Integrating Teaching Experience into an Introductory Chemistry Course
The Chemistry of Global Warming

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Introduction
Although non-science majors take science subject matter courses as a general education requirement, they are often discouraged by the overwhelming depth of the science content. It has been consistently reported that non-science majors are poorly motivated and have difficulties in understanding science concepts as well as finding the relevance of science to their careers (Duchovic et al., 1998; Glynn et al., 2009). Similarly, elementary education majors lack science content knowledge (Davis, et al., 2006) and self-efficacy in their ability to teach science (Fulp, 2002). In addition, the lack of science content knowledge impedes elementary teachers’ implementation of inquiry-based teaching approaches during which, elementary students are encouraged to generate and test hypotheses by collecting empirical evidence in science class (Bransford, et al., 1999).

To help more students become interested and engaged in learning science and math, Roosevelt University professors from science, math and education departments have adopted new teaching approaches that are advocated by Science Education for New Civic Engagements and Responsibilities (SENCER). While the Roosevelt University SENCER team incorporated SENCER techniques and ideals into existing courses, we designed a new SENCER course, CHEM 100: The Chemistry of Global Warming for non-science majors, especially elementary education majors.

Two features were taken into consideration in developing this introductory chemistry course. First, the course integrated chemistry concepts into the unifying social issue of global warming. It has been argued that the inclusion of social issues in science classrooms is imperative to the development of a responsible citizen capable of applying scientific knowledge (Driver, et al., 2000). Therefore, we believed that teaching through the theme of global warming would help non-science majors not only connect various chemical concepts, but also see the relevance of science to our society and daily lives.

Second, a service-learning teaching component was incorporated into this course, differentiating it from the pre-existing global warming SENCER model course. Non-science majors need more hands-on experiences with which they
can transfer their scientific knowledge to other contexts (e.g., teaching K–12 students). The fact that urban public school students often do not have sufficient and on-going support for science materials and instruction served as additional motivation for this service learning project. As the intentionally designed opportunity, the global warming workshop required the enrolled non-science majors to present global warming activities to middle school students from an urban public school.

The purposes of the present paper are to describe how the service-learning component was integrated into our introductory chemistry course and to present how the non-science majors self-evaluated their teaching experience from the service-learning project.

Methods
The introductory chemistry course was offered in the spring of 2009 and a total of fourteen undergraduate students (ten females and four males) were enrolled. In contrast to our expectations, however, only one elementary education major was enrolled.

The course began with assessing the students’ prior knowledge about global warming. In groups, the undergraduates used markers and large pieces of paper to draw their models of global warming and its causes. After the groups had presented their models, a class discussion led to the generation of questions regarding areas of uncertainty, or confusion, in the concept of global warming. The discussion produced eighteen questions including:

- What is ozone?
- Are sea levels increasing and why?
- What is the relationship between carbon dioxide and ozone?
- How does ozone affect the greenhouse effect?
- Is carbon dioxide the only greenhouse gas?
- How long has global warming been occurring?
- How does global warming affect diversity of living organisms?
- Is there any positive impact of global warming?

These questions and related concepts were used as a template for the course content. As shown in Table 1 (following page), from the second week to the tenth week, demonstration, lecture, and discussion were employed to address various concepts in the fields of chemistry and physics. After every three weeks, the undergraduates had a chance to revisit and revise their model of global warming that they drew during the first class.

Global warming workshop
During weeks 11 and 12, the undergraduates prepared workshop presentations for middle school students. To introduce the concept of global warming to middle school students, the undergraduates developed a sequence of teaching: what are the consequences of global warming, what causes global warming, and what we can do to reduce global warming. Activities related to global warming from middle school curricula were introduced and five small groups of undergraduates chose one or two activities within the sequence of teaching. The undergraduates researched the purpose of their activities and the targeted content, and planned how to implement them effectively to middle school students.

During week 12, the undergraduates had a rehearsal in which each group taught their peers using their activities, followed by a discussion aimed to present feedback to the presenters. This rehearsal not only served to make sure each group was prepared for their station activities, but also helped them reinforce their understanding of global warming as a whole by actively participating in all stations.

On Saturday of week 14, the undergraduates presented this global warming workshop to middle school students and their parents in the organic chemistry lab at Roosevelt University’s downtown campus. Table 2 (following page) lists the topic, main question, and activity that was presented at each station. Based on the sequence of teaching topics, lab stations (five total) were set up for each group of undergraduates to engage middle school students in the prepared activities. Approximately 150 middle school students at one Chicago public school were invited, however only five attended the workshop due to the concern about an outbreak of the H1N1 virus—people were not willing to visit public places at the time. The middle school students were divided into two groups that progressed through the five stations in sequence of teaching topics, in a staggered fashion. This allowed the undergraduates to present their activities twice during the workshop. The five stations are described in detail below.

