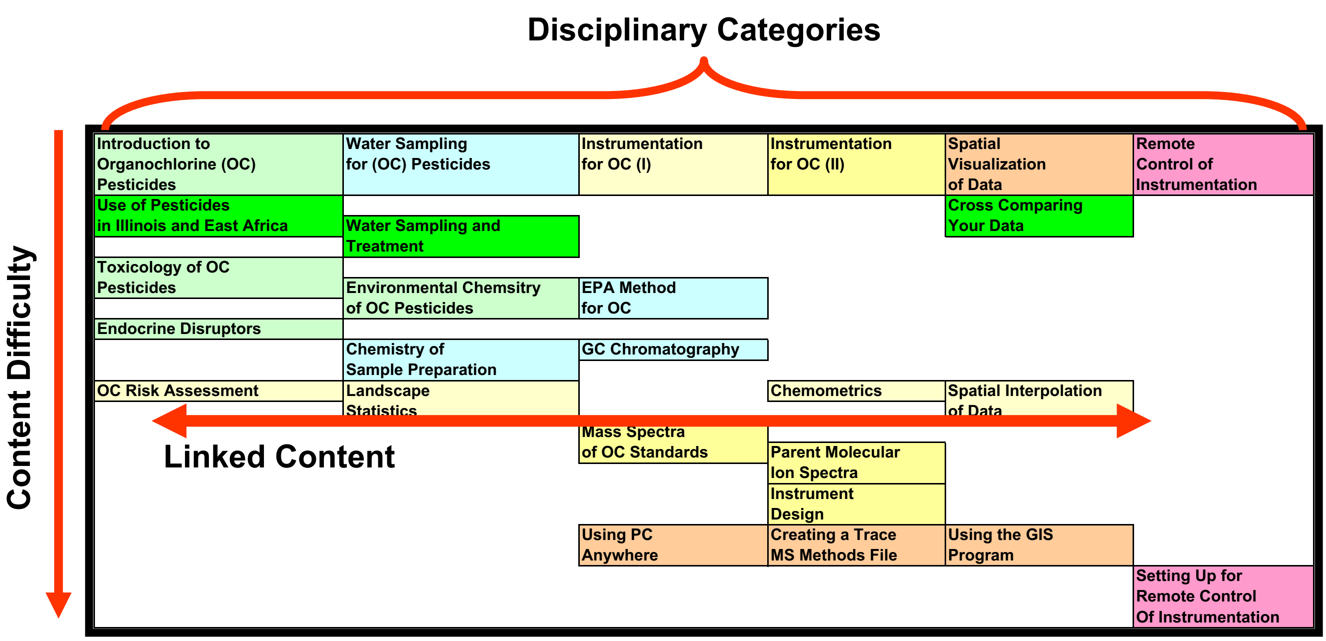

Figure 4 Nineteen content modules have been designed for water analysis for pesticides. They are grouped according to disciplinary categories, difficulty, and theme or linked content. Based on a particular course, modules may be selected and rearranged

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From left to right: Alice Muriithi, M. Kishimba, Alanah Fitch, Ward Mavura.

Alanah Fitch has a Ph.D. in agronomy and is a Full Professor of Chemistry at Loyola University Chicago, USA, where she specializes in environmental chemistry. She is known for her educational innovations in developing the single-analyte model for the teaching of instrumental methods of analysis which is also coupled with service learning in the Chicago area. Students in her 1996 class won a national award from Anheuser Busch for the study of metal deposition around a solid municipal waste incinerator operated by the City of Chicago. She has written on the ethics of such community-based collaborations. During the years 1999–2003 she was the founding director of the interdisciplinary major "Environmental Studies/Sciences Program." She has recently been elected councilor for the Analytical Chemistry division of the National American Chemical Society.

Michael Kishimba has a Ph.D. in chemistry and is an Associate Professor of Chemistry at the University of Dar-Es-Salaam, Tanzania, specializing in tropical pesticide use and analysis. He is secretary-general of the African Association of Pure and Applied Chemistry and executive secretary of the African Network for Chemical Analysis of Pesticides (ANCAP).

Alice Muriithi is the Chair of the Department of Applied Biology at Kenya Methodist University (KEMU), located on the slopes of Mount Kenya outside of Meru town. The university, founded in 1997, began with 24 students and now has more than 630 students, including full-time and distance learners. She is also the Executive Secretary for the Horticultural Association of Kenya, and founding member of the Meru Association of Women in Science. She has an M.S. in horticulture.

Ward Mavura, an analytical chemist at Egerton University, Njoro, Kenya, is a board member for the Southern and East African Network of Analytical Chemists (SEANAC) and has an M.S. in chemistry, a Ph.D. in chemistry, and an M.Ed. in science education.