



# SCIENCE EDUCATION & CIVIC ENGAGEMENT

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## **Science Education and Civic Engagement: An International Journal**

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# From the Guest Editor



It is with great delight and appreciation that I announce the Summer 2013 issue of *Science Education and Civic Engagement: An International Journal*. The focus on community colleges demonstrates the inclusive and innovative thinking of the editorial staff whose mission is the publication of articles that share insights and assessment results with an international community of educators.

The interview with **George Boggs** sets the stage for understanding the growing role of community colleges in STEM education, both nationally and internationally. Boggs is President and CEO Emeritus of the American Association of Community Colleges where he served for over 10 years as a well-respected advocate for broad access and success in higher education. For this issue, he offers his perspective on barriers to STEM degree attainment, the global role of community colleges, and the criticality of relationships between educational institutions and businesses.

The issue also features a Teaching and Learning piece by **Sreedevi Ande** of LaGuardia Community College, that identifies the underlying quantitative reasoning skills embedded in the Project Quantum

Leap and SENCER projects. In addition, **Abour Cherif** and **Maris Roze** of DeVry University, along with their colleague **Dr. Matthew Bruder**, have written a Project Report that details a learning activity designed to create healthy meals in order to counter nutrition-related diseases. Another Project Report by **Mangala Kothari** of LaGuardia Community College describes an essential tool used to measure student success in Project Quantum Leap. And **Jeffrey Webb** of Southern Connecticut State University has contributed a research article on how to integrate SENCER into a large lecture general education chemistry course. Finally, in a Point of View piece, **Dennis Lehman** of Harold Washington College in Chicago, reflects on how SENCER's resources and strategies have impacted and helped improve curriculum, retention and faculty development at an urban community college.

Many thanks to all the contributors to this special issue and the educational champions they inspire!

— *Judy C. Miner*  
President, Foothill College

# The Ever-Evolving Landscape of America's Community Colleges

An Interview with George R. Boggs  
by Judy C. Miner, President of Foothill College



George R. Boggs is President and CEO Emeritus of the American Association of Community Colleges (AACC), where he served for more than 10 years as a leading post-secondary education advocate and spokesperson.

Dr. Boggs served as faculty member and administrator at Butte College in California and, for more than 15 years, as the Superintendent/President of Palomar College in California. Dedicated to American excellence in science, technology, engineering, and mathematics (STEM), he serves as a member of the Board on Science Education of the National Academy of Sciences and has served on several US National Science Board and Foundation panels, commissions, and committees.

Community colleges have played a crucial role as broad access institutions ever since the founding of Joliet Junior College in 1901, but have only recently emerged into the national spotlight that now shines on college completion and global competitiveness. For its Summer 2013 e-journal, SENCER has chosen to focus on various aspects of community college contributions to STEM education. George Boggs was a natural choice to interview on overarching issues, given his decades of successful experience in both policy and operations at the local and federal level. He was asked to answer three questions.

1. In 2010, you wrote an article for *Science Magazine* titled: "Growing Roles for Science Education in Community Colleges." A key challenge you discussed was the improvement of completion and transfer rates if the United States were to hire resident talent in the growing numbers of jobs in STEM. What is your assessment of progress in meeting that challenge nearly three years since your article appeared?

There is a lot of attention these days to the importance of college completion. As I pointed out in the 2010 *Science* magazine article, President Obama has challenged community colleges to increase degree and certificate completion rates by 50 percent over a ten-year period. Last year, the American Association of Community Colleges in its report, "Reclaiming the American Dream: Community Colleges and the Nation's Future," embraced President Obama's challenge with a recommendation to increase completion rates of students by 50 percent by 2020.

There is some evidence that efforts to improve degree attainment are having an effect. While I have not seen STEM-specific data, on June 12, 2013, the *New York Times* reported a rise in college degrees in general. In 1995, 24.7 percent of Americans had at least a bachelor's degree. Last year, the percentage rose to 33.5 percent. *Inside Higher Ed* reported on June 13, 2013, that college degree holders in the United States are projected to reach 48 percent of the population by 2025.