Station 1. Middle school students were shown a video clip about natural phenomena, such as melting massive glaciers in
**Table 1. Course Schedule and Activities**

<table>
<thead>
<tr>
<th>Week</th>
<th>Topic</th>
<th>Activity</th>
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| 1    | Introduction  
Discussion on global warming | Students drew a model of global warming by answering what caused global warming  
Students generated questions about global warming |
| 2    | Atom/molecules, gases, pressure  
Combustion  
Kinetic energy and temperature | Demonstrations of a burning candle, paper and CO\(_2\) generation, a crushing can, dry ice, etc.  
Discussion on the relationship between combustion and photosynthesis  
Lecture on kinetic energy and its relationship to temperature  
Answering students’ questions from week 1 |
| 3    | Ozone layer | Lecture on the ozone layer to answer students’ questions and to clear confusion evidenced from week 1 on the difference between the ozone hole and global warming |
| 5    | History/basic idea of climate change | Lecture and discussion on climate change with the evidence in favor of our current model of climate change |
| 6    | Exam 1 | |
| 7    | Electromagnetic radiation  
Black body radiation dipole moments | Lecture with a presentation to cover the relationship between electromagnetic radiation and energy, wavelength and frequency and with a demonstration of blackbody radiation using a prism and overhead projector |
| 9    | Greenhouse effect | Demonstration of two aquarium experiments to show the effect of CO\(_2\) concentration on temperature |
| 10   | The 1st and 2nd Laws of Thermodynamics  
Conventional/alternative energy sources | Lecture on thermodynamics to bridge climate change and energy sources  
Lecture on energy sources |
| 11   | Exam 2  
Preparation of a global warming workshop (service-learning project) | Introducing global warming activities geared toward middle school students |
| 12   | Debate over global warming  
Preparation of a global warming workshop (service-learning project) | Reading papers written about global warming in two opposed positions  
Critically examining the papers  
Group discussion on global warming activities for the workshop |
| 13   | Global warming workshop practice | Rehearsal of the global warming workshop: each group of students implemented their activities to their peers |
| 14   | Global warming workshop (service-learning project)  
Screening of An Inconvenient Truth | Running 1.5-hour workshop with middle school students  
Discussion on the movie in relation to global warming |
| 15   | Final exam | Final research paper due |

**Table 2. Global Warming Workshop Topics and Activities**

<table>
<thead>
<tr>
<th>Topic</th>
<th>Questions</th>
<th>Activity</th>
<th>Station</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural phenomena</td>
<td>What is happening on the earth?</td>
<td>Discussion: students’ prior knowledge with video clip and pictures</td>
<td>1</td>
</tr>
</tbody>
</table>
| Causes | What is carbon dioxide?  
How can we detect carbon dioxide? | Chemical reaction: vinegar plus baking soda  
CO\(_2\) detection: BTB color change  
Combustion: burning and extinguishing a candle | 2 |
| Causes | What is the greenhouse effect? | Temperature change of a greenhouse model made with a 2-liter plastic bottle | 3 |
| Causes | What is the outcome of burning fuels? | Burning gasoline as opposed to the alternative fuels (e.g., ethanol, methanol) | 4 |
| Taking action | What can we do to reduce global warming? | Summary with a drawn model and discussion of how to reduce global warming | 5 |
the Arctic and floods attributed to global warming. Students were asked their thoughts on why this was happening, and a discussion on rising temperatures and climate change followed. The middle school students had indeed heard about global warming, but did not know much about its causes.

**Station 2.** To deepen middle school students understanding of concepts such as molecules and carbon dioxide, generation and detection of carbon dioxide were demonstrated. Vinegar and baking soda were mixed and the evolved CO₂ was collected in a balloon and blown through a straw into bromothymol blue (BTB) solution. The CO₂ formed carbonic acid (H₂CO₃), and resulted in a color change from blue to yellow in the BTB solution. This was compared to the color change when they gently blew through a straw into the BTB solution. Students also observed the extinguishing of a burning candle due to carbon dioxide.

**Station 3.** Middle school students constructed a greenhouse model using a two-liter bottle filled with a few inches of soil and covered with clear plastic wrap. For a control, they used another two-liter bottle left open to the atmosphere. A thermometer was placed inside each of the bottles, which were equidistant from a lamp. The change in temperature of each model, as a function of time, was observed. They soon discovered that the temperature of the wrapped bottle was increasing more quickly than the control bottle and discussed its possible causes. The undergraduates used an analogy between the greenhouse model and the earth to help students understand the greenhouse effect and the role of carbon dioxide.

**Station 4.** To compare the efficiency of different fuels, the undergraduates burned gasoline, ethanol and methanol in a crucible. Middle school students clearly observed smoke coming out of burning gasoline, comparing to smoke-free fuels. Residue from the combustion was also examined for each fuel. The amount of energy released (heat of combustion) was then compared to the amount of CO₂ released for each fuel.

**Station 5.** The undergraduates led a discussion on what middle school students learned from the four stations and asked them to draw a model of global warming, which was followed by a discussion on what steps they could take to reduce global warming.

**Assessment**

The purpose of the assessment was not to determine how much knowledge was gained by the undergraduates, but rather to assess how they self-evaluated the impact of this service-learning project. Immediately following the global warming workshop, the undergraduates were asked to write a reflection on this project by answering the following questions: What did you learn from this service-learning project? What worked and what did not work in this project? Did this project help you reinforce your understanding of global warming? Any other reflections? Any suggestions for this service-learning project?

