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Wm. David Burns

Editors
Trace Jordan
Eliza Reilly

Managing Editor
Marcy Dubroff

National Center for Science and Civic Engagement
1604 New Hampshire Ave., NW
Washington, DC 20009
202.483.4600
www.ncsce.net

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Contents

From the Editors

This issue of the journal continues our tradition of publishing peer-reviewed scholarship that uses issues of civic importance to enhance science and mathematics education.

We are pleased to highlight three articles in a featured section on "Mathematics and Civic Engagement." Rikki Wagstrom from Metropolitan State University (Minneapolis, Minnesota) contributes a research article titled "Teaching Pre-College Algebra Mathematics Through Environmental Sustainability: Curriculum Development and Assessment." Prabha Betne provides a project report on "Project Quantum Leap," an innovative mathematics curriculum at LaGuardia Community College in New York City. A second project report by Laura Jacobsen and Jean Mistele at Radford University (Radford, Virginia) describes challenges and effective strategies when introducing social issues into a mathematics education curriculum for pre-service teachers.

This issue also includes a "Teaching and Learning" section in which the authors share strategies to promote student learning and engagement. Antonio Villaseñor and Farahnaz Movahedzadeh from Harold Washington College (Chicago, Illinois) describe the impact of inviting a research scientist as a guest lecturer in a community college biology course. We should also mention that the first author of this article is an undergraduate student at the college. On a different topic, a team of three authors—B.D. Stillion and J.M. Pratte of Arkansas State University (Jonesboro, Arkansas), and A. Romero of Southern Illinois University–Edwardsville (Edwardsville, Illinois)—describe their use of "Science in the Cinema" to examine and challenge students' stereotypes of scientists.

The remaining articles in the issue contain a diverse set of project reports that provide insights into teaching molecular biology, connecting physics with service learning, and engaging non-majors with the chemistry of global warming. We wish to thank all the authors for sharing their work with the readers of this journal.

—*Trace Jordan and Eliza Reilly*
Co-editors in chief

Please Don't Do "Connect the Dots"

Mathematics Lessons with Social Issues

Laura J. Jacobsen and Jean M. Mistele
Department of Mathematics and Statistics
Radford University

Introduction

While internationally there is considerable interest among mathematics educators in social justice, the literature on mathematics teacher education for social justice is nearly nonexistent (Gates and Jorgensen, 2009). Among the limited existing literature is research such as Garii and Rule's (2009), describing student teachers' difficulties in planning lessons to integrate social justice with mathematics and science concepts. Garii and Rule concluded that student teachers needed additional support and guidance from faculty, extended over time, in order to develop their knowledge and confidence to present lessons meeting both academic and societal needs. For example, one difficulty faced is that teachers may have limited experience in making connections between the mathematics they teach and the real-world uses in technological and professional practice (Garii and Okumu, 2008).

DeFreitas and Zolkower (2009) explained how social semiotics tasks may enhance teachers' preparation to teach for diversity as well as their disposition toward mathematics and beliefs about the relationship between mathematics and social justice. Boylan (2009) emphasized the connection between emotionality and mathematics teaching for social justice, suggesting the need to create space for dialogue about emotional aspects of mathematics teaching and about sometimes oppressive and alienating mathematics classroom practices. Aside from occasional recent studies such as these, practically speaking, almost no attention has been given thus far to preparing preservice teachers to teach mathematics for social justice. Additional research is sorely needed.

The Mathematics Education in the Public Interest (MEPI) project is centered on goals to support equity and social justice in mathematics teacher education. MEPI's foundation rests on an assertion that mathematics curriculum and instruction can be improved by maintaining overlapping objectives that:

1. Incorporate National Council of Teachers of Mathematics (NCTM, 2000) standards-based reform practices;
2. Are more culturally relevant and responsive (e.g., Ladson-Billings, 1995);

3. Make use of individuals' and groups' funds of knowledge (e.g., Civil, 2007; Moll and Gonzales, 2004);
4. Engage learners more fully, more meaningfully, and more responsibly with their communities (e.g., Hart, Donnelly, Youniss, and Atkins, 2007); and
5. Explicitly aim to achieve social justice locally and globally (e.g., Frankenstein, 1989; Gutstein, 2006).

In recent years, an increasing number of mathematics educators have begun to ground mathematical investigations in meaningful personal and social contexts. A small group of teachers and researchers have begun to document students' experiences and learning from this process, as well as their own experiences and learning. Classroom practices and studies such as those in *Rethinking Mathematics* (Gutstein and Peterson, 2005) are among those helping to break the ground for defining and shaping mathematics education in new ways. For example, Turner and Strawhun (2005: 86) described New York City middle school students' mathematical investigations of overcrowding at their school, concluding: "Not only did opportunities to engage in responsive action support students' sense of themselves as people who can and do make a difference, but using mathematics as a tool to support their actions challenged students' view of the discipline." Brantlinger (2005) provided Chicago students with opportunities to research, assess, and compare the density of movie theaters, liquor stores, and community centers in their own communities to those in a mixed-income suburb. Brantlinger communicated the challenges and sometimes pitfalls of teaching mathematics in sociopolitical contexts, also suggesting the activity was powerful for many students.

This article describes research conducted in a junior-level Mathematics for Social Analysis course for elementary and middle grades preservice teachers, as part of the MEPI project. We summarize preservice teachers' overall reflections on their experiences in the course, and we discuss their experiences with writing K–8 mathematics lesson plans/units centered on social issues. We explain preservice teachers' struggles to balance emphases on mathematics, reform-based pedagogy, and social issues in these lessons. We describe the use of traditional and/or nonchallenging mathematics, the trivializing of social issues, the arbitrary connecting of social issues and mathematics, and the creation of artificial connections and questions about the social issues. We conclude by summarizing lessons learned from these challenges.

Math for Social Analysis

Math for Social Analysis is the third course in a three-course sequence of mathematics content courses for preservice teachers. All elementary and middle grades preservice teachers are required to take Mathematics Content for Teachers I and II, both of which are prerequisites for Math for Social Analysis. Math for Social Analysis is a required course in the elementary education program and is a strongly recommended course in the middle school education program. After completing this mathematics sequence, students later take a mathematics methods course in the education program.

Math for Social Analysis integrates mathematics content, reform-based pedagogy, and critical analysis of social issues. Preservice teachers and faculty identify social issues, such as endangered species, distribution of wealth, and child labor. We encourage preservice teachers to identify and use multiple mathematical methods to understand the relevant mathematics content and to become informed and to critique the social issues. Each classroom unit of study or semester project engages preservice teachers in group learning, and we encourage involvement based on the studies, which may contribute to positive social change.

In Math for Social Analysis, students choose between a service-learning option and a group research/teaching project option. For the group research/teaching project, each group of two to four students choose a social issue on a local, national, or global level. The group studies the issue, writing a research paper to answer the research question of their interest. Next, groups create two or three related mathematics lesson plans, including the relevant NCTM standards and state standards of learning across all disciplines relevant to the lesson. They then teach their classmates the issue, including the pertinent mathematics. Teaching the social issue across disciplines is encouraged, and the use of multiple solution methods to enhance the understanding of the mathematics is expected. We further expect preservice teachers to use inquiry-based and hands-on lessons, focusing on helping learners develop a deep understanding of elementary and middle school concepts.

For the service learning project, preservice teachers work with a local nonprofit community organization supporting low to moderate income families. They attend an orientation session and training sessions on discipline and conflict resolution and on cultural and economic diversity. Preservice teachers work with children at different after-school programs three hours each week, engaged in mentoring, tutoring, mediation, discipline, and activity planning and implementation (both mathematics-related and otherwise). They assist during recess and snack time and ride the bus as a chaperone or walk children home, thereby learning about their communities. Preservice teachers also prepare and present five mathematical activities designed to meet the interests and needs of the children assigned to them. One activity must include children's literature, two must address a social issue appropriate for the age of the children, and the remaining two are open. Each week, preservice teachers write reflections on their experiences. At the end of the semester, preservice teachers present to their classmates on experiences and learning over the semester.

Analysis

Final project lesson plan and course reflection assignments from fifty-two preservice teachers taking Math for Social Analysis in Fall 2008 and Spring 2009 were used as data for this article. Of these preservice teachers, sixteen (or 31 percent) had completed the service learning project option and thirty-six (or 69 percent) had completed the group research/teaching project option. However, regardless of which of the two project options preservice teachers had completed during the semester, all fifty-two preservice teachers completed the final project lesson plan and course reflection assignment. Feedback provided by the course instructor (a co-author of this article) to these preservice teachers was also included as data, given that this feedback addressed the ways in which lesson plans met—or did not meet—project guidelines and requirements for the mathematics content and for the addressing of social issues. All assignments were read and re-read multiple times analyzing overall course reflections as well as issues and challenges associated with creating mathematics lesson plans with social issues. These lesson plan assignments and reflections were coded and sorted to classify the issues and challenges into one or more of four different types, described below. Additionally, we summarize preservice teachers' reflections on their overall experiences of the course, in their own words. Our goal is to document the types of challenges faced overall. We do not aim to differentiate challenges faced by preservice teachers on the final project in relation to which of the two semester projects they had completed, given that those differences were relatively minor.

Issues and Challenges

> This assignment [of making lesson plans] was a good way for us to see if we can bring social issues into play with our own ideas, and make it interesting for our future students. It was a helpful way to see how long a lesson on a social issue will take to plan, and how we want to bring the issue and mathematics together without forgetting about the [state standards]. Knowing that the [state standards] must be included in a lesson is going to make having a social issue relevant to that particular [standard] more challenging than if there were no standards of learning that the teachers were forced to follow. —*Amy, preservice teacher in Math for Social Analysis class*

Our public-interest approach counters the traditional approach of teaching mathematics in mostly context-free environments or using artificial applications. In our approach, preservice teachers and faculty identify social issues of personal or professional interest for examination. Preservice teachers participate in determining which mathematical techniques provide insight on the issue. This encourages preservice teachers to listen to their data and draw their own conclusions on the issue, based on their mathematical analysis and understanding of the issue within context. Each classroom unit of study or semester project includes discussion in ways to take action and contribute to positive change. For example, one successful project asked students to think critically about the amount of clean water available in countries across the world and emphasized water conservation. Students estimated their own average daily water usage, compared and graphed average per capita water consumption in numerous countries, located those countries on a world map, examined children's books related to water conservation, converted water usage to different units of measure, discussed difficulties people face in countries where access to clean water is less, and calculated ways to reduce their own water usage.

In creating their lesson plans for their final projects, preservice teachers are reminded of the importance of teaching the mathematics itself, in the context of a social issue. This requirement is in contrast to the idea that a lesson might focus only on the social issue and assume students already know the required mathematics. For example, assignment guidelines require that if the lesson plan are carried out in a classroom, students must understand the mathematical topic in more than one way. Additionally in their lesson plans, preservice teachers are asked, specifically, to explain how they will teach the mathematics for understanding, such as through the use of manipulatives and/or drawings.

Overall, nearly all preservice teachers' projects demonstrated at least one high-quality component among mathematics, reform-based pedagogy, or social issues. However, some preservice teachers struggled to produce high quality in all three of these components at the same time. We characterize these struggles related to quality among the three components as a problem of balance. Many of the examples provided below simultaneously represent multiple challenges and are labeled as they are for descriptive purposes only. We organized the challenges they faced as:

1. Use of mathematics without mathematics instruction;
2. Use of traditional and/or nonchallenging mathematics;
3. Trivializing of social issues; and
4. Disconnect or artificial connections between social issues and the mathematics.

Use of Mathematics without Mathematics Instruction

One of the greatest challenges facing preservice teachers as they created MEPI lesson plans was the challenge of not only *using* mathematics in their lessons addressing social issues, but also simultaneously or in partnership *teaching* the relevant mathematics in their lessons. For example, one group of preservice teachers studied healthy diets and compared the old Food Pyramid and new MyPyramid. One of their related lesson plans involved having students use multiple fast food restaurant menus to select meals and then calculate the number of calories consumed by selecting meals that fit into the serving sizes specified in MyPyramid. Although the group's lessons proved interesting and informative according to our classroom standards for addressing social issues, nowhere in the lessons did the preservice teachers teach students how to do the mathematical operations required to answer the questions they posed.

Use of Traditional and/or Non-Challenging Mathematics

Occasionally mixed into preservice teachers' lesson plans on social issues were traditional mathematics worksheets with numerous procedural problems, such as a page of addition problems. Although we explicitly emphasized our expectations for lessons in writing and verbally, and we also modeled the kind of instruction we wanted to support, sometimes students paid too little attention to the mathematics component of their lessons. They struggled to balance quality emphasis on the social issues with quality emphasis on the mathematics, often *using* elementary school mathematics in relevant ways for understanding the social issues, but then *teaching* the mathematics in using very traditional approaches. In other cases, the mathematics content was trivialized or nearly nonexistent.

As an example of the most blatant limitations in mathematics content, one group of preservice teachers focused their lesson plan project on supporting animal shelters. One mathematics activity involved having students find the total number of cats and the total number of dogs in pictures. Included in their lesson packet was a worksheet of numerous simple calculations such as 4+4, 6+3, and 5+6. Other activities included a "connect the dots" of a dog and a rabbit. Sometimes, the social issue became so prominent in lesson plans that preservice teachers needed to be reminded of the need to focus on rigorous, challenging mathematics. We find ourselves sometimes having to rule out overly simplistic approaches to mathematics, such as by announcing to groups, "Please don't do 'Connect the dots.'"

Trivializing of Social Issues

In their attempts to connect mathematics with social issues, sometimes preservice teachers gave only cursory attention to the social issues. For example, one of our preservice teachers who chose the service-learning project described her intentions to create an activity addressing weather pattern changes and natural resource depletion. However, the mathematics activity she produced included seemingly random and isolated "social issue math word problems," none of which were based on any real-world data, such as:

- A forest in California contains thirty-five acres of trees. With all of the forest fires happening lately twenty-five of the acres have burnt down. How many acres are left in the forest?
- A farmer has seventy-seven acres of corn growing on his farm. Since there has been a drought, a lot of his corn is dying and he can only harvest thirty-three acres. How many acres have died because of the lack of water?

Disconnect or Artificial Connections between Social Issues and the Mathematics

Another struggle faced by preservice teachers was the effort to make meaningful connections between the social issues and the mathematics. Students created word problems with sometimes only cursory connections to the social issue at hand, or they asked questions where no one would care about the answer to those questions. For example, one preservice teacher completed a project addressing the topic of recycling in relationship to human consumption and waste. As the mathematical focus of his work, he chose the calculation of the weight of objects discarded or recycled, also addressing conversion of units.