However, this is far short of Lumina Foundation's goal for 60 percent of the population to hold degrees or certificates by 2025. Moreover, the data show that young Hispanics and Native Americans are less likely to hold a degree than their older peers, and attainment rates for African-Americans are flat across age groups. Young men now lag far behind young women in degree completion.

What is most troubling is the apparent resistance to implementing improvements in STEM educational practices in colleges and universities. In the June 21, 2013, issue of the *Chronicle of Higher Education*, Paul Baskin reports that last year, both the National Research Council and the President's Council of Advisors on Science and Technology said that validated methods of improving the teaching of science and math simply have not found widespread adoption at American colleges. I was one of the lead authors of the 1997 NRC report, "Science Teaching Reconsidered," which specifically addressed STEM teaching and learning with clear models for engaging, helping, and assessing students. Since its publication, I have seen no mention of the report or its recommendations. The June 21 Baskin article points out Carl Wieman's frustration at higher education's resistance to change. When Dr. Wieman was White House Science Adviser, he proposed an annual survey of STEM teaching practices that was opposed and killed by higher education leaders who saw it as an unnecessary intrusion of government into academic matters. But why isn't higher education itself doing more to improve STEM teaching?

2. *America's community colleges appear to be viewed as an international model for workforce development as many other countries face a comparable skills gap for their own jobs in STEM fields. What are the benefits of global engagement vs. an exclusively local focus for our community colleges?*

There was a time when the United States could be comfortable knowing that it controlled the resources it needed to sustain the highest quality of life in the world, that our isolation protected our national security, and that no other nation could compete with us economically. But the world has changed. The 21st century ushered in a new era, with the highest level of global interconnectedness in human history.

Technology now allows us to view live images of events taking place virtually anywhere in the world—24 hours a day and 7 days a week. We can communicate with people

in remote parts of the world, listen to music that suits our desire, or read documents without physically holding them. Text, voice, and images can be transferred with a click on a cellular phone or a computer.

Jobs that once needed to be done in local communities can now be done anywhere on earth that is connected by technology and inexpensive modes of transport. Students in community colleges today must be prepared to compete in a global economy. Thomas Friedman describes this concept well in his speeches and writings on today's "flat world." Manufacturing and service jobs, once done in local communities, have been shifted to other countries such as China and India. Our economy is now intertwined with that of other nations, and our students will be, or perhaps already are, working in that environment.

Today, the United States has more than 20 trade agreements with other countries and regions and is a member of the World Trade Association. More than a quarter of the US domestic product is trade-related, supporting more than 12 million American jobs, including one in five of our manufacturing workers. We are the world's largest importer of merchandise and commercial services, and we are the second largest exporter of merchandise while exporting more commercial services than any other country. US companies have become international, having realized that the vast majority of the world's consumers and purchasing power lie outside our borders.

America's community colleges, now educating nearly half of all US undergraduate higher education students, have a significant role to play in preparing students to live in an increasingly global society and economy. In addition, US government officials have recognized the great potential for the nation's community colleges to promote national security and world peace by helping to educate students from developing countries and by promoting the study of foreign languages.

If community colleges are to serve their communities well, they must prepare their students for the culture in which they will live and work. The communities and workplaces in today's America are much more interdependent with those in other countries than ever before. In many cases, community colleges present the first and perhaps only opportunity for students to become globally competent. Understanding how to work with others who differ in language and culture is a necessary job skill, even for those who never intend to travel abroad or leave their local communities. Moreover, if the

United States is to remain competitive, its leaders and future leaders (many of whom will come through community colleges) will need to know and respect other cultures, understand the culture of international negotiations, and know how to cultivate partnerships across national borders.

Today's environmental problems can be addressed successfully only if we can develop cooperative and trusting relationships across the world. Automobile exhausts in the US and coal-burning power plants in China both contribute to global warming. A nuclear mishap in Russia soon spreads around the globe. Students need to learn just how interconnected we are and to understand that we must work together to protect the planet that we share.

America today is largely a country of immigrants. Approximately 25 percent of our people identify themselves as being something other than "white," and nearly 12 percent of us are foreign born. Yet many of our citizens are insular, ignorant of world geography, untrained in foreign languages, and insensitive to cultural differences. Beyond our borders, people in other countries have a distorted view of Americans, shaped by our foreign policy, our movies, our popular music, and our video games. If the emerging global society is to be a healthy one, we need American students to learn about other cultures and languages—and we need people from other countries to have a more accurate understanding of American culture and values.

