Chemistry and the Environment: Pedagogical Models and Practices

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Foreword

The ACS Symposium Series was first published in 1974 to provide a mechanism for publishing symposia quickly in book form. The purpose of the series is to publish timely, comprehensive books developed from the ACS sponsored symposia based on current scientific research. Occasionally, books are developed from symposia sponsored by other organizations when the topic is of keen interest to the chemistry audience.

Before agreeing to publish a book, the proposed table of contents is reviewed for appropriate and comprehensive coverage and for interest to the audience. Some papers may be excluded to better focus the book; others may be added to provide comprehensiveness. When appropriate, overview or introductory chapters are added. Drafts of chapters are peer-reviewed prior to final acceptance or rejection, and manuscripts are prepared in camera-ready format.

As a rule, only original research papers and original review papers are included in the volumes. Verbatim reproductions of previous published papers are not accepted.

ACS Books Department

Preface

As evidenced by the chapters within this volume, the field of chemical pedagogy is diverse. Models employed by authors of these chapters include guided-inquiry learning, peer-mentoring, service learning opportunities, project-based exercises, flipped classrooms, and studies-abroad. While these approaches differ, the one common thread is the use of environmental topics to capture the attention of students who then use chemistry concepts to further explain those issues and concepts. However, there is no single, optimal methodology that triggers maximum learning for all students. Additionally, different institutions are equipped with varying resources and have distinct student requirements. To complicate the matter, the way students learn is changing with the advent of new communication technologies. Therefore, different strategies are necessary now and into the future. What makes this volume unique is the compilation of examples that traverse the pedagogical field in chemistry. Each chapter within this volume provides a brief background on the specific methodology used, as well as reference to published works in the field. Thus the reader interested in environmental issues and concepts can extract detailed information from these pages on how to develop context-based activities or courses using a range of different models.

This volume, *Chemistry and the Environment: Pedagogical Models and Practices*, is a product of a symposium sponsored by the Environmental Chemistry Division of the American Chemical Society held during the 249th National ACS Meeting in Denver, Colorado in March of 2015. Several of the models in this volume were presented as papers at that symposium; other models came from invited authors. The common theme for these methods is context-based pedagogy in which chemistry concepts are presented to students through the examination of environmental issues and concepts.

King *et al.* (Chapter 1) provide an introduction to context-based learning through use of Process Oriented Guided Inquiry Learning (POGIL). A description of the learning cycle is included as well as how it is used by the authors to develop the climate change, context-based POGIL activities presented here. Five different information models, typically used in POGIL activities, are outlined with specific examples to introduce the process of model choice for the development of new context-based POGIL activities.

Eves *et al.* (Chapter 2) outline the peer-mentoring program presently used in the Southern Utah University Water Laboratory where students manage and run day-to-day operations of a water quality testing laboratory. In order to circumvent problems associated with frequent turn-over, a highly-organized peer mentoring program facilitates the process of management, training and information transfer. This chapter chronicles the evolution of a context-based approach where students

learn by on-the-job training of laboratory techniques, management, teamwork, and customer service.

Weaver and Eves (Chapter 3) describe an analytical laboratory course in which environmental chemical analysis is the main focus. In this pedagogical model, principles and techniques are introduced to students and then applied to environmentally-oriented service learning projects. Students work in groups to carry out various water quality tests of a creek near Southern Utah University. Students are required to compile the data and report their findings for dissemination to the community. The real-world application of the projects and their impacts are detailed here.

Lanigan and Roberts-Kirchhoff (Chapter 4) offer an example of how context-based projects can be adapted for various levels of chemistry instruction. This chapter illustrates the use of drinking water quality as the theme for activities and experiments that were developed for Allied Health majors, science majors, and middle school students. A novel investigative activity, two experiments, and four mini-projects are detailed, as well as several assessment methods for evaluating the effectiveness of pedagogical practices.

Kahl (Chapter 5) reports a project-based experiment where students compare a simple smartphone spectrophotometer to a traditional one. After comparing results of water quality tests, students use an engineering approach to generate different designs to improve the smartphone spectrometer.

Archey *et al.* (Chapter 6) outline a pedagogical approach which introduces general chemistry concepts through consideration of environmental issues such as carbon dioxide uptake by the Amazon jungle. Application of concepts such as stoichiometry, molarity, solubility, and graph interpretation to the "carbon footprint" discussion of global sustainability exemplifies the utility of context-based pedagogy.