However, he did not seem to realize this mathematical emphasis added no value to understanding the social issue. Without drawing connections to the topic of recycling, his mathematics lesson included mathematics questions such as:

- If an apple weighs 14 ounces, how much would that be in pounds?
- If a shoe weighs 43 ounces, how many pounds does the shoe weigh?

This preservice teacher did also include more meaningful questions in his lesson, such as, if a family is able to recycle or spare sixty pounds of garbage a week for an entire year, how much trash can the family recycle or spare in a year?

Preservice Teachers' Reflections on Overall Experiences

Feedback from preservice teachers on the Math for Social Analysis course has been mixed, but overall very positive. Our research demonstrates that a mathematics classroom focused on social justice can produce tensions for preservice teachers to resolve between their backgrounds with traditional mathematics and their new experiences using social issues and interdisciplinary applications to better understand mathematics and the world around them. Questions and concerns most commonly raised by preservice teachers relate to appropriateness of addressing social issues with elementary school students in general, or in the mathematics classroom in particular, as well as school emphases on "teaching to the test" to prepare children to pass state standardized tests.

Students universally label this course as their first extended experience with learning mathematics in connection with multiple meaningful real-world applications and social issues. Many of our preservice teachers enter Math for Social Analysis describing high levels of mathematics anxiety, and many have suggested that integrating social issues into the mathematics classroom has reduced mathematics anxiety (Mistele and Spielman, 2009),* which generated positive attitudes towards mathematics and teaching mathematics. In Mistele and Spielman (2009), we communicated how Math for Social Analysis proved beneficial in reducing mathematics anxiety among our preservice teachers by increasing the utility of mathematics, redirecting attention away from anxiety, and building confidence to teach.

One strength of the course thus far has been that preservice teachers develop greater understanding of how to integrate social issues and mathematics, and most describe their interest in incorporating social issues into their mathematics classrooms in the future. We have also previously reported on survey results that provided evidence that preservice teachers' views about mathematics and about mathematics teaching changed over the semester (Spielman, 2009). They came to see mathematics as increasingly useful for understanding and engaging with important issues and increasingly connected to home and community experiences. The following comments from Amy (the preservice teacher in Math for Social Analysis class quoted on page 12) summarize many of the preservice teachers' thoughts concerning this course:

> I will be able to make a difference for generations to come by making their math experience much better than mine was. . . . I liked learning about all of the different social issues . . . such as mountaintop removal, which I had no clue was happening until this semester . . . I [also] never knew about [manipulatives] such as algeblocks and base-ten blocks that can be used as an aid in teaching math . . . I possibly would have had an easier time with school work in math class . . . instead of just going through the motions and memorizing . . . . I thoroughly enjoyed this class and all of the knowledge that I have gained from it. I am now geared and ready to go out into the world and teach students

* Laura Jacobsen Spielman recently changed her name to Laura J. Jacobsen. Thus, references to Spielman are likewise references to the first author in the current article.

not only the lessons of math, but also the lessons of what is going on in our world.

Conclusion

Our mathematics teacher education classroom experiences have led us to a better understanding of the complexity of supporting preservice teachers to teach mathematics in the public interest. The challenges of helping preservice teachers who have primarily experienced traditional mathematics classroom instruction to teach in reform-based ways have been well documented in the literature. The use of mathematical applications having social relevance adds a new layer of complexity to mathematics instruction. Mathematics teacher educators will need to make explicit the multiple complex lesson plan objectives when carrying out similar project assignments with preservice teachers, also providing ongoing and detailed feedback to help preservice teachers be successful in their struggles to balance emphases on mathematics, reform-based pedagogy, and social issues. Preservice teachers clearly improved dramatically over the duration of the semester in their abilities to make connections between mathematics and social issues, and they suggested the course helped to reduce their anxiety toward mathematics (e.g., Mistele and Spielman, 2009; Spielman, 2009). However, as is clear from the summary of challenges presented in this paper, and similar to a suggestion made by Garii and Rule's (2009), it may be necessary for preservice teachers to have multiple, extended and mentored experiences with integrating mathematics content with social issues. Preferably, this would include support through a combination of coursework, internships, and student teaching.

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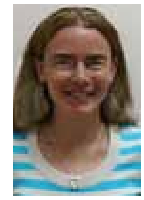
About the Authors

Laura J. Jacobsen is an assistant professor in the Department of Mathematics and Statistics at Radford University. She



completed her Ph.D. in mathematics education at Virginia Tech in 2006. Her primary research interests are in issues of equity and social justice in mathematics education, and she is principal investigator for the Mathematics Education in the Public Interest project funded by the National Science Foundation (Award Number: DUE-0837467). She is also interested in recruitment and retention of underrepresented populations in fields of science, technology, engineering, and mathematics. Contact: lspielman@radford.edu.

Jean Mistele is an instructor in the Department of Mathematics and Statistics at Radford University and currently on educational leave pursuing a Ph.D. in mathematics education at Virginia Tech. She is the co–principal investigator on the Mathematics Education in the Public Interest project, where her major research interest addresses equity issues related to mathematics and other literacy skills for elementary and middle school students. Other interests include researching reading skills associated with the mathematics textbook and mathematics specialists programs for professional development of in-service teachers. Contact: jmistele@radford.edu

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Project Quantum Leap and SENCER at LaGuardia Community College

Prabha Betne

Department of Mathematics, Engineering, and Computer Sciences
LaGuardia Community College

Introduction

The majority of students entering community colleges are unprepared for college. A large number of the incoming students are placed into basic-skills math courses. At LaGuardia, more than half the students need basic-skills math courses, and more than 60 percent aspire to obtain a baccalaureate or higher degree. More than 60 percent of the students specified their major to be in science or applied sciences. More than half of LaGuardia graduates transfer to a four-year institution to pursue higher degree (CUNY, 2009: 15–34). Many of these students start at the basic skills level. Succeeding in basic math skills is important for students to stay in college and successfully complete their degree. Yet at community colleges, now the major gateway to higher education in this country, remedial classes accounted for approximately 57 percent (Lutzer, et al., 2005: 138) of mathematics program enrollments. Nationally, however, pass rates in remedial math remain lower than those for remedial writing and reading. Lack of math skills proficiency has a major effect on student retention (Parker, 2005).

Students in basic math courses have often had repeatedly unsuccessful experiences, viewing the subject as uninteresting and irrelevant. More than 35 percent of the students in basic-skills math courses retake the course at least once. We need to convince these students that mathematics makes sense and provide them with the tools and opportunities to think and reason. They are perhaps most in need of an approach such as SENCER—an interdisciplinary approach to teaching math and science that can deepen the settings and contexts and engage them. Some of the other approaches—such as the discovery method and inquiry-based learning—may seem unfocused without establishing an overall "compelling context." Most textbooks that use a problem-solving approach discuss applications that are disconnected and none of which can be explored deeply enough to become compelling. Instead, in adapting the SENCER approach, we can create a single, engaging context to be explored throughout the entire semester. The Project Quantum Leap (PQL) program at LaGuardia Community College, New York, was established to explore the SENCER approach to improve the basic-skills math education.

Method

To support the plan of adopting the SENCER approach to improve students' success in math basic skills, several mathematics faculty (Drs. Frank Wang, Gordon Crandall and I) and Dr. Kamal Hajallie (chair, Department of Mathematics, Engineering, and Computer Science) collaborated with Dr. Paul Arcario (Dean of Academic Affairs), and Dr. Bret Eynon (Director, LaGuardia Center for Teaching and Learning [CTL]) and applied for a U.S. Department of Education grant FIPSE (Fund for Improvement of Secondary Education) for $500,000 over three years (2007–2009). The project was funded.

The goal of the PQL project is to adopt the SENCER approach of teaching to a new setting and population: high-risk, urban community college students in basic-skills mathematics classes. The funding provided support for developing the required teaching material, training core faculty, and implementing the SENCER approach in classrooms. The project recently received support for an additional two years through a U.S. Department of Education Title V CCRA/STEM grant. The three courses targeted for the SENCER approach are Introduction to Algebra (MAT095), Elementary Algebra (MAT096), and College Algebra and Trigonometry (MAT115). MAT095 is the first basic-skills course and includes topics mostly in arithmetic; MAT096 is the second basic skills course and includes basic algebra topics; and MAT115 is a bridge course between math basic skills and pre-calculus. To contextualize the math topics, different themes were selected for each of the courses—environmental issues for MAT095, public health issues for MAT096, and financial issues for MAT115. The participating faculty attended professional-development seminars conducted by the PQL leaders with support from the LaGuardia CTL in order to develop the teaching materials and to discuss ways to implement them in the classes.

First Year

In the first year of the project, eight faculty from mathematics joined one faculty each from English, critical thinking, economics, and accounting and managerial studies for a year-long professional development seminar. Participants were divided into three teams corresponding to the three courses: MAT095 led by myself; MAT096 lead by Dr. Frank Wang; and MAT115 lead by Dr. Gordon Crandall. All participants from mathematics were also required to teach at least one section of the math course corresponding to their team. The four faculty not from math departments were involved in course pairs and learning-community settings with the targeted math courses. During the first semester, the math and non-math faculty pairs worked together to plan and develop joint class activities and projects. The paired courses were taught in the second and subsequent semesters.

Dr. David Ferguson (Distinguished Service Professor of Technology and Society and Applied Mathematics and Statistics at Stony Brook University and Chair of the National SENCER Leadership Fellows Board) joined us as a consultant during the first year. He provided insight into the SENCER philosophy and discussed ways to engage students in the classroom by providing examples of his own teaching lessons. Seminar activities were designed by the faculty leaders to engage the participants in studying several existing SENCER course models (SENCER, 2009) and discussing the issues related to adaptation to the LaGuardia setting.

We drafted and shared curriculum units and activities that link the chosen contexts to sequential development of mathematical skills and understandings. Many activities were shorter and more suitable for half-hour in-class activity, while other activities were lengthier and more involved, which are ideal for homework assignments following up to classroom discussions. Other activities included multiple math topics designed to be used as a synthesis of several math concepts contained in the course. Some activities were developed to review a specific math topic. A few were intended for introducing specific concepts to motivate students to learn math. Most of the activities required some writing by students to encourage them to use numerical facts in making decisions or to articulate their understanding of the non-math context. The more involved activities also asked students to write their reflections about learning math through such activities. Three websites were created as resources to collect research, articles, and links that faculty could use to contextualize the themes of their course.

In the second semester, all participating faculty were required to implement at least two larger and three smaller PQL-SENCER–type activities in their classrooms. These PQL classes were similar to the regular math basic-skills sections, with thirty students in each class. No special selection method or criteria was used to assign students into the PQL classes. Although all basic-skills math courses have a common departmental syllabus and textbook with online component for tutorial, homework, and quizzes, the participating faculty were asked to prepare a one-page syllabus cover sheet describing the purpose of SENCER approach and listing the various projects they were going to work on in the course. Attention was paid to ensure that the PQL-SENCER type activities were spread throughout the course and was integrated in our teaching. Students' math work and written responses to the activities were graded by the instructor and were part of the overall grade in the course. Two assessment instruments, Community College Survey of Student Engagement (CCSSE) and ACT, a national college admission and placement examination, were used for the assessment purpose. Pre- and post-student surveys were administered to measure the increase in student engagement with math and satisfaction with math courses that were taught using the PQL-SENCER approach. The pre- and post-student surveys were also administered to comparable (matching the time of the class, day or evening, and instructor type, more experienced or less experienced) non-PQL math section to compare the gains.

Second Year

To support faculty with content and resources in the areas of the environment, public health, and finance, we invited three consultants to present relevant information in the seminar and to lead discussions. This helped us find reliable resources and build knowledge for the activities, which allowed us to conduct insightful class discussions and to make the activities more powerful and relevant to the students.

Eight additional mathematics faculty joined the returning seven faculty members. In addition, one faculty each from critical thinking, English, and oral communication joined for the second-year PQL seminars. The four non-math faculty taught paired courses in learning community set-up. Over the course of the second year we refined and implemented the activities in our teaching. As in the first year, the pre/post student surveys and the assessment instruments were administered to track effectiveness. Seminar activities included discussions about writing lessons, shared lesson write-ups, and feedback. The lesson write-ups incorporated faculty reflection about conducting the activity and students' responses to the activity. A collection of twenty-four lessons were internally published as a sampler, available through the LaGuardia CTL website. This collection served as a teaching resource for current and future faculty. Environment-oriented math lessons in the sampler included diaper debates, asthma and air pollution, and the height and thickness of dust cloud. The public-health math lessons included topics ranging from the HIV and AIDS epidemic to the analysis of cheddar cheese cubes. Math lessons involving business and finance covered topics such as car buyers in Asia, investment rates, rising gas prices, and price per square foot.

Third year

A third cohort of seven full-time math faculty, six adjunct math faculty, and one faculty from the adult and continuing education department joined sixteen returning faculty in the Fall 2009 PQL program. To engage experienced PQL participants in advanced/leadership work, we divided participants into an advanced PQL group (ALEC [Advanced Leadership and Curriculum]) and a new participants group (intro PQL). The ALEC team—lead by Drs. Yasser Hassebo, Judit Torok, and myself—was responsible for leadership initiatives to advance PQL goals both within and outside the college via workshops, conference presentations, collaborations with other institutions, writing journal articles, mentoring junior and adjunct faculty, strengthening pedagogy, reshaping curriculum, and deepening teaching practices. In addition to sharing and revising PQL-SENCER activities and projects, the seminar activities also consisted of researching and discussing relevant articles in the areas of student-centered teaching approaches, curriculum development, assessment issues, and the scholarship of teaching and learning. The intro-PQL team—lead by Drs. Gordon Crandall, Frank Wang, and Roslyn Orgel—continued to explore the SENCER approach, develop additional new activities, and adopt existing activities from the sampler into their teaching.

Result

Over the three years, thirty-three math faculty and seven non-math faculty have participated in PQL seminars who taught twenty-six PQL-math courses and thirteen PQL-math learning communities and approximately one-thousand students were served. Together, faculty have created twenty-four class projects and activities that are part of the PQL sampler. A preliminary analysis of the students' responses to the CCSSE survey data from 2008–2009 shows that students in PQL classes demonstrated more confidence, comfort, and engagement with mathematics, when compared with students in non-PQL comparison classes (Table 1).

TABLE 1. Student Attitudes Towards Math for PQL Versus Comparable Non-PQL Classes

Question	PQL Classes (%)	Non-PQL Classes (%)
Find math interesting and enjoyable (percentage answering "agree" or "strongly agree")	71.3	44.1
I am confident writing reports using data as evidence (percentage answering "agree" or "strongly agree")	55.3	35.1
How much has your experience contributed to knowledge, skills, and personal development in thinking critically and effectively? (percentage answering "quite a bit" or "very much")	76.6	55.0

Table 2 compares the pass rates for PQL classes with non-PQL classes. Overall, the course pass rates in PQL classes is 54.7 percent compared with 47.6 percent in non-PQL comparison classes. However, these gains were concentrated in MAT095 and MAT115 courses. We continue to collect data and plan to conduct further analysis using appropriate statistical procedures. We hope to share a more-detailed and complete version of the results in the near future.