- 3. You have championed the creation of business internships for community college students, as research has shown that STEM majors are more likely to persist if applied learning is an integral part of their educational experience. How might colleges best develop relationships that will result in internship opportunities?*

Students generally have little knowledge of or perhaps inaccurate perceptions of STEM careers. Popular movies and television shows often portray scientists and technicians as socially isolated individuals who work alone in laboratories with equipment instead of with other people or directly helping other people, fostering a belief that especially discourages women from wanting to enter these fields. Students need better and more accurate information about STEM careers, and they need to see

role models, people who look like them who have chosen STEM career paths.

Community college faculty and administrators should bring students as early as elementary school and continuing through middle school and high school onto campus to tour science and technology laboratories and to talk with STEM faculty and STEM students. Involving school students in college projects or discipline research can be a motivator. Arranging for tours of STEM-related businesses can give students a more accurate perception of what it means to pursue a STEM career.

Faculty and administrators can develop beneficial relationships with the employers in their communities. Often representatives from these companies are happy to serve on college advisory boards, where they have some input into how students are prepared for the jobs that will be available in the future. Business leaders are also usually open to establishing agreements that allow students to become interns in their companies. In addition to the satisfaction of contributing to the hands-on education of students, employers get the chance to view the interns in action and perhaps to employ some of them upon completion of their programs. Student interns benefit greatly from the first-hand experience they get in the application of the STEM principles they are learning in the classroom.

# Teaching Pre-Algebra with the Theme of Environmental Science

**Sreedevi Ande, Ph.D., P.E.,**  
*LaGuardia Community College, C.U.N.Y.*

## Abstract

Pre-algebra is the first course of a sequence of two basic skill math courses offered at LaGuardia Community College. In order to contextualize and make the material relevant to students, the faculty of the college have integrated into the curriculum the PQL (Project Quantum Leap) projects. These projects are based on the SENCER (Science Education for New Civic Engagements and Responsibilities) approach and allow students to learn real world math in a single engaging context. This paper identifies the underlying quantitative reasoning skills embedded in these projects. I discuss the details of three projects that were piloted in my class and how effectively they supported students' learning when compared to a non-PQL class.

## Introduction

Statistics indicate that about 60% of all U.S. community college students enroll in at least one remedial course in English or math, where they can get stuck studying elementary- and middle-school-level concepts; only 31% of the remedial math students ever move beyond the remedial level, according to the Community College Research Center at Columbia University's Teachers College (Redden, 2010). Nationally, pass rates in remedial math remain lower than those for remedial writing and reading (Melanie, 2005), and remedial math courses often become hurdles in the degree completion process. At LaGuardia Community College, more than half the students need basic-skills math courses, and more than 60% aspire to obtain a baccalaureate or higher degree (CUNY, 2009). Therefore, succeeding in basic math skills is important for students who want to stay in college and successfully complete their degree (Lutzer et al. 2005).

At community colleges, now the major gateway to higher education in this country, remedial classes account for approximately 57% of mathematics program

enrollments (Lutzer et al. 2005). Students in basic math courses have often had repeatedly unsuccessful experiences and view the subject as uninteresting and irrelevant. More than 35% of the students in basic-skills math courses retake the course at least once (Betne 2010), and lack of math skills proficiency has a major effect on student retention (Parker 2005).

Students can in fact learn mathematics and science with understanding, and the teachers' instructions should enhance the students' abilities to connect ideas and concepts and enable them to apply what they know to new situations and phenomena (NCISLA, 1995-2005). More than 60% of LaGuardia students specified their major to be in science or applied sciences (CUNY, 2009). Researchers at National Center for Improving Student Learning and Achievement in Mathematics and Science have found several ways to connect math with science and have reasoned that these abilities, in addition to students' mastery of basic skills, are vital for students facing an increasingly complex world. As today's world has become technologically information-driven, students need to know more than the basics in mathematics and science to cope with accelerating changes (NCISLA, 1995-2005).