Berliner (Chapter 7) describes two approaches for introducing chemical concepts through the use of flipped classrooms. The two courses described here require students to engage in discussion of contemporary environmental chemistry and toxicology issues. Both require readings over controversial issues in environmental chemistry, student presentations and guest lecturers on related topics. The significant difference in Berliner's two approaches is that one course is offered as a two-week international travel course to Thailand. This latter approach includes opportunities for cultural enrichment as well as laboratory experience measuring water quality in the communities visited by students.

Mio *et al.* (Chapter 8) present a description of an organic laboratory course that integrates concepts of green chemistry throughout the experimental and writing components of the course. Emphasis is made on training chemistry and biochemistry students as future professional scientists by requiring students to submit ACS-style manuscripts that undergo a peer-review process prior to final submission. Details of the writer and peer-reviewer rubrics are included in this chapter.

These examples of context-based instructional practices are diverse and evaluation for each requires its own methodology. Therefore, there is a great need in the chemical education community for more published examples of practices and assessment tools for chemical educators. This volume of papers provides examples for those interested in applying chemistry concepts to environmental topics to stimulate student learning.

Editors' Biographies

Katherine C. Lanigan

Katherine Lanigan is an Associate Professor of Chemistry and Biochemistry at the University of Detroit Mercy. Lanigan's research includes analysis of trace metal accumulation both in plants and invertebrate and adsorption studies of metal-complexed EDTA on metal oxide thin films by ATR-FTIR. Lanigan received a B.S. degree in Chemistry from the University of Dayton in 1990 and a Ph.D. degree in chemistry from the University of Iowa in 1996. She joined the University of Detroit Mercy in 1999.

Elizabeth S. Roberts-Kirchhoff

Elizabeth Roberts-Kirchhoff is Professor of Chemistry and Biochemistry at the University of Detroit Mercy. Her research interests include the mechanism of action of cytochrome P450 enzymes; the analysis of metals in food and health supplements including kelp, clay, and protein powders; and the analysis of pesticides in water. Roberts-Kirchhoff received a B.S. in Chemistry from Texas A & M University and a Ph.D. in Biological Chemistry from the University of Michigan. After postdoctoral research at Wayne State University and The University of Michigan, she joined the faculty at the University of Detroit Mercy in 1997.

Kendra R. Evans

Kendra Evans is an Associate Professor of Chemistry and Biochemistry at the University of Detroit Mercy. Her research focuses on the development and use of automated liquid chromatography-mass spectrometry methods to investigate long-term insulin secretion dynamics. Her research interests also include the detection of pesticides in water and animal tissue, as well as the development of stability-indicating assays to monitor the forced degradation of pharmaceutical compounds. Evans received a B.S. in Chemistry from Western Kentucky University and a Ph.D. in Analytical Chemistry from the University of Michigan. She joined the faculty at the University of Detroit Mercy in 2009.

Mark A. Benvenuto

Mark Benvenuto is a Professor of Chemistry at the University of Detroit Mercy and a Fellow of the ACS. His research thrusts span a wide array of subjects, but include the use of energy dispersive X-ray fluorescence spectroscopy to determine trace elements in land-based and aquatic plant matter, food additives, and ancient and medieval coins. Benvenuto received a B.S. in chemistry from the Virginia Military Institute, and after several years in the Army, a Ph.D. in inorganic chemistry from the University of Virginia. After a post-doctoral fellowship at the Pennsylvania State University, he joined the faculty at the University of Detroit Mercy in late 1993.

Alexa Rihana-Abdallah

Alexa Rihana-Abdallah is an Associate Professor of Environmental Engineering at the University of Detroit Mercy. Her research interests include water and soil remediation, in particular contaminant fate pathways and remediation design for surface and groundwater polluted with metals or chlorinated compounds, as well as energy sustainability and clean technology. Rihana-Abdallah received a B.S. in Electrical Engineering from Ecole Sup*é*rieure des Ing*é*nieurs de Beyrouth – Universit*é* St. Joseph, a M.S. and a Ph.D. in Environmental Engineering from the University of Michigan. She joined the faculty at the University of Detroit Mercy in late 2000.

Chapter 1

Choosing Appropriate Models – Incorporating Climate Change into General Chemistry

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A set of in-class activities were developed that use climate change concepts to help students learn general chemistry content. The activities are based on POGIL (Process Oriented Guided Inquiry Learning) pedagogy, in which students work in groups to develop conceptual understanding of the topics presented in the activity. A challenge faced in the development of these activities was how to effectively incorporate the climate change context. The result was a set of activities that incorporate climate change in a variety of ways. This chapter will present different model types used in these activities, along with discussion of the corresponding benefits of each particular model type. It is hoped that the reader will gain some insight into model development, and that the examples presented will make it easier for others to incorporate context-based examples into their own curricular materials.