Discussion

Many issues in our civic life depend on quantitative information and our ability to synthesize that information to make decisions. The preliminary results suggest that the PQL-SENCER approach has a positive impact on students' quantitative literacy skills (Madison and Steen, 2008) as well as on the course pass rate. The benefits of adopting the SENCER approach, however, has not affected all courses equally, especially the Elementary Algebra course.

The outcomes in the college-level course College Algebra and Trigonometry matched our expectations: the increased confidence in science skills, interest in science, and civic behavior have been noted with SENCER approach applied to college level courses in other institutions (SENCER, 2006).

TABLE 2. Pass Rate Comparison for PQL Versus Comparable Non-PQL Classes

Pass Rate	PQL classes (%)	Non-PQL classes (%)
MAT095 course	46.6	44.8
COMPASS*	89.5	80.7
MAT096 course	40.5	42.3
COMPASS*	77.4	84.3
MAT115 course	74.9	64.7

* A computer-adaptive standardized college placement test,

The Introduction to Algebra course showed only slight improvement in pass rate. Though not consistent, students' comfort level in using math improved. This is a course in arithmetic, designed to develop number sense, percentages, proportions, and basic geometry—everyday math. It provides ample scope for engaging students using current issues such as the environment, with many reports, articles, and data directly related to the math. Due to an overabundance of topics to be covered in a short period of time, however, both students and instructors found themselves unable to pursue a topic of particular interest in greater detail.

MAT096, Elementary Algebra, did not show similar gains. The reason for this could be multifold. Much of the content is based on algebraic manipulation skills, with little or no applications. There is a very limited scope in the curriculum to interpret the solutions. The topics discussed include concepts related to linear equations, solving liner and quadratic equations, and equations with rational expressions and radicals. In a technique-based course as this, many students find the discussion related to the interpretation of numbers out of context. Real-life problems often involve more complex models than those covered in the course. An overloaded curriculum also limited the use of SENCER approach in this course.

The math basic-skills students at LaGuardia College have to pass the course as well as the COMPASS standardized test—a computer-adaptive college placement test—in order to exit math basic skills. The course syllabi include all topics covered in the COMPASS exam. While we want students to develop the basic math skills and pass the COMPASS exam, we also want to prepare them for college-level math courses and the non-math courses for which basic math is a prerequisite. The PQL-SENCER approach appropriately addresses these objectives.

Each of these issues and objectives were discussed in the seminar at length. To incorporate the SENCER approach throughout the course we proposed using smaller activities. To tackle the overloaded curriculum, we are revising the curriculum by combining some topics and reducing the emphasis on others. In addition, we are exploring and piloting active-learning pedagogy in the classroom to improve student engagement in class.

Faculty training and the availability of resources are important components of any project intended to have impact on the outcome of an entire course. We have already trained thirty-three faculty (including adjuncts) in the math department and continue to train more. Resources and activities with complete lesson plans are being collected and are available online. We also are in the process of revising the common syllabi for the basic-skills courses to include PQL-SENCER-type activities and elements of student-centered pedagogy. With the available resources and support, we believe that we will be able to use the PQL-SENCER approach to teaching in most sections of basic-skills courses, as mentioned in the PQL project proposal.

Certainly much work remains to be done. It is possible that, while this approach is effective in certain types of courses, it may not be as effective in other courses. This requires further inquiry. The impact on follow-up courses taken by these students will also need to be studied. With strategies in place to follow up on these details, we hope to discover a methodology to improve basic-skills education and design a curriculum that is rich enough to engage students so their interest in math and science continues to grow.

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About the Author

Prabha Betne (Ph.D., 1994, University of Missouri-Columbia) is an associate professor in the Department of Mathematics, Engineering, and Computer Sciences at LaGuardia Community College, New York. Previously, she was a research statistician at the Columbia University and credit risk manager at Citigroup. Her research interest is to develop strategies to improve teaching basic mathematics and statistics.

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Teaching Pre-College Algebra Mathematics Through Environmental Sustainability

Curriculum Development and Assessment

Rikki B. Wagstrom
Department of Mathematics
Metropolitan State University

Introduction

The curriculum detailed in this article was developed for use in a pre-college algebra course, MATH 101 Exploring Functions, offered at Metropolitan State University (2009), an urban institution with a strong commitment to civic engagement. The new curriculum was developed with the objective of engaging students' interests in the study of mathematics and improving mathematical learning.

During the early 1990s, a formal study assessing the impacts on student learning of a college algebra curriculum (*Earth Algebra*) integrating civic/environmental issues was undertaken by Christopher Schaufele and Nancy Zumoff at Kennesaw State College. The *Earth Algebra* text, developed by Schaufele et al. (2003), applies algebraic content and data analysis to a quantitative exploration of anthropogenic greenhouse gas emissions and global warming. In their 1996 report to the Office of Post Secondary Education, U.S. Department of Education, they provide a detailed description of their study (Schaufele and Zumoff, 1996). Pre- and post-course tests assessing algebraic skill, data analysis achievement, mathematical modeling capability, and personal attitudes were administered to students enrolled in both traditional sections of college algebra and those enrolled in sections using the *Earth Algebra* text. Statistical analyses revealed that *Earth Algebra* had no different effect on students' knowledge of algebra when compared to traditional sections of college algebra, despite the decreased emphasis on traditional algebraic skills and concepts in the *Earth Algebra* course. Sections using the *Earth Algebra* curriculum did show statistically significant gains in the areas of data analysis, mathematical modeling, and attitudes toward mathematics over traditional sections of the course.

Other existing lower-level mathematics texts integrating environmental issues include *Environmental Mathematics in the Classroom* edited by Fusaro and Kenschaft (2003) and *Mathematical Modeling in the Environment* by Charles Hadlock (1999). These texts, appropriate for use in general education or mathematical modeling courses, apply mathematical modeling techniques to a diverse range of environmental issues.

In light of the Kennesaw State College project and other existing mathematics curriculum integrating environmental issues, the significance of the present project described in this report can be summarized in the following two points:

1. The MATH 101 curriculum is the first curriculum to integrate environmental sustainability issues, quantitative reasoning, and mathematical modeling into pre-college algebra level mathematics.
2. The MATH 101 assessment study supports the gains observed in the Kennesaw study. The MATH 101 study furthermore suggests that mathematical performance may be enhanced by teaching course content from a modeling perspective and integrating real-world applications.

Curriculum Development

The MATH 101 curriculum consists of a workbook—which serves as the textbook for the course—and two sustainability projects. The workbook has been in the development process since Spring 2008. By Fall 2008, the organization of the book had stabilized, and most revisions were minor. Beginning Fall 2008, two sustainability projects exploring ecological footprints were added. Between Fall 2008 and Summer 2009, six sections of MATH 101 piloted the workbook. The two projects were incorporated into all of these later sections except for one concentrated summer session course. Each project was completed outside of class over a three-week period.

The workbook begins by introducing four key modeling concepts: (1) functions, (2) unit analysis, (3) measurement of change, and (4) linear and exponential trends. Unit analysis, or rather, deriving mathematical relationships (equations) between quantities by using their units, serves several functions in this course. It is used for (1) motivating fraction arithmetic, (2) making "back-of-the-envelope" quantitative estimates, and (3) deriving and correcting mathematical models (linear and rational functions). In this first segment of the course, students also explore how change is measured over time. Students calculate and interpret average rates of change as well as percentage changes in a diverse range of real-world contexts. Students then proceed to study trends resulting from quantities that exhibit either a constant rate of change or a constant percentage change, that is, linear and exponential trends.

These four modeling concepts come together to derive equations for linear and exponential functions. The remaining sections of the workbook focus on modeling with linear and exponential functions, interpreting rates of change in other contexts, introducing inverse functions and logarithms, and developing and applying algebraic skills.

The two sustainability projects were designed to enable students to apply the quantitative reasoning, mathematical modeling, and algebraic skills acquired to the topic of ecological footprints and biocapacities. (The Global Footprint Network (2010) defines the ecological footprint as a measure of the demand a country places on its biological resources, while a country's biocapacity represents the supply of biological resources available (World Wide Fund for Nature 2009.)

The first project focuses on estimating ecological footprints, as defined by the Global Footprint Network. Students use unit analysis to create a per capita carbon footprint calculator for gasoline-powered automobiles. The calculator they derive is a rational function with four independent variables, namely the fuel efficiency of the vehicle, the average daily miles driven, the ridership of the automobile, and the average rate of carbon dioxide uptake (tons per acre per year). Students use their function to study the affects of each variable on the carbon footprint, and to estimate their own carbon footprint. In the second part of this project, students use unit analysis to estimate the amounts of cropland required per capita to meet current U.S. demand for a few food staples. Comparisons of all of the footprint estimates (for food and carbon sequestration) give students a relative measure of which demands require the greatest land use.

The second project explores the impact of population growth in the United States on per capita biocapacity and the hypothetical policies to eliminate U.S. overshoot by the year 2050. Students use a linear regression population model, obtained from U.N. data, to project population growth out to 2050 (U.N. 2007). They also use this model to create a per capita biocapacity model, a rational function, which they use to project the decrease in land availability up through the year 2050. In the second half of the project, the students create mathematical models, exponential functions, to explore hypothetical policies for reducing the total U.S. carbon and forest footprint, the two largest components of the U.S. ecological footprint, to sustainable levels by the year 2050.

Assessment

During the summer of 2008, the Human Subjects Review Board for Metropolitan State University approved an assessment study to evaluate the new curriculum. Nine sections of MATH 101 participated in the study between Fall 2008 and Summer 2009. Six sections piloted the new curriculum and three used a more traditional curriculum. Of the thirty-two students originally enrolled in eight of the sections, the number completing the course varied from seventeen to twenty-two in the sections using the piloted curriculum and from nineteen to twenty-one in sections not using the piloted curriculum. One section of MATH 101 using the piloted curriculum was offered during Summer 2009; it enrolled nine students of which eight completed the course. Ultimately, 167 students both completed the course and consented to participate in the study. Of these students, sixty-one were enrolled in the three sections that were not using the piloted curriculum. Of the six sections using the piloted curriculum, five sections were taught by the author of the curriculum.

The following assessment tools were used:

- **SENCER math SALG pre-course and post-course surveys.** These surveys collect demographic information about the students, and evaluate changes in student interest and confidence in using mathematics (SENCER, 2009). The surveys were administered in all sections of MATH 101 using the piloted curriculum. Of the 106 students completing both surveys, pair-wise comparison was possible for only ninety-seven students. Only the results from these ninety-seven students are included in the study. Of these students, thirty-six identified themselves as males, sixty identified themselves as females, and seventeen students identified themselves as African American, Asian, or Hispanic.
- **Pre-course quizzes.** Quiz content focused on making plausible estimates, solving linear equations and inequalities, and determining rates of change and percentage change. These closed-book quizzes were collected after 15 minutes and were not returned to the students. The quizzes were administered in five of the six sections of MATH 101 using the piloted curriculum.
- **Final examinations.** Pre-course quiz questions were embedded within the final examination for sections of MATH 101 taught by the curriculum author. Instructors teaching three sections of MATH 101 who were not using the piloted curriculum, were asked to choose questions on this final examination that they felt were appropriate for their students and embed these questions on their final exams.

Figure 1 compares the percentage of correct responses to questions on the pre-course and post-course mathematics assessments. Questions 6a–6c evaluate students' abilities to solve linear equations and inequalities. Questions 9 and 10 are quantitative literacy/reasoning questions. Questions 9a and 9b ask students to calculate the percentage increase and the average rate of change of the world's population, respectively, between 1970 and 2005. For question 10, students are asked to estimate the total cost to the taxpayers of a city for environmental hazards resulting from the disposal of plastic bags.

Figure 2 compares the percentage of correct responses on selected final examination questions between students enrolled in sections of MATH 101 using the piloted curriculum and sections not using the new curriculum. Because instructors were free to select which questions they wanted to include in their final examinations, the sample size varied by question. For all questions, the sample size for the sections using the new curriculum ranged from eighty-nine to 106, while the sample size for the sections not using the new curriculum ranged from forty to sixty-one.

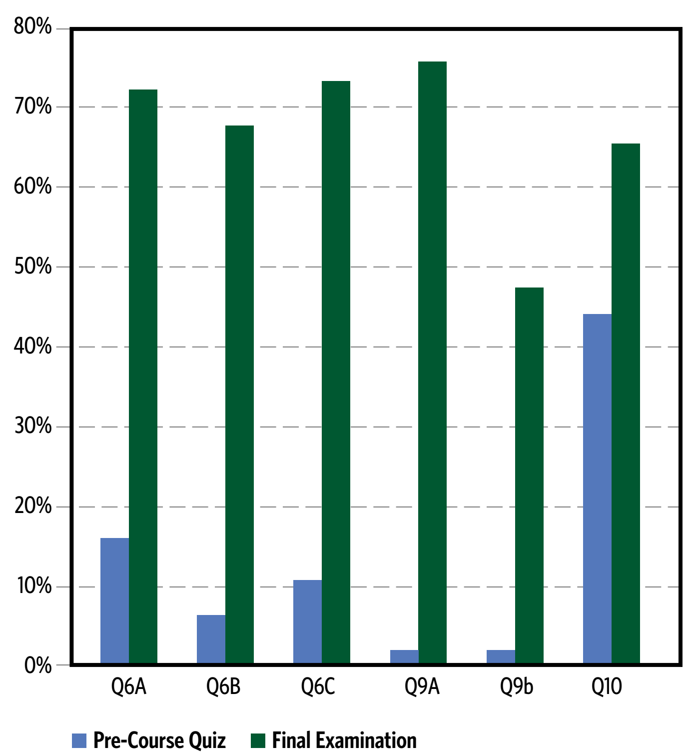

FIGURE 1. Percentage of Correct Responses, Pre-course and Post-course Mathematics Assessments