In order to engage students' interest in mathematics and enhance mathematical learning, Metropolitan State University developed a new curriculum for the Pre College Algebra course in 2009, which included real-world environmental sustainability issues, quantitative reasoning, and mathematical modeling. Six sections piloted the new curriculum and three used the traditional curriculum, and an assessment study was conducted to evaluate the effectiveness of the new curriculum. The study showed that the new curriculum integrating civic/environmental issues is at least as effective as a traditional mathematics curriculum at building students' mathematical skills, increasing students' confidence in using mathematics, and increasing students' interest in learning and applying mathematics. (Wagstrom 2010).

Similar efforts have been made at LaGuardia College for three courses, namely, Introduction to Algebra, Elementary Algebra, and College Math and Trigonometry. The Project Quantum Leap (PQL) program at LaGuardia College was established in 2007 to explore the Science Education for New Civic Engagement and Responsibilities (SENCER) approach—an interdisciplinary

approach to teaching math and science that can deepen the settings and contexts and engage students. A curriculum and a pedagogy that “contextualized” the process of learning mathematics skills and concepts were developed by the LaGuardia PQL program in Fall 2012 (LaGuardia Center for Teaching and Learning 2009). Introduction to Algebra was contextualized with issues of energy, climate change, and environmental science; Elementary Algebra with issues of personal and public health; and College Algebra and Trigonometry with issues of economics and personal finance. Twenty-six PQL math courses and 13 PQL math learning communities were taught, and approximately one thousand students were served. A preliminary analysis of the students' responses to the Community College Survey of Student Engagement (CCSSE) survey data showed that students in PQL classes demonstrated more confidence, comfort, and engagement with mathematics, when compared with students in non-PQL comparison classes. This study indicated that the course pass rate in PQL classes was 54.7% compared with 47.6% in non-PQL comparison classes.

In light of the LaGuardia PQL project, I attended the professional development seminars conducted by the PQL Program leaders with support from the LaGuardia Center for Teaching and Learning (CTL), in order to develop teaching materials such as class activities and projects, and to discuss ways to implement them in the classes. I taught two sections of the Pre Algebra course in Spring 2010 and implemented PQL environmental science activities described in this report in one of these sections. The PQL section originally had twenty-eight students enrolled, while the non-PQL section had twenty-four students. Only twenty-six students from the PQL section and only eighteen from the non-PQL section completed the course. All students participated in the study, and the approval of the Institutional Review Board (IRB) was obtained in order to publish the research findings.

The results obtained from the previous study on the PQL program at LaGuardia focused on the overall pass rates of PQL and non-PQL sections taught by several full-time and part-time faculty. My research is a further continuation of this PQL program and focuses on the students' performance in PQL vs. non-PQL sections when taught by the same instructors; this approach minimizes the variables such as PQL activities, teaching

methodologies, tests, assessment rubric etc. The significance of this report can be summarized in the following two points: (1) The quantitative reasoning skills embedded in environmental science activities were engaging and supported students' learning. (2) The PQL approach has a positive impact on the course pass rate, which is explained by comparison between the pass rates of my PQL class and my non-PQL class.

## The PQL Approach in the Classroom

The course Introduction to Algebra has a problem-solving approach that emphasizes the importance of mathematical reasoning in addressing real-world problems drawn from diverse disciplines. Topics include arithmetic (signed numbers, fractions, decimals, and percents), elementary algebra (solving first degree equations and inequalities, rules of exponents, equations of lines) and basics of geometry (area and perimeter), as well as numeracy (estimation, unit analysis).

This course is intended for students with little or no algebra background. Some of the common errors that I observed in my students' work were

- ✦ Do not understand the significance of numbers
- ✦ Do not understand the importance of units and assign them in the wrong places
- ✦ Get confused with the word problems; what is given and what is asked

- ✦ Either underestimate or overestimate the numbers in problems
- ✦ Incorrectly assign positive and negative signs
- ✦ Fail to analyze the answers or analyze the answers incorrectly

## Objectives and Design of Projects

I designed classroom activities and piloted them in my PQL course with four goals. These goals in systematic order are as follows: *First goal*— the activities had to address causes and consequences of global warming and the impact of our living habits on earth's resources, on both the individual and global levels. *Second goal*—the projects had to involve students in the regular practice of skills common to both math and critical thinking, such as decision-making, problem-solving logic, and argument building. *Third goal*—the projects must address the above-mentioned common math errors. *Fourth goal*—the sustainability and environmental science content for the activities must be designed specifically for each math topic.