**Results**

**What Did You Learn from this Service-Learning Project?** All of the undergraduates’ responses indicated that they learned pedagogical knowledge and skills, such as methods to explain global warming, how to get middle school students interested in their activities, how to interact with them, and how to ask appropriate questions. Some sample reflections are as follows:

- “I find it absolutely amazing as to how much we have covered over the semester. I admit I was concerned that I could not explain global warming in terms that a middle school student could comprehend . . . . Therefore, I was thrilled when the students seemed to understand what I was talking about.”
- “I learned a few things about how to interact with other younger students and also what is a good way to explain certain concepts in simple language. Asking questions was also important and it was a trial-and-error kind of thing, to find out what works and what doesn’t. Explaining something can be hard at times and also the language used is very important. Some things that worked were visual aides and using expressive language. Asking the right questions was also important, and not repeating oneself.”
- “I learned several things about the difficulties of teaching. Even for a simple experiments involving vinegar and baking soda became complicated when every step had to be explained in terms of its scientific significance. Also, I learned that I had to be prepared in a presentation to answer questions that my audience might ask.”
What worked and what did not work? Eleven out of fourteen responses indicated that the undergraduates felt everything went well. The other three responses included challenges in teaching middle school students. The undergraduates stated that:

- “I found complicated language not to work and also too many details affected their attention span. Staying focused and succinct is very important. A good approach was to progressively involve the students instead of revealing too much from the beginning. Letting them figure it out on their own is a great approach and it gets them more involved than just telling them everything. They are using their own brains instead.”
- “By participating in the service learning project I learned the importance of being able to explain a complex issue by synthesizing it into its various contributing factors. For the group I was in I think the visual aide of seeing the residue left by burning gasoline as opposed to the alternative fuels was very effective. The various numbers and conversions were a valid support but were not easily relatable to the audience.”

Did this project help you reinforce your understanding of global warming? All of the undergraduates appreciated this service learning experience and felt that this project helped them clarify their understanding of global warming. Sample responses included:

- “This project helped me reinforce my knowledge and understanding of global warming. It made me apply the topics we have learned in class. There are few classes where I actually am forced to apply what I learn, so this was a nice change of pace. There are so many possible ways to test a person's knowledge and by doing something like this, I thought it was a breath of fresh air. I feel that teaching someone about what one has learned is the best indicator of one's grasp on the subject matter.”
- “I think that this project did reinforce my understanding of global warming. Since I was in the introduction group, I really had to have a good grasp of what I was talking about.”
- “We learned so much in Chemistry 100 about global warming this semester, my understanding on the topic is not as blurry and much more refined. I felt that this workshop was an excellent way to test the knowledge we’ve gained this semester, as well as a great way to end the semester.”

Any suggestions? Four suggestions were made from the reflections. First, half of the undergraduates mentioned their disappointment about not having more students during the workshop, stating that “I have to admit I was really disappointed that more students did not show up. I understand that families are concerned about the H1N1 flu and venturing into public places when not necessary to do so. Obviously, there was no control over this—but for me at least, I think it would have been a more fulfilling experience for more students to come and take part in this workshop.” Second, six out of 14 undergraduates felt they needed more time to prepare for this workshop, saying that “I feel that more time for preparation may have resulted in greater confidence for all parties, so maybe in the future more time ought to be allotted for this project.” Third, four undergraduates provided a suggestion about more interactive experiments. Although some activities in this workshop were hands-on, they felt that students would appreciate it more if they engaged in even more hands-on experiments. Finally, two undergraduates suggested that each station should be in a separate room so as not to disrupt each other.

Conclusions
Conclusions are twofold. First, a teaching experience in the introductory chemistry course can be a great opportunity for undergraduates, especially education majors to improve their pedagogical knowledge and skills. It was evident from the results of the present study that the teaching experience helped the undergraduates become aware of the challenges present when explaining their knowledge of global warming to middle school students. In addition, it helped them recognize the importance of engaging students in hands-on activities, providing appropriate questions in middle school levels, and interacting with students when deliver their knowledge. According to Dewey (1933), such challenges motivate reflection on teaching and lead to learning from experience. The global warming workshop appears to be an opportunity to learn from experience.

Second, the undergraduates’ reflections indicate that the integration of a teaching component into the introductory chemistry course can reinforce their understanding of science
content. Although the global workshop project dealt with science content in middle school levels, it was necessary for the undergraduates to grasp the fundamental understanding of global warming in order to teach middle school students. They had to apply what they learned in the chemistry class to the teaching context, which required the process of knowledge transfer. In short, teaching experiences, like the global warming workshop, can be a powerful means for examining and reinforcing not only pedagogical knowledge, but also personal understanding of science content.

From the undergraduates’ suggestions, it was evident that they appreciated the experience of teaching students. They wanted to have more students. Providing undergraduates with more chances to interact with students can bring more benefits in transforming what they learn in college science classrooms into the context of teaching K–12 students, as long as an ample amount of preparation time is given.

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References