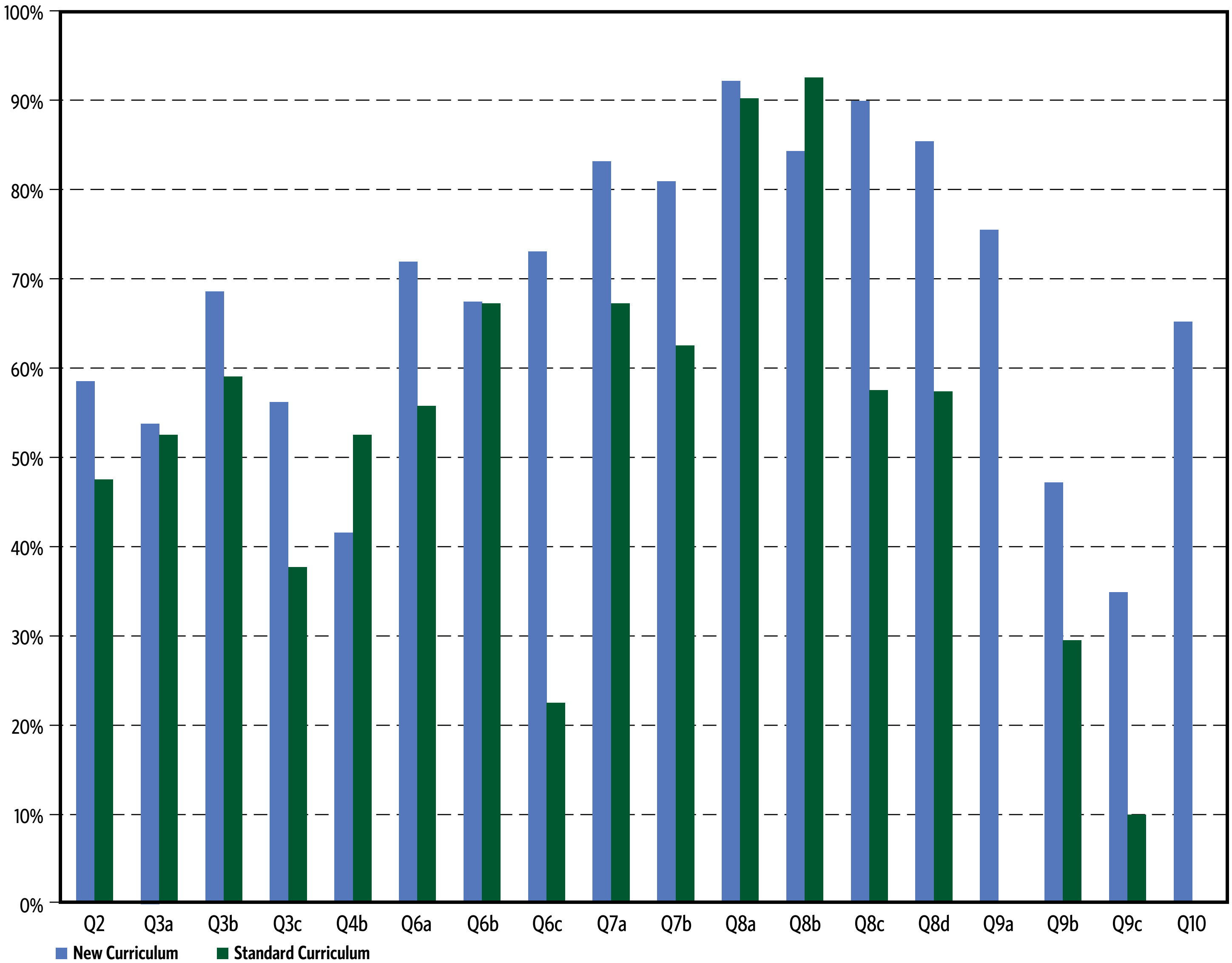

FIGURE 2. **Percentage of correct responses on selected final examination questions between students in MATH 101 using the new curriculum and those using the standard curriculum.**

Question 2 assesses students' understanding of slope. Questions 3a–4b ask students to determine equations of lines and exponential functions. Questions 7a–8d evaluate students' understanding of function notation. Questions 6, 9, and 10 are described above, with the exception of 9c. This question asks students to provide a one-sentence practical interpretation of the average rate of change obtained in question 9b.

Figures 3–6 highlight the results from administering the SENCER math SALG in six sections of MATH 101 using the piloted curriculum. Questions 1.2–1.10 solicit information regarding students' confidence in using mathematics. Questions 2.2–2.11 solicit information about students' interest in learning and using mathematics. For each question, students rate either their confidence level or their interest level on a scale from 1 (not confident or interested) to 5 (extremely confident or interested). The figures show the p`.

Conclusions

Trends in the data obtained from this study do suggest that the MATH 101 curriculum integrating civic/environmental issues is (1) at least as effective as a traditional mathematics

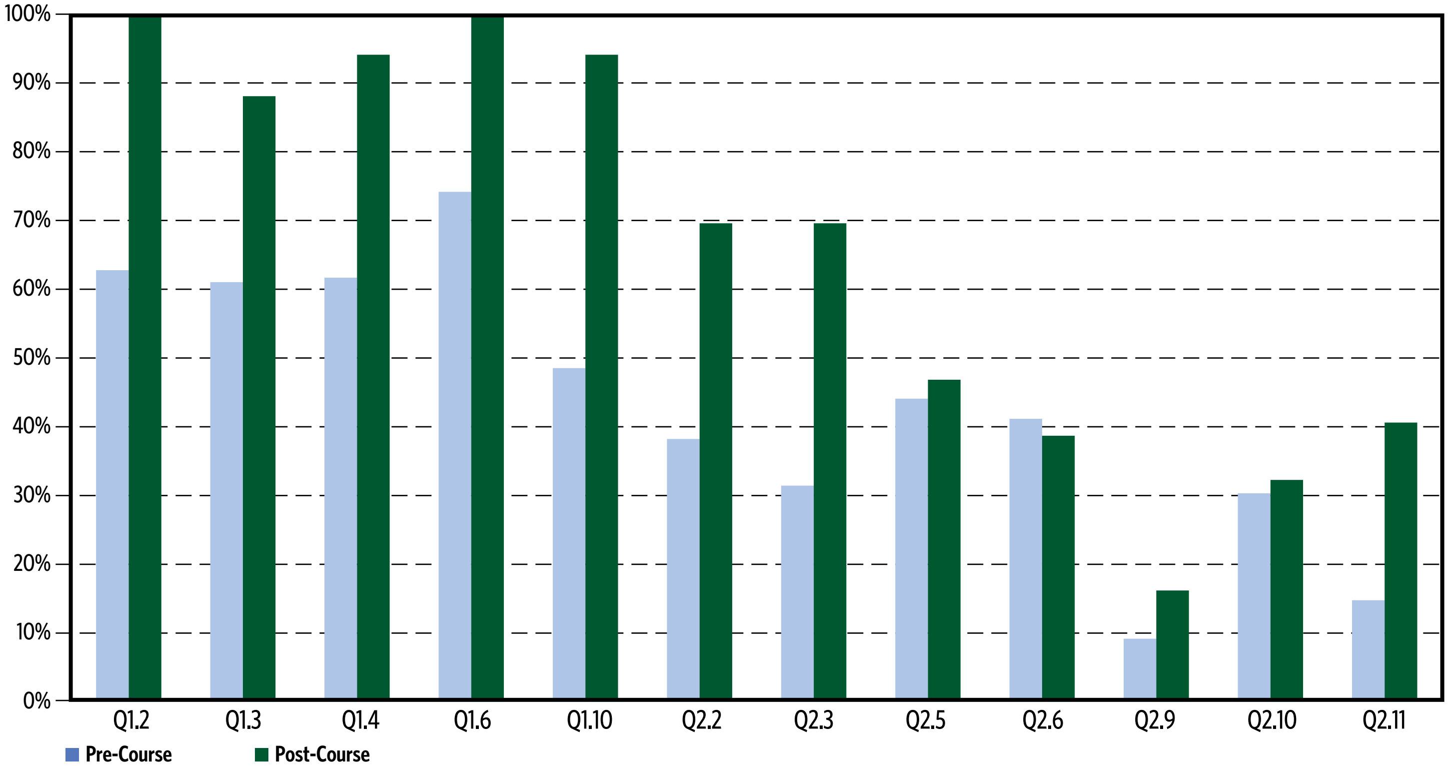

FIGURE 3. **Percentage of students who rate their confidence level or their interest level in MATH 101 at 3 or higher, aggregate results.**

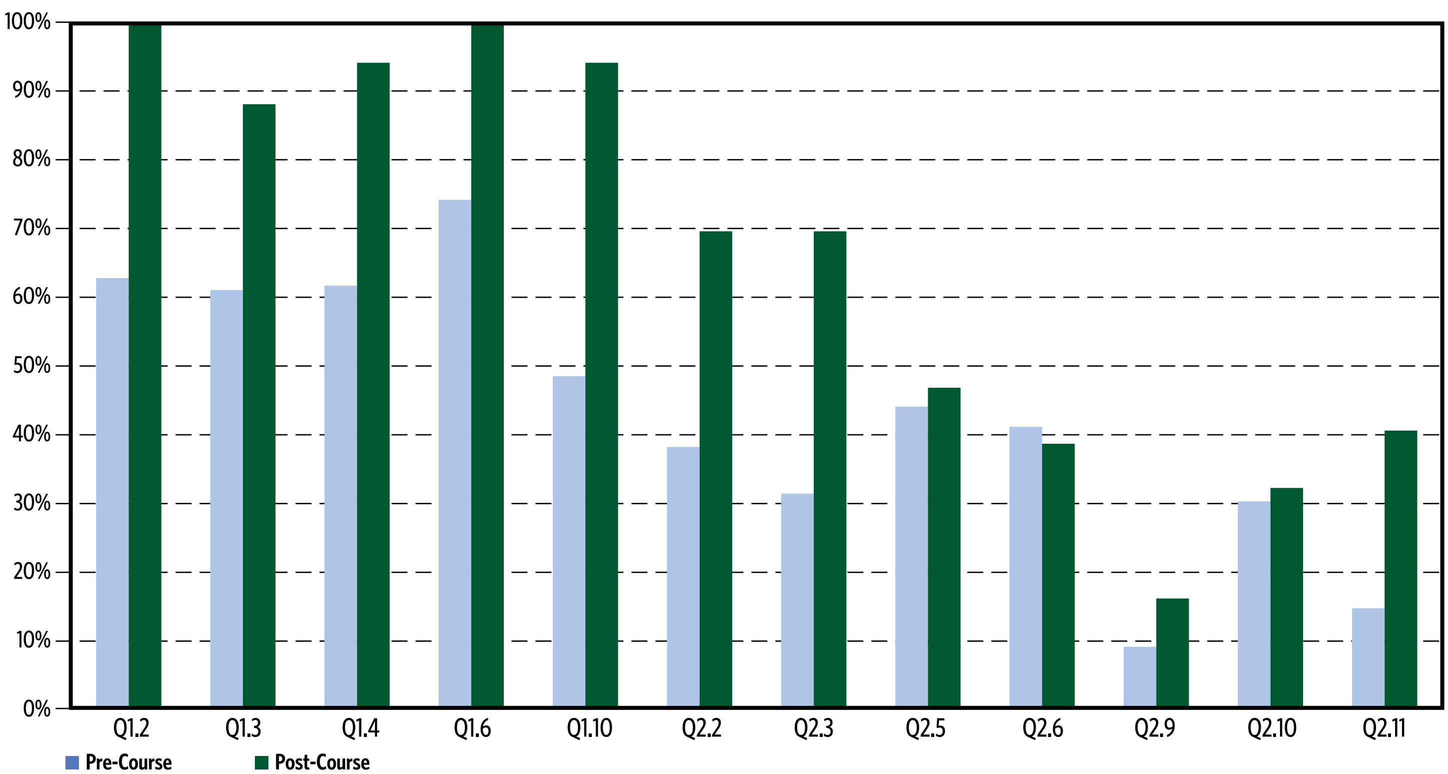

FIGURE 4. **Percentage of male students who rate their confidence level or their interest level in MATH 101 at 3 or higher.**

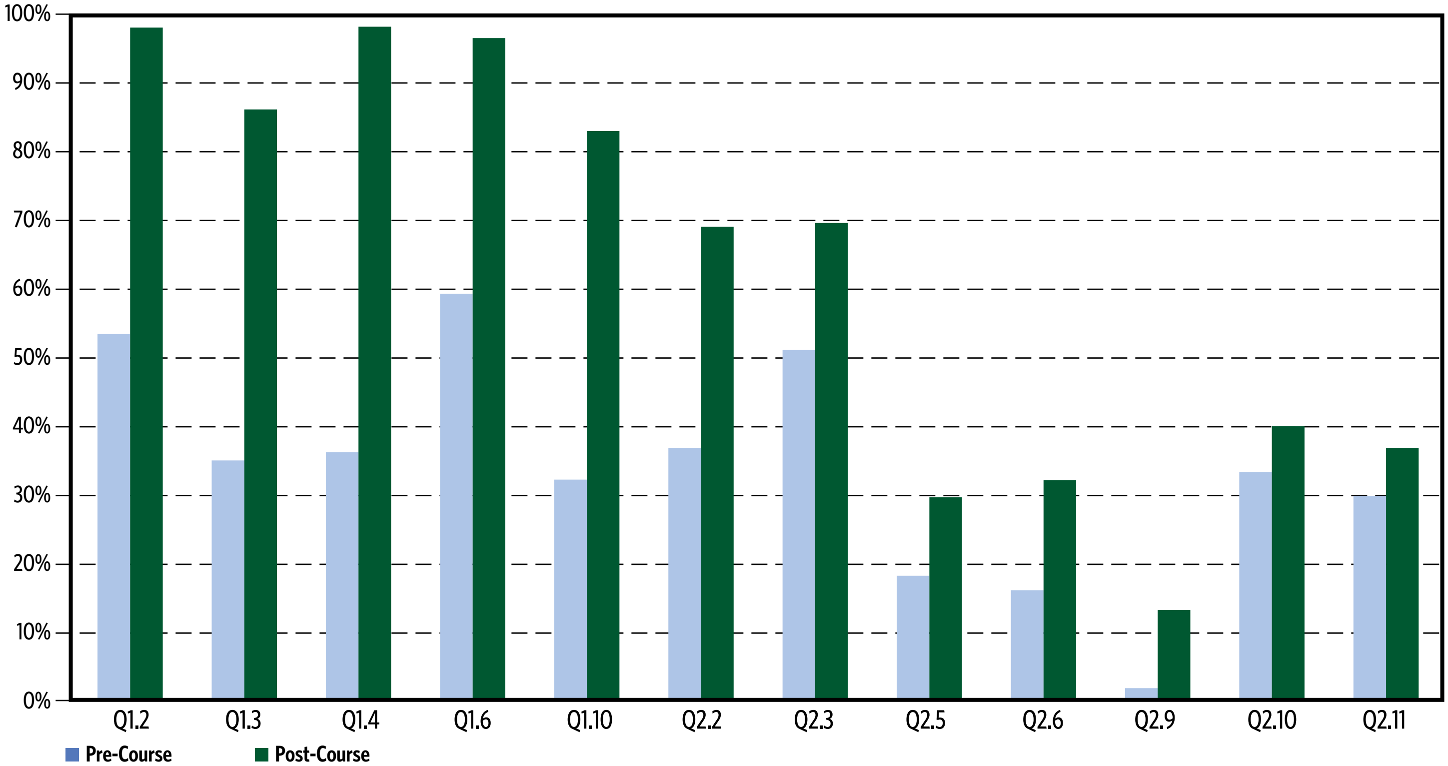

FIGURE 5. Percentage of female students who rate their confidence level or their interest level in MATH 101 at 3 or higher.