The activities listed in Table 1 consisted of both in-class discussions and homework assignments designed to motivate the students (Ande and Kothari 2009). The in-class discussions involved my introduction of environmental issues to the class followed by the students' participation in discussing these issues. The homework

**TABLE 1.** PQL activities designed for the course Introduction to Algebra

Syllabus Topic	Activities	Learning Objectives
Whole numbers. Place value. Rounding whole numbers.	Greenhouse gas: carbon dioxide (CO <sub>2</sub> ) emissions	1. Understand what numbers mean in terms of CO <sub>2</sub> emissions 2. Be able to successfully write numbers in words and vice versa 3. Be able to round numbers 4. Rank each country with respect to CO <sub>2</sub> emissions
Solving equations	Greenhouse effect and global warming	1. Understand what greenhouse effect and global warming are 2. Be able to calculate the amounts of carbon dioxide released and absorbed 3. Be able to write and solve one-step equations 4. Analyze the answer and write a reflection
Average. Understanding rates. Adding and dividing decimals. Converting decimal to percent	Ecological footprint: How much do we consume?	1. Be able to compute average acres 2. Be able to find the difference between the world average and the average computed 3. Be able to calculate percent 4. Analyze the answer 5. Reflect on how our consumption habits impact our environment and climate and contribute to global warming

assignments involved reading, finding numerical results using basic computations, and subsequently reflecting on their responses and views on environmental issues based on the knowledge gained. After completion of each activity, a quiz based on the math topic learned was given to the class in order to assess their knowledge.

## Greenhouse Gas: Carbon Dioxide (CO<sub>2</sub>) Emissions

The activity, Greenhouse gas: carbon dioxide emissions, was developed not only to help students overcome the common errors (explained above) in the first week but to see the connection between math and a global problem. A definition of greenhouse gases along with references and a list of carbon dioxide emissions by each country were given as a handout to students after instruction on whole numbers and rounding whole numbers. Students were asked to read the handout first and then complete a table by writing the emissions in word form or in scientific form and rounding the numbers to the nearest thousands, hundreds, tens, or ones, and ranking them in ascending order. This assignment was conducted in class in order to observe students' perception of global problems and their response to the assignment. Students did well in completing the table. However, some students were confused about whether to rank the countries after rounding or before rounding.

## Greenhouse Effect and Global Warming

The original activity was developed by Dr. Prabha Betne. I tailored the activity to suit the students' need and to emphasize quantitative learning. This activity targeted word problems based on fractions, decimals, and forming and solving one-step equations. It was introduced to students using a short PowerPoint presentation on the greenhouse effect, global warming, and the contribution of carbon dioxide (CO<sub>2</sub>) to global warming. Graphs depicting the trends in atmospheric concentrations, anthropogenic emissions of CO<sub>2</sub>, and prospects for future CO<sub>2</sub> emissions were shown, followed by in-class discussion. A picture depicting the global carbon cycle was displayed, and as a part of an in-class activity, students were asked to

recognize the sources that release and absorb CO<sub>2</sub>. They were asked to formulate the one step equation showing the imbalance between the amount of carbon dioxide that is released into the atmosphere and the amount that is absorbed by various sources, and the effects of the imbalance. As an assignment, they solved the equation. They were also asked to estimate the amount of CO<sub>2</sub> that would be released in next 15 years if the same trend continued, and to analyze and reflect on how they would contribute towards a safer environment by minimizing emissions.

## Ecological Footprint

This activity was originally developed by Dr. Betne. I tailored the activity to suit the students' need and to emphasize quantitative learning. Average, rates, addition and division with decimals and conversion from decimal to percent were the topics covered through this activity. The ecological footprint assignment required students to calculate their own ecological footprint (acres of land required to support the lifestyle) and compare that value with the available land space, countrywide and worldwide. Students were given sample data in acres for 15 students in the age group 16-20 years that was obtained from an online survey conducted to study the consumption habits (food, mobility, shelter, and goods and services) of students in the college. Calculations were performed to find the ecological footprints (equivalent earth resources as the number of acres) required per person to support such living habits, and to find the total acres required for each student.

