Green Analytical Chemistry: Teaching Towards Sustainable and Responsible Choices

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Ignatian pedagogy

As a new faculty member of Xavier University who came from a different culture, I was a little worried about how to adjust into not only the western culture but also the "Jesuit" and "Ignatian" culture. I joined the "Ignatian Mentoring Program" with the aim to learn more about the mission of Jesuit universities, and Xavier's Ignatian pedagogy, in particular. After reading many books, having conversations with my mentor, and listening to various seminars, I have come to realize that the mission of Jesuit and Ignatian pedagogy are not at all foreign to me. I have come to believe that by nature, all responsible teachers everywhere already possess the same belief and strive for the same quality as the Jesuit and Ignatians do, as similarly stated by Debra K. Mooney in the Introduction on page 1 of *Do You Walk Ignatian?* (2012) that "In fact, you may be surprised to discover that you already, and quite naturally, serve in a manner that reflects Jesuit traditions." According to page 18 of that same booklet *Do You Walk Ignatian?*, I realize that just by deciding to join this program to improve my familiarity and understanding of the mission and identity of Xavier University is, in itself, already an Ignatian act called "Magis," or "Continuous Quality Improvement."

The question is then, what is the difference between Jesuit/Ignatian teaching pedagogy as compared to other institutions? Throughout the year and a half that I have been here at Xavier University, I have felt a stronger focus on the continuous improvement in teaching than was the case at other universities that I have experienced as a student or as a faculty member. Here at Xavier, The Center of Teaching Excellence welcomes new faculty members with various activities and resources to improve their teaching quality, such as the "Teaching Mentoring Pair Program" and seminars on various teaching tactics by outside and inside speakers. The Center for Mission and Identity also has various seminars and activities that promote the mission of Xavier, "Men and Women for Others." Some programs I have joined include "Xavier Service Day," where we volunteered to help out at various local organizations around Cincinnati, and "Mission and Sustainability Workshop" where we shared thoughts on world problems and learned how our university has tried to be a responsible member of the society by doing things to contribute to the improvement of these issues. Therefore, now I can answer the above question. Xavier is different from others institutions in that Xavier puts the belief and mission into practical everyday work, not just talking and believing, but actually working toward the mission. Xavier gathers great qualities and ideas and spreads them out so that all the Xavier members realize the same goal, rather than only a few people conducting the mission alone.

Ignatian pedagogy in Chemistry

For many years sciences and technologies seemed to focus only on "efficiency" with very little connection to "civic responsibility" concerning chemical exposure and pollution (from Toward a new U.S. chemicals policy: Rebuilding the foundation to advance new science, green chemistry, and environmental health, *Environmental Health Perspectives* (2009) 117, pp. 1202-1209 by Wilson M.P and Schwarzman M.R.). With environmental problems resulting from some irresponsible uses of chemicals and technology, especially in some factories, the chemistry community realized the importance of finding ways to use chemicals and technologies in harmony with environmental and human health. This is called "Green Chemistry" and it aims to reduce energy

consumption, waste production, and the use of toxic chemicals. Already some institutions around the globe have made attempts to transform their laboratory experiments to be more "Green". The recent global economic crisis led the United Nations to announce the World Decade of Education for Sustainable Development between the year 2005-2014 and green chemistry is one of the approaches for sustainable development (From Education for sustainable development (ESD) and chemistry education, *Chemistry Education Research and Practice* (2012) 13, p. 59 by Burmeister M., Rauch F., and Eilks I).

I learned about various novel and advanced instrumentation relevant to chemical analyses during the time I spent in the higher education in the US. However, since I come from a developing country where teaching resources as well as social services are scarce, I have encountered situations where such highly sophisticated instrumentation cannot be put into use, either because of limited budget or unavailability of the trained personnel to run the instruments. When you actually look around, you see that those who need chemical analysis the most are the local residents who live next to factories, mines, and garbage dumps, those who live far away from the hospitals, and those who have no money or education. Most of my colleagues, having also been educated in the western world, and I have considered and discussed the relevancy of learning about highly expensive technology. What is the point of educating our students if they cannot make use of their knowledge to serve the society? Does this mean we are educating our students to be able to survive only in the rich societies? From such thoughts we realized that we require adaptation in our teaching. It is important to educate our students about the state of the art instrumentation so that they are up to date and can function at the international level. However, if the particular instrumentation is not available, it is important that students can still make use of their knowledge in alternative ways which may be more suitable in their particular future working situations.