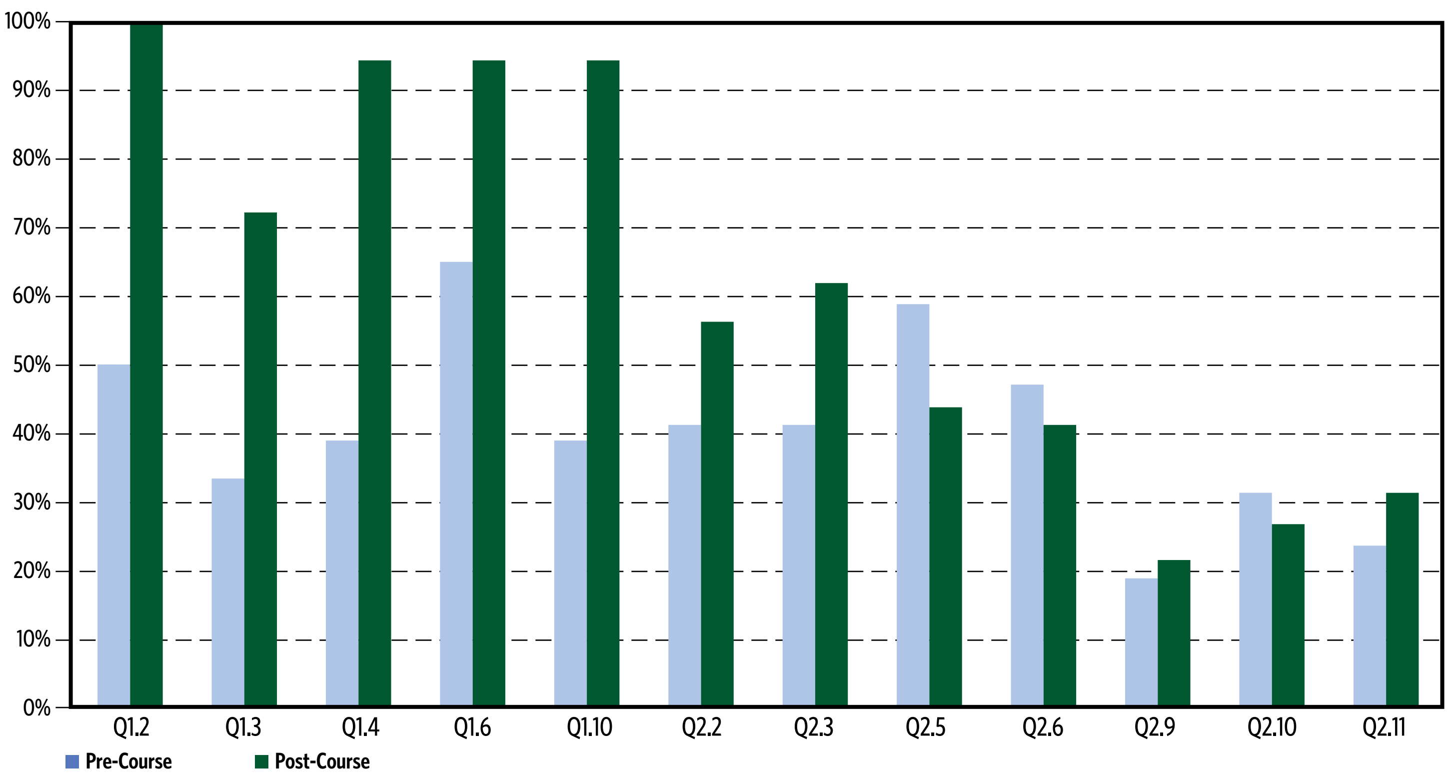

FIGURE 6. Percentage of African-American, Asian, and/or Hispanic students who rate their confidence level or their interest level in MATH 101 at 3 or higher.

curriculum at building students' mathematical skills, (2) increasing students' confidence at using mathematics, and (3) increasing students' interest in learning and applying mathematics.

In future assessments, the following additions would be made to make the overall assessment more effective:

- The SENCER math SALG should be administered in sections of MATH 101 not using the piloted curriculum. In the present study, the math SALG was administered only in sections using the new curriculum.
- There should be a common set of final examination questions that all MATH 101 instructors participating in the study agree to use. In the present study, instructors were free to choose which questions they felt were appropriate for their classes.

The curriculum detailed in this article, originally developed for MATH 101, is currently being expanded for use in a new course MATH 102, Mathematics of Sustainability, piloted in Fall 2009. The improvements noted above for the MATH 101 study will be incorporated into a similar study for MATH 102.

About the Author

Rikki Wagstrom is currently assistant professor of mathematics at Metropolitan State University in Saint Paul, MN. She earned her Ph.D. in applied mathematics from the University of Nebraska–Lincoln in 1999. Her primary interests lie in undergraduate mathematics education. Although she teaches all levels of undergraduate mathematics, in recent years, she has focused her attention on introductory-level courses, developing curriculum and pedagogies integrating civic issues into mathematics courses.

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PROJECT REPORT

Presenting Molecular Biology in an Ecological Context

The Maine ScienceCorps Partnership in Rural High School science Education

Samuel E. Frankel, M.S.
Department of Biology, University of Southern Maine; Maine ScienceCorps Fellow

Frank E. Riley, M.S.
Department of Applied Medical Sciences, University of Southern Maine; Maine ScienceCorps Fellow

Darrin Ramsdell, B.A.
Department of Applied Medical Sciences, University of Southern Maine; Maine ScienceCorps Fellow

Douglas Currie, Ph.D.
Department of Biology, University of Southern Maine

Ah-Kau Ng, Ph.D.
Department of Applied Medical Sciences, University of Southern Maine

S. Monroe Duboise, Ph.D.
Department of Applied Medical Sciences, University of Southern Maine; Director, Maine ScienceCorps

Introduction: Structure and Goals of the Maine ScienceCorps

The Maine ScienceCorps (MSC), one of approximately 200 NSF-sponsored "GK–12" (Graduate STEM Fellows in K–12 Education) programs nationwide, provides graduate fellowship support connected with opportunities to work with science teachers in rural Maine high schools to design and implement inquiry-based research projects, interacting with several hundred students each year (NSF, 2009). Fellows have contributed to various courses including biology, astrobiology, chemistry, health, and research methods, working with students at a broad range of ability levels. Students have ongoing interaction with teams of two graduate student Fellows who are in each classroom six to eight times a year and are also available electronically to guide students in using laboratory technology to conduct open-ended research. The project provides significant benefits to all participants that include: (1) Access in rural schools to interdisciplinary laboratory based projects that typically include a synthesis of environmental, microbiological, molecular biological, and immunology concepts and lab activities that would not be otherwise possible in the rural classrooms; (2) connection of diverse students in rural schools with scientific role models; and (3) effective development of each graduate student's teaching and communication skills while increasing their awareness of their potential for contributions to pre-college science education.

The MSC has been active since 2001, with classroom visits initially centered on self-contained activities that explained pieces of laboratory technology and specific biological concepts (e.g., exploring the role of antibodies in immune response using an ELISA assay). Beginning in 2004, program staff and fellows began developing inquiry-based research projects that could be explored through linked laboratory activities. The goal of these classroom research projects was to present laboratory science in contexts accessible and interesting to high school students. By 2006, projects increasingly were driven by high school students' questions and focused on using molecular tools to explore particular natural or model environments as year-long frameworks for classroom inquiry.

Model System and Field-based Projects

Teams of MSC Fellows designed low-cost "pond-and-stream" habitats (Figures 1 and 2) that allowed students to observe a simplified ecosystem in the classroom. Systems were stocked with native plants, invertebrates, and organic matter collected from Maine ponds and streams (by students when possible). Fellows avoided using vertebrates due to regulations governing the care and use of research animals, as compliance would have been challenging in a classroom setting.

Projects diverged according to the interests of the students, teachers, and Fellows. However, projects were linked by a commitment to incorporate the concepts and techniques of molecular biology in both ecological exploration and the experimental investigation of environmental change. Elements common to all projects included water quality monitoring, microscopic analysis and identification of protozoan life, and Fellow and USM laboratory assisted isolation of environmental bacteria and bacteriophages followed by molecular analysis in the high school classroom to explore the richness of the microbial world. Fellow's assistance in microbial cultivation was critical because any handling by high school students of unknown microorganisms would involve unacceptable biosafety concerns. These activities introduced students to the diversity of life from the macroscopic (e.g. plants, mussels, and other invertebrates) to the microscopic (e.g. protists, bacteria, and bacteriophage) organisms.

Students, teachers, and Fellows, in consultation with faculty mentors, developed research questions that applied laboratory techniques to investigate specific issues of environmental change. These techniques included extraction of DNA from soil community biota, phylogenetic analysis of microbial life by ribosomal RNA gene sequencing, and measurement of DNA damage in freshwater mussels via comet assay (Comet

FIGURE 1. A simple "pond-and-stream" model system constructed by ScienceCorps Fellows Samuel Frankel and Melissa Hamel. Recirculating water through a PVC "stream" into an aquarium "pond" provided differential habitat for microbial and invertebrate life. Habitats provided a contextual framework for molecular investigation of macroscopic and microscopic organisms.

FIGURE 2. A more elaborate habitat, the Mobile Aquatic Research System (MARS) constructed by ScienceCorps Fellow Jon Letendre. "Control" and "Experimental" streams fed into separate ponds for side-by-side comparison of alterations following environmental stress.

Assay Interest Group, 2009). Research projects involved comparisons between control conditions and those altered by the application of motor oils, household detergents, and road salt to intentionally reflect contamination problems relevant to aquatic environments in Maine.

Recently many of the student projects have involved gathering environmental field samples and in some cases, projects have been significantly integrated with a graduate Fellow's research interests. For example, several 2008–2009 GK–12 Fellows at USM pursued thesis research projects investigating microbial and viral ecology in acidic and metal-rich environments. Students at three rural high schools near historical mining sites or unmined massive sulfide deposits chose to work with graduate Fellows to extract DNA from these environments to investigate the microbial biodiversity present using molecular analyses.

MSC partnerships enable the use of university laboratory resources to expand classroom possibilities. For example, USM's transmission electron microscopy services have been available to extend classroom observations to the nano scale. More routinely, microbes isolated by the graduate Fellows from class samples were subjected to enzymatic inactivation under appropriate biosafety conditions at USM and then brought to the classroom for subsequent analysis. Thus, university facilities allowed projects to incorporate more advanced technologies as well as use techniques that could potentially involve risk to students if conducted without appropriate facilities and equipment.

Model System–based and Field Sample–based Projects as Contextual Frameworks for Scientific Inquiry

MSC Fellows recognized that students required an intuitive framework to organize abstract scientific information such as concepts of molecular biology. Projects based on model systems were made relevant by the ongoing presence of these simplified ecosystems throughout the school year while field sample based projects provided direct but intermittent connections with natural habitats. Model systems used were constructed to represent pond-and-stream environments that would be familiar landscapes for students in rural Maine and that, unlike natural environments, could be subjected to experimental manipulation to stimulate and facilitate scientific inquiry into problems of environmental contamination.

One goal of the MSC is to develop students' relationship to scientific inquiry and the use of science in daily life. Thus there is significant overlap between the approach of the MSC and the goals of the SENCER program, which have informed project development. The SENCER model of science education attempts to explore public issues from a scientific perspective, and in the context of that exploration effectively convey scientific information (SENCER, 2010). We have found that in high school classrooms modeling ecological systems to discuss issues of local environmental change can provide a powerful, accessible context to convey observational and experimental science.

Although the SENCER approach has been predominately aimed at undergraduates, situating laboratory science within a contextual framework greatly benefits younger students as well. High school students develop a greater depth of cognitive understanding regarding the world and its interrelationships during adolescence. Part of that development is a gradual transition from thinking that is predominately concrete to the progressive integration of more complex, abstract concepts (Santrock, 2001).

From a student's perspective, scientific information can be very abstract. Presenting molecular biology in the context of a public issue like environmental contamination provides a narrative structure in which to deliver information regarding the tools and concepts of experimental science. We have found this approach to be effective in teaching students who are in a process of learning to integrate these more abstract ideas.

Scientific Communication and Assessments of Student Learning

The approach of the MSC emphasizes that communication is vital to the practice of science. Students are given the opportunity to design scientific posters that present the results of their research projects. Teachers help students determine what information posters contain, but they are primarily written by students and reflect their understanding of the research projects and their findings. This provides an opportunity to identify misconceptions in student understanding of biological concepts and laboratory techniques.

Students during the past three years have been given the opportunity to present their posters to the USM community at USM's annual "Thinking Matters" research symposium. At the most recent April 2009 event, twenty-five students from four participating high schools also presented their projects to each other orally. The presentation of research projects and responses to questions asked by conference attendees have provided opportunities for students to demonstrate their understanding, as well as to experience ways that scientists communicate experimental findings. Posters were printed at USM, presented at Thinking Matters, and then returned to teachers for use in presentations to school boards and groups of parents, offering other opportunities for students to discuss their projects outside the classroom.

Maine ScienceCorps Commitment to Civic Engagement and Responsibility

The MSC promotes civic engagement and responsibility for high school students and Fellows. Students are introduced to scientific research by participating in an active investigation of model real-world problems. They also learn that scientists are responsible for communicating their findings.

An integral aspect of the MSC is that Fellows conduct their graduate bioscience research while engaging with the educational community outside the university. This interaction is demonstrably "two-way" with several affiliated teachers subsequently choosing to pursue graduate study through the MSC. Graduate students from other backgrounds are introduced to the challenges and rewards of teaching and communicating science. Also, Fellows specifically develop educational research projects that emphasize the role of laboratory biology in studying public problems, stressing the importance and immediacy of these connections for themselves as well as their students. University faculty mentors provide advice and guidance for developing research projects and periodically accompany Fellows on classroom visits. They share their expertise with students and demonstrate the role of scientists in mentorship, research and education.

Ongoing Program Development

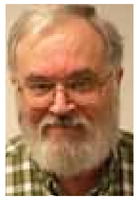
Development of model system and field sampling based projects continues each academic year and includes studying the effects of climate change on plants, further exploration of aquatic ecosystems, the role of wetlands in filtering contaminants, and further exploration of aquatic ecosystems and metal sulfide deposits. MSC Fellows, university faculty, and teachers continue to work to improve delivery of scientific knowledge in context, as well as expand opportunities for assessment of student learning through scientific presentations and development of a sustained online component utilizing the "Manhattan" virtual classroom (Western New England College, 2010).