Students calculated the average total acres required for a student, and the difference between the average they computed and the given 4.5 biologically productive acres per person (world average). As part of an assignment, students were asked to convert the difference found as a percentage (above or below the world average value) and estimate the number of planet earths we need to live the way we are living. They were required to review their calculations, analyze their answers, and write reflection on their learning from this exercise, for example the role of math in understanding the environmental issues and how math helped them find a solution for these problems.

## Conclusions

The Greenhouse gas: carbon dioxide (CO<sub>2</sub>) emissions assignment was well received by the students. About 90% of students completed the table in class, which showed that they are interested in real world problems. About 82% of students rounded the numbers correctly. It was interesting to observe that about 87% of students were confused and asked questions whether to rank the countries after rounding or before rounding. Students answered this question themselves, after being asked to rank the countries before and after rounding. The ranks were then compared and discussed. Students clearly understood that rounding emissions did not affect the ranks, as the emissions are large numbers and emissions released by each country are far apart. When the same quiz was given to both sections, the quiz average on whole numbers for a PQL class was 76.8%, compared to a non PQL class quiz average of 65.3%. This indicated clearly that the PQL approach was effective in helping the students to understand the topic.

The Global warming assignment graphs drew students' attention with respect to the seriousness of global warming and the sources that impact emissions. Most of the time in class was spent on discussing the graphs, the importance of units, and analysis of data. About 81% of students were able to correctly formulate an equation using the global carbon cycle picture. The interaction with individual students revealed that they liked this topic and the class discussion. About 85% of students completed the assignment and the class average on the assignment was 70.7%. When the same quiz was given to both sections, the quiz average on word problems, forming and solving equations was 67.2% for a PQL class, which was higher than the quiz average of 62% for a non-PQL class. The above results indicate that these PQL assignments improved student understanding, learning and remembering the quantitative skills, and applying them effectively in various scenarios.

Approximately 87% of students were able to correctly compute their own ecological footprint and compare that value with the available land space worldwide and countrywide. 74% of students were able to successfully convert decimals to percentages and interpret their results. About 84% of student responses on the reflection assignment indicated that the students were intrigued and fascinated

with ecological footprint facts and that their understanding of the environmental issues increased.

These PQL assignments allowed students to read the facts on environmental science topics and clearly showed them the connection of math with science. The mathematical part of the assignment helped students to develop the appropriate number sense and enhance their knowledge of numeracy and calculations, and, in turn, improved their quantitative reasoning skills. Moreover, the use of PQL projects, a student-centered approach, engaged students in critical thinking and reasoning, and supported them in becoming independent learners. In particular, the activities described above gave them a sense of civic and social responsibilities of the real world they live in. The research study that I undertook indicated a 61.3% course pass rate in my PQL section as compared to 55.7% in my non-PQL section.

## Future Study

The LaGuardia PQL program internally published a collection of PQL activities as a sampler, available through the LaGuardia CTL website. This collection serves as a teaching resource for faculty. My research as an environmental engineer working in the fields of water and air pollution, environmental health, toxicology, and hazardous waste management will help me to develop new PQL activities and revise the current ones in order to keep up with the most current real-world data on environmental issues.

I am in the process of incorporating more PQL-type activities for math topics listed in the Introduction to Algebra syllabus. I also plan to administer SENCER math SALG pre-course and post-course surveys in order to collect demographic information about the students and evaluate changes in students' interest and confidence in learning mathematics. The activities I have developed and the ones that are in the developmental stage will be shared with other faculty members, so that they can implement them in their classes to assess student performance.

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## About the Author



*Sreedevi Ande* earned her Doctorate in Materials Engineering and Science from South Dakota School of Mines and Technology and completed her Post Doctoral Study at Western Kentucky University.

She is an Associate Professor in Mathematics, Engineering, and Computer Science Department at LaGuardia Community College. She is registered as a licensed professional engineer in Michigan.