Taking both the environmental and economic concerns into consideration, I started my chemistry research involving students in a way geared towards "Green Analytical Chemistry" by making use of natural reagents from plants and food wastes as well as developing alternative chemical analysis methods/systems that utilized lower cost materials. Here, at Xavier, apart from conducting research in this area with students, I have tried implementing the results from my research work as well as the concept of "sustainability" into teaching Instrumental Analysis Laboratory class via adaptation of some laboratory experiments. The objective is to reinforce social responsibility to chemistry students while educating them without changing the main objectives of the course which is hands-on experience on the state of the art instrumentation. I would like students to realize that whenever possible, they should make a safer choice and keep in mind the consequences of their choices and actions on the society. The chemicals they choose to use and the amount of chemicals they prepare will eventually turn into waste and have some effect on the environment and other people's health. This brings us to one of the main points of the Ignatian pedagogy known as "Discernment." It is a process for making choices, when the option is not between good and evil, but between several possible courses of action, all of which are potentially good (From *Do you speak Ignatian?,* 12th Ed. (2012) p.1, and *A Jesuit Education Reader* (2008) p.28, George W. Traub, S.J., Xavier University). Apart from thinking of "efficiency" of their scientific works, students should also broaden their thought to think about safety and cost. In addition, if students know how to adapt, they will be able to better help people who need help. Without having any sophisticated and expensive technologies at hand, can our students perform their jobs effectively using only what available? Can they actually become "men and women for others" in situations that are less than ideal? I hope that by implementing green chemistry choices into my teaching it will help improve students' awareness of the relevancy and responsibility of chemistry within our global society.

Summary of My Teaching and Research Activity on Green Analytical Chemistry and Sustainability

The Ignatian pedagogy concepts of continuous quality improvement (Magis) and making choices (Discernment), have been applied in my teaching and research. I have chosen to incorporate the Green Analytical Chemistry methodologies for the betterment of my students and society through the use of alternative teaching materials. Some aspects of these applications in my teaching/research and student learning objectives are listed below.

Teaching:

- Use of tea extract as a safe chromogenic reagent in place of synthetic chemical for determination of iron using UV-Vis spectrophotometry (based on my previously published research work, Flow injection determination of iron ions with green tea extracts as a natural chromogenic reagent, *Analytical Sciences* (2010), 26, pp. 619-623)
  - Students have hands-on experiences on operating UV-Vis spectrophotometer
  - Students understand and can interpret the data obtained from the instrument
  - Students gain awareness of possibilities in performing micro-volume analysis to reduce chemical waste
  - Students learn how to prepare pharmaceutical samples using iron supplement as a model
  - Students learn about metal-complexing property of phenolic compounds in tea
  - Students gain awareness that local resources may be used for chemical analysis

- Advanced analysis of biodiesel with gas chromatography and infrared spectroscopy techniques (based on Renewable Energy Workshop, offered by Chemistry Collaborations, Workshops & Communities of Scholars (cCWCS), Beloit College, WI that I attended on June 24-29, 2012)
  - Students have hands-on experience operating a Gas Chromatograph and an Infrared Spectrometer
  - Students understand and can interpret the data obtained from the instruments
  - Students learn about making biodiesel, an important current topic on alternative energy
  - Students realize the important role of instrumental analysis in the development of sustainable energy

Research:

- Continue research on the use of Indian Almond leaves extract for determination of aluminum ions in waste water from ceramic factories
- Start the research topic on low pressure chromatographic separation using ultra-short column as a lower cost alternative chemical separation system to a high pressure liquid chromatograph
- Start the research topic on investigation for the use of enzyme extracted from food waste for chemical analysis