A professional external evaluation team focuses much attention upon the MSC project's impacts on graduate Fellow's communication and teaching skills and on classroom activities and resources for participating teachers. The inquiry-based learning fostered through classroom research experiences clearly assists teachers in meeting state learning standards that address "skills and traits of scientific inquiry and technological design; the scientific and technological enterprise; the physical setting; and the living environment." (Maine Department of Education, 2007) The project brings connection with the scientific world to high school students in rural communities where exposure to scientific role models is otherwise rare and where there are few cultural expectations that higher education is important for future success. Observations by teachers, fellows, and others have indicated that frequently students who do not typically excel academically are highly engaged in the classroom research process. Several years of sustained experience in collaboration with some of the rural high schools have demonstrated benefits to all participants, which are encouraging MSC program staff efforts to continue integrating this program into USM graduate education.

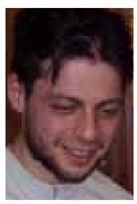
Acknowledgements

Numerous MSC Fellows, faculty mentors, and high school science teachers have contributed to the success of MSC classroom research projects. Particular thanks is due for contributions to development of model systems approaches to MSC Fellows Jon Letendre, Melissa Hamel, Adam Curtis, Sandra Fussell, Allison Gurney, and Erik Pietrowicz. Advisory contributions of Dr. Gail Fletcher (MSC Program Coordinator), Dr. Stephen Pelsue, Dr. Terry Theodose, Dr. Walter Allen, Dr. Robert Sanford, and USM Virology and Electron Microscopy Laboratory staff Karen Moulton and Jennifer Jamison are gratefully acknowledged. Support for the Maine ScienceCorps has been provided by grants (DGE-0086341 and DGE-0440560) from the National Science Foundation's Graduate STEM Fellows in K–12 Education (GK–12) Program and the University of Southern Maine Office of Research Administration.

About the Authors

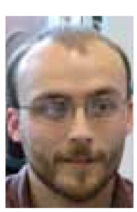


Corresponding author: S. Monroe Duboise, Department of Applied Medical Sciences, University of Southern Maine, P.O. Box 9300, Portland, ME 04104-9300; phone: 207-780-4446; fax: 207-228-8023; email: duboise@usm.maine.edu. Duboise is associate professor in the Department of Applied Medical Sciences at the University of Southern Maine. He earned his Ph.D. in epidemiology of infectious disease from Yale University and is a broadly trained microbiologist (virology, parasitology, and bacteriology) with a keen interest in microbes and their viruses in extreme environments. He is director of the NSF-sponsored Maine ScienceCorps program at USM and of the NIH NCRR-sponsored Science Education Partnership Award program at USM, which provides professional-development opportunities in microscopy, virology, and microbiology for bioscience teachers in southern Maine. He served as faculty advisor for MSC fellow and co-author Frank E. Riley.



Samuel E. Frankel earned a B.S. degree in psychology and a M.S. degree in biology at USM. As a M.S. student studying the effects of arsenic on neuronal development, he served for two years as a NSF GK–12 Fellow in the Maine ScienceCorps and was advised by co-author Douglas Currie. Upon completion of his M.S., he entered the Peace Corps through which he has been working in Ghana on an agricultural development project exploring innovative cash and food crops such as *Moringa oleifera*.

Frank E. Riley, a native of a small town in mid-coastal Maine, earned a B.S. in biology at the University of Maine and an M.S. in applied medical sciences at USM. He was employed in the biotechnology and biomedical diagnostics industry prior to his graduate research investigating microbes and viruses in environments with high or low pH conditions. He served for two years as a NSF GK–12 Fellow in the Maine ScienceCorps and was advised by co-author S. Monroe Duboise. Frank currently is employed by Carolina Health Care System and is involved in research on adipose tissue–derived mesenchymal stem cells.



Darrin Ramsdell is completing M.S. thesis research at USM investigating the role of osteopontin in breast cancer development and progression in the laboratory of co-author Ah-Kau Ng. A native of Maine and a graduate of Saint Joseph's College, he served for two years as a NSF GK–12 Fellow in the Maine ScienceCorps working with rural high school students and teachers in northern Maine.

Douglas A. Currie is associate professor in the Department of Biological Sciences at USM. A developmental neurobiologist with research interests in cell signaling in the developing mammalian brain, Currie earned his Ph.D. at University of Cambridge, pursued postdoctoral training at the University of Washington in Seattle, and joined the USM faculty in 2003. He has been active as a faculty mentor for MSC fellows including co-author Samuel E. Frankel.

Ah-Kau Ng is professor in the Department of Applied Medical Sciences at USM with a Ph.D. in microbiology/immunology from Temple University. The focus of his work has been in immunology (in areas of infectious disease, cancer, transplantation and autoimmune diseases), cancer biology and, more recently, nanomaterials. In addition to his devotion to undergraduate and graduate science education in biomedical sciences and biotechnology, since 1990 Ng has been actively involved in pre-college science education. He has served as faculty mentor for MSC fellows including co-author Darrin Ramsdell.

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PROJECT REPORT

Integrating an Elementary School Service-Learning Component into a College Physics Course for Non-Majors

Katalin Othmer and **Carolyn Sealfon**

Department of Natural Sciences and Mathematics, Marymount Manhattan College

Department of Physics West Chester University

Motivation

While service-learning courses have experienced great success in many disciplines (NSLC, 2010; Prentice and Robinson, 2010), including many sciences (SENCER, 2010; Middlecamp et al., 2006; Broverman and Ogwang-Odhiambo, 2005), there have been few efforts to fully integrate service-learning into standard physics courses. There is increasing alarm that our country's scientific literacy is falling behind other developed nations (Augustine, 2005). In today's technological world, scientific literacy is invaluable; it provides citizens with analytical skills to solve problems, to decipher truth from nonsense, and to better compete in a global economy.

It is advantageous to learn concepts and skills needed to approach the physical sciences in elementary school (Dykstra and Sweet, 2009). Sadly, science is often taught as a mélange of disconnected facts or methods to be memorized for a standardized test. There is thus an educational demand for concept-based science outreach at the elementary-school level.

Physicists and physics students have implemented many excellent outreach programs directed towards K–12 education, particularly in the form of lectures, demonstrations, and workshops for K–12 teachers and students (e.g. SPS, 2010; Alford Center, 2009). Some colleges have formalized these outreach efforts by offering college credit for service-learning projects (Purdue, 2010; Morningside, 2009). Other physics service-learning courses focus on high-school outreach (Netter Center, 2009), require physics prerequisites, and/or have course learning goals related to pedagogy (Finkelstein, 2003). As far as we know, we present the first course models that integrate elementary-school outreach into pre-existing introductory physics courses with traditional content learning goals.

Our non-majors physics courses aim to build students' confidence and analytical abilities to question and synthesize new ideas and to apply science to understand and predict phenomena. However, most students expect to simply memorize facts for exams. Service-learning programs invest students more deeply in rediscovering fundamental concepts, and student engagement can significantly improve physics learning gains (Hake, 1998; Iverson et al., 2009). By applying their understanding, students not only learn physics content better, but also acquire skills to help them succeed as decision makers in a complex universe governed by physical laws. Our programs were grounded in the belief that if one truly understands something, one can explain it in simple everyday language.

We propose that a community-based–learning model for non-major physical science students can be much more effective and powerful than traditional lectures and homework problems. We compare and contrast two separate models we created and implemented independently, focusing on the practical details of implementation. In both models, college students teach basic physics concepts to elementary-school students by designing and conducting science workshops. In one case, college students visit an elementary school classroom (the "during-school model"); in the other, they visit an after-school program (the "after-school model"). In both cases, our community partners served children from under-privileged socio-economic groups. Our hands-on activity approach is especially helpful for elementary-school students who speak English as a second language (Laplante, 1997; Amaral et al., 2002; Lowery, 2003).

Selecting a Community Partner

Many universities have a service-learning or community-based-learning (CBL) coordinator or office to help faculty find an interested and committed community partner. We both established a partnership at least one month prior to the start of the semester. Convenient and safe transportation between the college and the partner is important.

Establishing a Partnership

We each worked with our community partner to shape the collaboration.

After-school Model

The after-school program had no set curriculum, which allowed the flexibility to cover any topics in any order. The lessons and activities had to be accessible to children ages six through thirteen and structured so that the elementary students could begin the activities at different times as they finished their homework. The summer preceding the CBL course, the professor conducted two practice science activity sessions with the physics-major mentors for the CBL course. This gave them experience working with the children before supervising the general-education physics students in the fall semester.

During-school Model

The professor who partnered with an elementary school presented the school principal with a proposal detailing the motivation, the benefits to the school students, the background of the prospective college students, and the schedule. The enthusiasm and commitment of the principal and teachers to such a partnership is essential. Fourth-grade classes were chosen to participate in the CBL collaboration because of state science testing at the end of the fourth-grade year, and the topics covered in second-semester college physics were compatible with the fourth-grade learning units. A few weeks before the semester began, the professor met with the fourth-grade teachers to discuss schedule logistics, the topics to be covered, and special events such as meetings with the college students and the culminating event of the semester (a visit by the fourth-grade students to the college campus).

Logistics of the Community-based Learning Component

An overview of the student populations participating in the CBL programs is given in Table 1. The after-school model

TABLE 1. Overview of Organization

	After-school Model	During-school Model
College course	General Education ; Conceptual Physics	Physics for Non-Majors
Course structure (hours/week)	Lectures, 3	Lectures, 3; recitation, 1.5; Lab, 3
Number of students (college)	28	4
Project target audience	Elementary-school students (ages 6-13) in after-school program	Elementary school students in 4th-grade science class
Number of students (elementary)	20-30	~25 × two classes
Guidance	1 professor; 4 mentors*	1 professor; 1 elementary-school science teacher; 2 4th-grade teachers
College student groups	10 groups, 2-3 students each	2 groups, 2 students each
College student participation	Mandatory	Optional†

*College junior and senior physics majors. † All four students in class chose to participate.

allows more freedom with respect to the topics covered (see Table 2); the during-school model has the advantage of supervision provided by the elementary school teachers.

The logistics and schedule of visits to the community partner site are illustrated in Table 3 and further explained below. In both models, half the class participated in each visit.

After-school Model

The six hour-long sessions at the after-school program each focused on a different topic in physical science. For each visit, five groups of college students created their own "station" of hands-on activities. Each station focused on a different aspect of the topic. After a very short introduction, led by the professor or a physics-major mentor, the after-school children divided into groups and rotated around the five activity stations, spending about ten minutes at each station. Thus, each college student helped develop three different stations during the semester, and a total of thirty activities were conducted with the children.

During-school Model

Each team of college students developed four different one-hour workshops during the semester (for a total of eight workshops conducted with each elementary-school class), and each workshop was presented twice per visit (as there were two fourth-grade classes participating in the program). In addition, the during-school model had two planning sessions (one for each unit) where the college students, professor, and elementary school teachers decided which experiments and demonstrations would best satisfy the learning goals of both the college and fourth-grade curriculum.

Grading

The grading structure is highlighted in Table 4. Both models emphasized conceptual understanding and effective communication of scientific ideas. Students must truly understand the concepts underlying the physics to explain them without equations to elementary-school students. In the after-school model, the projects replaced three exams and thus counted for a significant portion of the final grade.

Curriculum

It was important to find topics appropriate both for the college course and for the workshop experiments/demonstrations; see Table 2.

After-School Model

The after-school model incorporated CBL into a general-education physics class with more curriculum flexibility. The course focused on six broad topics that lent themselves to hands-on activities at the elementary-school level. Topics were discussed in class before each session, and traditional reading (from Hewitt's *Conceptual Physics* textbook) and homework questions were assigned. Each student group chose a subtopic as the focus of their activity station, and connections between neighboring stations were encouraged.

During-School Model

The during-school model matched the established curriculum for second-semester, algebra-based, introductory college physics with the established fourth-grade curriculum. Of the college physics topics, all but optics were compatible with learning units covered in the fourth grade. Optics was

TABLE 2. Science Workshops

	After-school Model		During-school Model	
	College course workshops		*College course*	*Compatible 4th-grade unit*
Topics Covered	Motion and gravity Simple machines Sound and music	Phases of matter Electricity and magnetism Light and optics	Electromagnetism Fluids Thermal physics	Electricity and magnetism Properties of water
Session Outline	Introductory station run by mentors 5 demonstration stations (related to the day's topic) that students rotate through		Introduction (including vocabulary review) Demonstration Various experiment stations that students rotate through Discussion and conclusion	

incorporated into the CBL project via the culminating event of the semester, in which the fourth-grade students visited the college physics laboratory where students had prepared optics demonstrations as an enrichment activity.

Outcomes

After-School Model

Multiple methods were used to assess the effectiveness of the course.

We received positive feedback from the program director at the YWCA, and a post-survey of the after-school students, loosely based on the Test of Science-Related Attitudes (Fraser, 1981), confirmed their enjoyment of the activities and positive science-related attitudes.

The college students' performance on the final exam compared well with the performance of traditional sections of the same course taught by the same professor. On the individually completed portion of the final exam, the performance of the CBL section on identical questions was similar (i.e., within a standard deviation) to the performance of other classes, despite taking no other in-class tests during the semester. Their performance on a collaborative part of the exam was outstanding (an A+ average), and exceeded that of other classes. The Student Assessment of Learning Gains (SALG, 2010) survey indicated that doing activity stations helped the college

TABLE 3. Logistics

	After-school Model		During-school Model	
Class time taken	CBL replaces 2 classes per week for 6 out of 14 weeks](i.e. a total of 12 classes out of 42)		CBL replaces 7 out of 14 weekly lab sessions for each college student*	
CBL Sessions	***Wednesday***	***Thursday***	**CBL Sessions**	
1st session	Group A practices; Group B is audience	**Group A visit 1**	***1st session***	**Groups A and B Planning Session 1**
2nd session	Group B practices; Group A is audience	**Group B visit 1**	***2nd session***	**Group A visit 1**
3rd session	Group A practices; Group B is audience	**Group A visit 2**	***3rd session***	**Group B visit 1**
4th session	Group B practices; Group A is audience	**Group B visit 2**	***4th session***	**Group A visit 2**
5th session	Group A practices; Group B is audience	**Group A visit 3**	***5th session***	**Group B visit 2**
6th session	Group B practices; Group A is audience	**Group B visit 3**	***6th session***	**Groups A and B Planning Session 2**
			7th session	**Group A visit 3**
			8th session	**Group B visit 3**
			9th session	**Group A visit 4**
			10th session	**Group B visit 4**
			11th session	Elementary school visit to lab on college campus
Visit length	1 hour: 10-minute activity repeated 5 times + set-up and clean-up		One-hour workshop, repeated for 2 different 4th-grade classes	
Class information	Lectures held only on Mondays during CBL visit weeks Lectures held on Mondays, Wednesdays, and Fridays on other weeks Groups practice in front of classmates on the Wednesday before a Thursday visit		While Group A is visiting the elementary school, Group B is in a traditional lab at the college, and vice-versa. Each student completed 7 traditional labs during the semester	
Semester information	Length: 14 weeks; weeks not shown on this table met according to a traditional schedule: lecture three times a week		Length: 14 weeks; weeks not shown on this table met according to a traditional schedule: 3 hours of lecture, a 1.5-hour recitation, and 3-hour lab every week	

Notes: Group A = one-half of college class; Group B = other half of college class. Bold color text = college students at an off-campus location to run or plan workshops.

* The four visits by each group, plus the two planning sessions, plus the elementary school visit.

TABLE 4. Grading

	After-school Model	During-school Model
Percentage of final grade	55	20
Grading rubric and requirements	1. Activity Stations Significance and relevance to topic of session Encouragement of questions Challenge to assumptions Physics accuracy Clarity of explanations Engagement Originality References used and cited 2. Online journals Reflect on session; possible improvements	1. Notebook Research and ideas on appropriate experiments with citations Key concepts and vocabulary Complete lesson plans 2. Journals Reflect on class; both science content and communication Different ways of explaining the same concept 3. Presentation How program affected learning
Notes	Each station was videotaped which facilitated later grading	Elementary school teachers provided feedback to professor on performance of students in classroom

students' learning more than any other assignment or aspect of the pilot class, with more than one-fifth of respondents answering that the projects were a "great help" compared to fewer than one-tenth for other course aspects. It also indicated steps to improve the course. Physics-major mentors could become more invested in the course by giving them credit as an independent study course for their involvement. To avoid the difficulties of switching group members every session, student groups should be kept constant for the semester. The instructor could provide sub-topics and activities for the first activity session, while students get accustomed to the expectations and nature of the CBL course. Then, the groups could gradually be given less and less guidance as the course progressed, and later activity sessions would be weighted more heavily in the final grade. The course would also be more effective if fewer topics were covered, spending more time and going deeper into each topic.

During-School Model

The teachers and principal at the elementary school were very pleased with the science classes given by the CBL students and regarded the program as a "resounding success." Pre- and post-surveys indicated an increase in positive attitudes towards science amongst the elementary-school students. All of the participating college students would recommend the CBL option to other students and responded affirmatively to questions about better understanding the course material, feeling more scientifically creative, and having an improved ability to communicate scientific ideas in a real-world context, all as a result of the CBL component of the course.

Conclusion

Having college students develop science workshops for elementary-school students is a simple but effective community-based–learning model for a physics class aimed at non-majors. We have independently piloted such CBL models at two different colleges. These models can help meet standard physics course objectives for college students, while better engaging different learning styles and benefiting elementary students. We hope that colleagues at other institutions will consider adopting and adapting such course models and look forward to hearing your experiences and suggestions.

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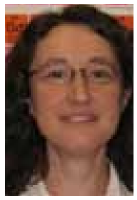
Compact, in particular their sponsorship of the STEM Summit on Incorporating Social Justice and Service-Learning in the STEM Curriculum, where the authors met and learnt about each other's course model.

About the Authors




Katalin Othmer (left) is assistant professor of mathematics at Marymount Manhattan College (kothmer@mmm.edu). Carolyn Sealfon (right) is assistant professor of physics at West Chester University (csealfon@wcupa.edu).

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PROJECT REPORT

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

Byoung Sug Kim and **David E. Szpunar**

Department of Teaching and Learning
Roosevelt University

Department of Biology, Chemical & Physical Sciences
Roosevelt University

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 preexisting 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

Week	Topic	Activity
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

Topic	Questions	Activity	Station
Natural phenomena	What is happening on the earth?	Discussion: students' prior knowledge with video clip and pictures	1
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 CO_2 was collected in a balloon and blown through a straw into bromothymol blue (BTB) solution. The CO_2 formed carbonic acid (H_2CO_3), 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 CO_2 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.

About the Authors

Byoung Sug Kim is the corresponding author for this article (bkim@roosevelt.edu). He is an assistant professor of science education at Roosevelt University. He teaches courses in science teaching methods and action research in the College of Education. His main research interests are related to the nature of science and scientific inquiry. He earned his M.E. from Korea National University of Education and a Ph.D. in science education from Illinois Institute of Technology.

David Szpunar has been an assistant professor of chemistry at Roosevelt University since 2006. He teaches general chemistry, physical chemistry, and non-majors courses. He has been a visiting scholar at the James Franck Institute and University of Chicago. His research interests lie in the field of reaction dynamics. After completing his M.S. and Ph.D. at the University of Chicago, he did postdoctoral work at the Lawrence Berkeley National Laboratory and the University of California, Berkeley.

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TEACHING AND LEARNING

Engagement at the Theater

Science in the Cinema

B.D. Stillion
Arkansas State University

J.M. Pratte
Arkansas State University

A. Romero
Southern Illinois University–Edwardsville

The deficiencies in the scientific knowledge of American students have been well documented both in educational journals and the popular media. The scores students have received on standardized tests—such as the Trends in International Mathematics and Science Study (TIMSS) and the Program for International Student Assessment (PISA)—over the last several decades have shown that U.S. students fall short of leading the world in the STEM disciplines (Wu, 2008). These scores have increased a bit over the last decade, but the achievement of students in the United States on these tests still fall below that of other countries such as Slovenia and Hungary (Martin et al. 2008). The results on this and many other tests drive much of educational policy making and funding in this country and lead to a public that is misinformed about science (NSF, 2010).

What is less often discussed is the public's lack of knowledge about scientists and how science is done. Other than possibly in a college or high school classroom, most people never have the opportunity either to do science or to interact with a real scientist. This leads to many inaccurate views by the public about who scientists are and what they do, as shown by surveys over the past fifty years. Since 1957 when Margaret Mead first surveyed schoolchildren about their attitudes toward scientists (Mead and Metraux, 1957), there has been a very clear stereotype that has predominated: a male wearing glasses and a white lab coat with a pocket protector, holding either a test tube or a flask.

The reason for this stereotype is quite simple: in the absence of any direct interaction with scientists, perceptions of scientists and the work that they do is filled in by the most popular public medium—visual entertainment such as movies and television shows. The time-compressed nature of these media means that they rely heavily on stereotypes in their character portrayal in order to grab the audience's attention. This time compression also means they do not have time to show the full way that a particular profession carries out its tasks, which leads to major misconceptions about the processes and procedures of that profession. In the case of scientists, the subset of stereotypes is fairly limited, measuring with six distinct ones being evident (Frayling, 2005). These popular character types are the alchemist, the absent-minded professor, the inhuman rationalist, the helpless scientist, the social idealist, and the heroic adventurer. The alchemist, otherwise known as the evil mastermind, seeks power and fame at all costs and uses science to control others and situations (e.g., Frankenstein, Dr. No). The absent-minded professor is so engaged in science that he or she neglects social responsibilities and often lose track of time (e.g., Doc Brown from *Back to the Future*). The inhuman rationalist believes that logic and protocol must outweigh any other consideration, such as the welfare of an individual (e.g., Lieutenant Commander Spock from *Star Trek*). The helpless scientists either have their discoveries taken from them and abused by the government/corporation, or their scientific experiments get out of hand and start doing harm (e.g. Dr. Bruce Banner from *The Incredible Hulk*). The social idealist, or altruist, believes that science should be offered freely for the good of society (e.g., Dr. Emma Russell from *The Saint*). Lastly, the heroic adventurer often does science for the pure sake of discovery and takes science where no one has gone before (e.g., Dr. Arroway from *Contact*).

While the use of these stereotypes in movies does lead to misperceptions about scientists and the science that they do, there are some positive aspects to their use. As Daniel Sarewitz points out (Sarewitz, 2010), these stereotypes are needed to allow the cinema to explore the mythic dilemmas of our time. Science and technology have the potential to change the world and our lives in incredible way, from curing horrible diseases to the extinction of all life. More accurate portrayals of science and scientists would be helpful in attracting more students to the field and in educating the public regarding the realities of science, but it is also important to allow authors and artists to fully explore the implications of our actions and our works. Authors often need to use stereotypes as shortcuts to follow issues to their logical conclusions and portray the philosophical issues involved in our actions.

Course

As scientists, our job is not to prevent these uses of stereotypes, but to educate people about them, and to discuss how their use effects the public's perception of science. In response to this situation, we have developed a novel hybrid course that is part traditional college course, part online course, and part informal science film series. This course, Science in the Cinema, started as a public science film series that was developed to show the portrayal of science and scientists. This series was somewhat different from normal science film series in that it was not centered on science fact or fiction, but on how scientists and the science that they do are portrayed in the movies (the audience was given a handout of scientific errors in the film in order to improve critical thinking skills, but it was not the focus of the discussions). This series involved a different film shown every month with a panel of scientists who had expertise in the area in question and who would discuss the portrayal at the end of the film. Movies were chosen to represent a diversity of disciplines and movie eras and had to include at least one scientist who was doing science. Below are samples of movies shown to the public.

- *Alien: Resurrection* (1997)
- *The Andromeda Strain* (1971)
- *The Boys From Brazil* (1978)
- *Buckaroo Banzai* (1984)
- *Contact* (1997)
- *The Day the Earth Stood Still* (1951)
- *The Day the Earth Stood Still* (2008)
- *Dr. Strangelove* (1964)
- *Fatman and Little Boy* (1989)
- *Honey, I Shrunk the Kids* (1989)
- *I Am Legend* (2007)
- *The Incredible Hulk* (2008)
- *I.Q.* (1995)
- *Jurassic Park* (1993)
- *Mary Shelley's Frankenstein* (1994)
- *Meteor* (1979)
- *Real Genius* (1985)
- *This Island Earth* (1955)
- *Tron* (1982)
- *20,000 Leagues under the Sea* (1954)
- *Twister* (1996)
- *Volcano* (1997)
- *Wargames* (1983)
- *War of the Worlds* (1953)

The popularity of this series led to giving students an opportunity to study the material in more depth and receive credit for their work. Rather than creating a separate course while maintaining the film series, we decided to marry the two projects into a single package. This action was not simply taken because of the obvious savings in time and effort by combining the two projects. One of the purposes of the course is to discuss the interaction between the portrayal of science by Hollywood and the public perception of science. By bringing the public into the room with the students, we are able to make that perspective more broad-based and readily available to the students.

With the creation of the class, there were several changes made to what we had been doing in the film series. The number of movies involved in the course has been greatly increased from that of the film series, as have the number of public viewings. These movies are organized around particular themes. Originally, we organized them around such themes as "alien scientists" or "scientists versus machines," but more recently we have adopted the six stereotypes listed above as the themes. Additional movies from each theme that are not shown in public are assigned to students to watch during the two-week period between public viewings. Students discuss these movies on the class discussion board, which is moderated by the faculty.

Based upon their viewings, discussions, and independent research, the students are required to write a paper analyzing each theme every couple of weeks. In their papers, the students are expected to dissect the various portrayals they have watched to delineate the basic features of the stereotypes and to discuss how these features help or hinder the film. By the end of the course, the students are expected to produce a major research paper on a topic of their choosing about some particular aspect of science in the cinema. These topics have ranged from gender roles of scientists to the use of nuclear energy in movies to the growth of scientists as consultants in movie over time. The goal of these exercises is to make the students more discerning consumers of media images of scientists and science.

Findings

The course has been now been offered four times, twice as a special topics course and twice as an upper-division elective course. Enrollment has increased from an initial group of four science majors to a class size of twenty-one, with most of the students still drawn from the sciences. Before class begins on the first day, students are asked to draw a picture of a scientist (we also ask them to draw a lawyer and a plumber, two other professions that are stereotypically male). While the vast majority of the students are upper-division science majors and have had a lot of interaction with science and scientists, they still fall back on the basic stereotypes that the general public does on such an assignment. They drew the scientist as male 70 percent of the time and female only 12 percent of the time (18 percent of the drawings had undetermined gender), even though females made up 52 percent of the classes. For comparison's sake, plumbers were drawn as males 64 percent and females 3 percent of the time, while lawyers were drawn as males 61 percent and 15 percent of the time. As one might expect from other surveys of this type (Griffith, 1983), no male student drew a female scientist and only a quarter of the female students drew a female scientist.

Beyond the question of gender, the drawings put scientists in stereotypical style and settings. The scientist was holding a beaker or test tube in 76 percent of the drawings, had a lab coat on in 67 percent, and had "weird" hair and glasses in 42 percent of the drawings. These results closely match results from the same survey given to entering science majors on our campus.

In the classroom, the greatest challenge faced so far is getting students to think critically about what takes place in the movies and television shows. Watching movies or television is a passive experience for most people, and our students mirror this experience in their early papers by merely stating the plots of what they have seen rather than dissecting it for the stereotypes that are portrayed. It is often not until the latter half of the course that the students are able to fully appreciate how to engage the material. As an example, here is an excerpt from one student's initial paper:

> In this movie (*The Core*), the scientists Dr. Josh Keyes, played by Aaron Eckhart, and Conrad Zimsky, played by Stanley Tucci, discover that the Earth's core has stopped rotating. This being the source of the electromagnetic field that protects the Earth from Solar Radiation without it we will all die [*sic*]. Therefore a team is put together to restart the core. Going to the core are the two discovers [*sic*] Keyes and Zimsky, along with the ships [*sic*] designer Dr. Edward Brazzelton, played by Delroy Lindo, the weapons specialist Dr. Serge Leveque, played by Tcheky Karyo, and two astronaut pilots Major Rebecca Childs, played by Hilary Swank, and Commander Robert Iverson, played by Bruce Greenwood.

The following is an excerpt from the final paper from the same student:

> The character in *Evolution* played by Julianne Moore is the naïve expert, though she has qualities of the assistant. She contributed little to the advancement of science and when she tried, a superior male character turned her ideas away. She was mocked sexually by her male colleagues and at the end of the movie, began a relationship with one of the men who participated in making fun of her.

Some students have gone beyond the bounds of the course, either continuing to come to the public viewings after having taken the course or by using the concepts discussed in the class for further research.

Future

To date, the course has focused almost exclusively on film, which for decades was the primary medium for scientist portrayals. However, the growth in the number of television channels and content delivery via the internet over the last decade means that there has been an explosion in the number of television shows and cartoons in which scientists play a lead role. These shows seem to have a greater diversity in their portrayals of scientists, at least in terms of gender, as there are more female scientists being portrayed. Also, there have been initiatives, such as the UCSB STAGE Script Competition (http://www.stage.ucsb.edu/) and the Imagine Film Festival (http://www.imaginesciencefilms.com), to connect plays and movies to science and scientists in a more realistic manner. In the future, we will spend more time looking at these portrayals and how they might be changing the stereotypical view of scientists.

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About the Authors

B.D. Stillion is a visiting associate professor at Arkansas State University. She has a Ph.D. in psychology from Emory University and is a published author and playwright. She has studied acting with the Royal Shakespeare Company and has taught theatre at the college level. Contact: Arkansas State University, P.O. Box 419, State University, AR 72467.

J.M. Pratte is chair of the Department of Chemistry and Physics and a Professor of Physics at Arkansas State University. Since 2008, he has been a SENCER Leadership Fellow. Contact: Arkansas State University, P.O. Box 419, State University, AR 72467.

A. Romero is dean of the College of Arts and Sciences at Southern Illinois University–Edwardsville. Before that, he was the chair of Biological Sciences at Arkansas State University and was co-developer of the Science Flicks Film Series upon which this course is based. Contact: Southern Illinois University–Edwardsville, College of Arts and Sciences, Edwardsville, IL 62026.

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TEACHING AND LEARNING

The Impact of Having a Research Scientist as a Guest Lecturer in a College Biology Course

Antonio Villaseñor

Undergraduate science major, Harold Washington College

Farahnaz Movahedzadeh, Ph.D.

Department of Biological Sciences, Harold Washington College

Introduction

Not enough young people are being educated or inspired to pursue careers in science, technology, engineering, and math (STEM). As one researcher noted, "the education in American junior high schools, in particular, seems to be a black hole that is sapping the interest of young people, particularly young women, when it comes to the sciences" (Friedman, 2005: 351). In the past, the United States was known as the world leader in scientific innovation and STEM education. Now only 15 percent of U.S. graduates are attaining degrees in the natural sciences and engineering, compared to 50 percent in China (Freeman, 2008). Clearly, the country's position as a global leader for innovation may be lost without a strong, focused commitment to ensuring that more students pursue advanced education in science, technology, math, and engineering. A report from the National Science Foundation states that:

> In the 21st century, scientific and technological innovations have become increasingly important as we face the benefits and challenges of both globalization and a knowledge-based economy. To succeed in this new information-based and highly technological society, all students need to develop their capabilities in science, technology, engineering, and mathematics (STEM) to levels much beyond what was considered acceptable in the past" (NAS, 2007).

What are some of the reasons for this lack of interest in science, engineering, math and technology? A recent National Science Teachers Association Report entitled *Steer Your Students to a Science Career* (Shapiro, 2008) identified the several causes for the decline, including a shortage of scientific mentors, parental pressure on kids to seek more lucrative careers, discrimination against science-bound women and minorities. These and other factors continue to discourage many students from going into STEM careers. What, if anything, can faculty members do to reverse this negative trend in STEM areas? Throughout a student's educational experience, science teachers often play a key role in inspiring their students to become scientists. It is imperative, especially at the college level, that teachers engage students in meaningful learning, a rigorous curriculum, real-life examples of STEM careers, and authentic research opportunities. In order to accomplish this, a variety of activities should be included in the classroom experience in order to inform participants about science as a possible career by offering content in the context of the real-life experience of working scientists. By connecting academic courses and the curriculum with STEM professionals from the community, students will have a more grounded understanding of what scientists do and have a better understanding of the real-world applications of what they are learning. The goal of this article is to highlight the positive impact that a research scientist can have as a guest lecturer in today's biology classroom.

According to the National Science Education Standards, teachers of science should be able to put a science curriculum/lesson into social context for their students and by doing so, relate it to the community, the field of biology, and their future careers (NAS, 2007). One effective way to accomplish this is to involve people from the community in the teaching of science in the classroom. Guest speakers share up-to-date, realistic information and bring their own distinctive perspective on a subject that more than likely would not be found in a textbook (Mullins, 2001). They contribute to the topic being presented and offer a different way to think about the topic and related issues. Speakers often offer a peek into the things students are studying and thinking about for their future.

To be effective, a number of steps should be followed when inviting a guest speaker. Host faculty members should:

- Find a speaker who conveys relevant and reliable information—someone who is credible.
- Engage a speaker who knows both the topic and the audience.
- Invite speakers who have knowledge that is interesting to the students—in this case, science/biology. The speaker's topic should enhance the material covered in the curriculum.
- Encourage speakers to talk from personal experience—to speak from the heart.
- Prepare the students—let them know there will be an "evaluation" and they will be graded (Mullins, 2001).

Methods

In order to discover the impact of having a research scientist as a guest lecturer in a college biology course from the students' perspectives, Dr. Paul Wheeler, a biochemist and senior scientific officer at Veterinary Laboratories Agency in Great Britain, was invited to a biology class at Harold Washington College in January, 2009, to share his experience as a professional scientist. As a part of this class, each student was required to write a summary of this experience and address the impact of his visit. This short paper was submitted by students for a grade in the class. Their feedback will be considered as a key result and will be discussed in the section that follows.

A second contact was made with the same group of students (electronically) in September 2009 through a follow-up survey, which asked them to respond to a set of questions. The format was such that it required them to indicate which of a series of statements best reflected their response to each question. These results will also be discussed in the following section.

Results

The Class Assignment of the Paper

Twenty-seven students completed the paper addressing the questions that were discussed in the classroom. Drawing conclusions from this type of classroom assessment requires the reader to look for common themes and words within the narrative responses of the students. Overall the feedback was positive in nature.

Every responding student described their impressions of Dr. Wheeler as positive. He was depicted as having a "joyful and inquisitive nature" that was ideal for his work. He was described as "intellectual and creative," and it was noted several times that he obviously takes pride in his work. Two quotations said a great deal about the visit:

- "Observing him I got a great sense of devotion and passion for his work, which made me very excited about what is to come as I continue my education in the science and health care field."
- "Regardless, of what career path I take, I was definitely inspired by his passion."

When assessing what they had learned, students wrote:

- "Each day is different and there is not a typical day in the life of a scientist."
- "The experience with a scientist in the lab was incredible. I have never met a scientist before, and just to be in his presence was amazing."

- "I found Dr. Wheeler's talk to be fascinating and also valuable because he dispelled many of my misconceptions about the work of a research scientist."
- "I stayed after class to talk a bit about it with him and I found everything he had to say extremely interesting."
- "Overall, the class learned that a research scientist must juggle many responsibilities, including the lab work itself, staff supervision, coordinating funding efforts, collaboration with other scientists."

The Electronic Survey

Twenty-seven students were mailed the survey electronically, of these twenty-five responded. This is a response rate of 92.5 percent which is notable considering the fact that eight months had passed since they had met Dr. Wheeler. The questions used in the survey mirrored those in the original assignment for the paper. However, because the students were provided with a series of statements to select from, there was more uniformity in their responses. In an attempt to be concise, the responses to several of the survey items are included in the charts that follow.

In addition, students were asked to respond to a short essay question which asked: "Why is it important to meet scientists or to be exposed to the science environment?" There were twenty-two responses to this, several of which are listed below.

- "There are many exciting innovations taking place in science—to hear about some of these firsthand adds interest to a course."
- "Students get a better view of science through a professional."
- "Personal account is 100 time more valuable than anything in a book."
- "I think it's easy to make assumptions about what scientists do. It's nice to have one tell you what her/his career actually involves."
- "It is important because it helps connect our studies to real professions. It also helps us gain a little more perspective on what exactly happens in a laboratory, and on why this work is done. Lastly, they can also instill realistic expectations as Dr. Wheeler helped me understand that it takes a lot of time and patience to work in research." (Figure 1)
- "Not only was meeting a scientist a perfect introduction to the field, it helped me focus on how my own career will take direction." (Figure 2)

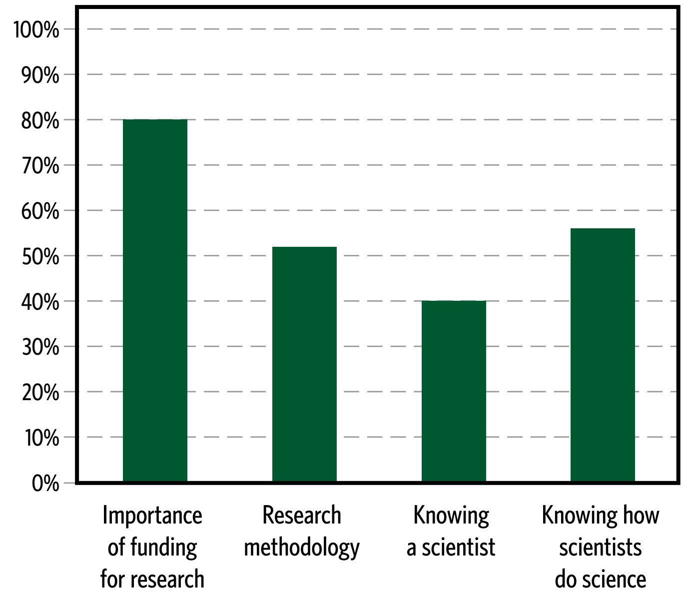

FIGURE 1. Student responses to the question: "What have you learned most from meeting and listening to how scientists do science?" (percentage responding to each category).

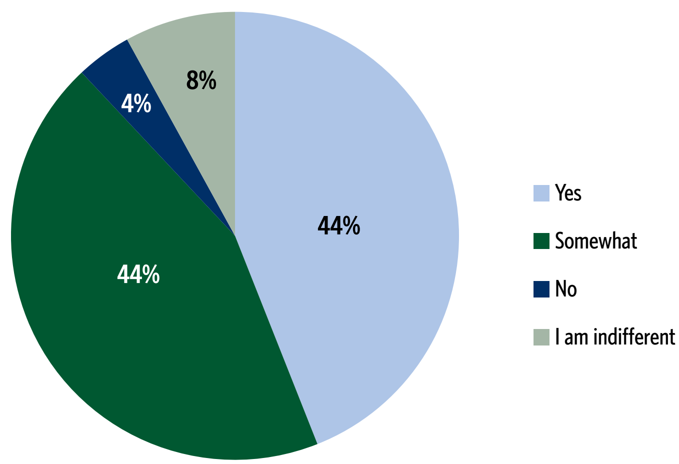

FIGURE 2. Student responses to the question: "Did meeting and listening to the scientist motivate you to study more science?"

Conclusion

We can conclude that the addition of a research scientist, whether a biologist, chemist, astronomer, geologist, or physicist (Figure 3), as a guest lecturer in the classroom would have a positive impact on the students' viewpoint and understanding of what a research scientist is required to do to be successful. The papers written as a part of an assignment, and relating

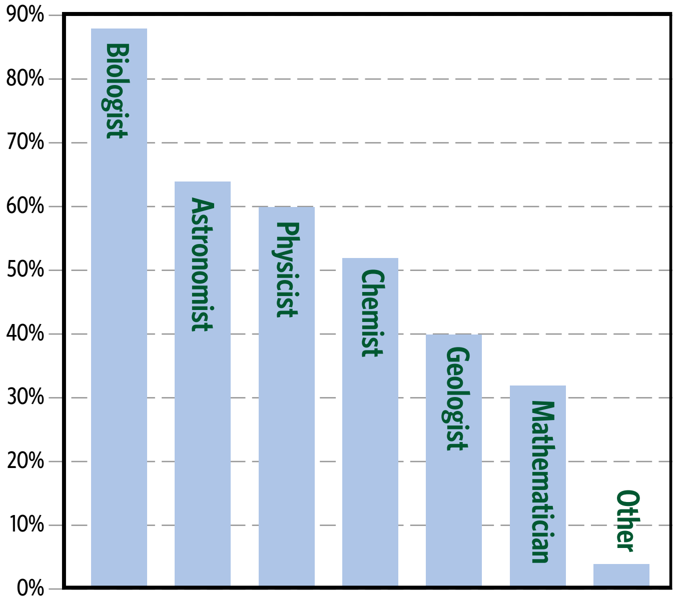

FIGURE 3. Student responses to the question: "What type of scientist would you like to meet?"

to the original class visit, reflect the positive and enthusiastic responses that students had to meeting a "real" scientist. Their initial positive feedback might have been attributed to the excitement of the event that took place that day in class. However, the positive impact of Dr. Wheeler's visit was reinforced when in September 2009 students responded to an electronic survey with a response rate of nearly 93 percent, after a eight month lapse since the classroom visit. Not only was the response rate high, students also had an overwhelmingly positive response to the questions asked. One excellent example of this is that 88 percent of the students taking the survey responded that it was very useful or useful to the question "How useful was meeting the scientist and learning 'how scientists do science' and the scientific method of inquiry?" (see Table 1).

The proposition that was put forward at the beginning of this article was that the addition of a research scientist as a guest lecturer in today's biology classroom would have a positive impact on the students' comprehension of the materials covered in class. It was also proposed that, in accordance with the National Science Education standards, teachers of science should be able to put a science curriculum/lesson into social context for their students and, by doing so, relate it to the community, the field of biology, and their future careers. We have concluded that a classroom visit by a research scientist from the scientific community is an effective way to

TABLE 1. How useful was meeting the scientist and learning "How scientists do science" and the scientific method of inquiry?

Answer options	Response (Percent)
Very useful	60
Useful	28
Not useful at all	8
I am indifferent	4

accomplish both of these goals. Guest speakers share up-to-date, realistic information and bring their own distinctive perspective on a subject that more than likely would not be found in a textbook. They contribute to the topic being presented and offer a different way to think about the topic and related issues. Speakers often offer a peek into the things students are studying and thinking about for their future. In Figure 3, students indicated other scientists they would like to meet.

So, with this in mind, it would be logical to conclude that the addition of a research scientist as a guest lecturer in a biology classroom had a positive impact on students' comprehension of the materials covered in class and their perception of what a scientist does. Not only did it have an impact, the students remembered the guest lecturer seven months later with as much enthusiasm as when they completed their first assignment seven months before.

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About the Authors

Farahnaz Movahedzadeh (fmovahedzadeh@ccc.edu) is a faculty member of Department of Biological Sciences at Harold Washington College in Chicago, Illinois. She received her Ph.D. from the University of London in 1997 in microbiology and molecular biology.

Her current research includes the development of a hybrid method of delivery for biology for non-science majors. She also actively pursues her research on essential genes as drug targets for tuberculosis at the University of Illinois at Chicago.

Antonio Villasenor-Marchal (alv.marchal@gmail.com) is an undergraduate in the Department of Biology at Harold Washington College in Chicago, Illinois. He presented the results of this study at the SENCER Washington Symposium and Capital Hill Poster Session in April 2010. He is pursuing a degree in microbiology.

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