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# Designing Healthy Meals to Counter Nutrition-Related Diseases:

## A Learning Activity

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### Abstract

Heart disease, cancer, stroke, and diabetes—four of the top ten death-causing diseases in the United States—are nutrition related and can thus be prevented or reduced through formal and informal education aimed at changing personal diet and lifestyle. In this learning activity, students work in groups to conduct research on nutrition, nutritional ingredients, and healthy diet, as well as on nutrition-related diseases. They design healthy diets and present their own recipes for healthy meals aimed at prevention and/or healing of a specific nutrition-related disease. Through this activity, students learn about the roles that nutrition and nutrients play in their lives and the importance of following a healthy, balanced diet and lifestyle. The goal for students is not only to learn what constitutes a healthy, balanced diet and the relationships between nutrition, health, and nutrition-related diseases, but also to apply that knowledge to their lives. For educators, the goal is to involve students in a meaningful activity based on the scientific method, as well as to contribute to restoration of the nation's health and wellness.

### Nutrition and Disease

Nutrition is the process by which our body takes in and makes use of food substances. Nutrients are chemical substances supplied by food, from which our body obtains the essential ingredients to perform the chemical and electrical processes required to maintain homeostasis. Carbohydrates, fats (lipids), proteins, vitamins, and water supplied by food are the six classes of nutrients that the body needs for growth, maintenance, and repair.

Failure to obtain these essential nutrients can lead to disruption in the physiological functioning of the body, which in turn can lead to illness or disease. Disease is an abnormal state of form, structure, or function due to the effects of cellular damage within the body (Nesse and Williams 1994). The abnormality not only affects the performance of vital functions, but usually also provides diagnostic symptoms. Specifically:

Disease occurs when the cellular environment changes to such a degree that tissues are no longer able to perform their function optimally. For example ... in

diabetes, the extracellular tissue of blood vessel walls undergoes changes that lead to decreased blood flow, decreased oxygen delivery, and eventually irreversible damage to tissues such as the retina, skin, heart, and kidneys. In cancer, mutations accumulating in the nucleic acids of cells result in distorted structure and function of proteins, which in turn affect the way the cells interact with or react to other cells, growth factors, hormones, and the extracellular matrix in their environment. In multiple sclerosis, destruction of the protective myelin sheath around axons in the brain results in decreased electrical conduction, which manifests neurologic signs and symptoms such as weakness, double vision, and lack of coordination. In each of these conditions, the ability of cells or tissues to perform their function optimally is compromised, with deleterious consequences to the organism (Hart and Loeffler 2012, 4).

Food is not only a source of nutrients that our body needs for energy, growth, maintenance, and tissue repair, but can also be used as therapeutic medicine (Aziz 2010). The physician and philosopher Moses Maimonides was quoted as saying, “No illness which can be treated by diet should be treated by any other means” (cited in Carleton and Wait 2001, 44). After all, food is one of the best “medicine[s] for a healthy heart, and nowhere does this statement ring more true than when it comes to conquering [the rising of] cholesterol [levels]” (Hausman and Hurley 1989, 136).

## Background and Rationale

The ongoing health care debate in the United States and the Childhood Obesity Taskforce’s report and recommendations have brought needed attention to the issue of health in America and the role that nutrition plays in reducing and preventing some of the leading causes of death and disease, including heart disease, cancer, stroke, and diabetes. Experts agree that proper nutrition (and consuming fewer calories) and regular exercise could help not only in preventing some types of diseases, but also in delaying age-related degeneration of physiological processes of the body (Aziz 2010; Ornish 2007; Hark and Deen 2005; NIH 2002; Carleton and Wait 2001).

Cardiovascular disease, which starts with the buildup of plaque in the arteries, has been the number one cause of adult deaths and a leading source of adult disability in the United

States since 1918 (Blake 2008,151). Childhood obesity, which can lead to debilitating and costly diseases, such as type-2 diabetes, high blood pressure, and high cholesterol levels, affects 25 million young Americans and is the fastest growing health problem in the United States.

Making nutrition and exercise an important component of any regimen for promoting optimal health and the prevention of chronic disease should be one of the goals of modern society. It is true that some diseases have a genetic component or microbial root cause, but with the right diet and lifestyle, these propensities can often be overcome. Education has become one of the most important means of addressing the issues of diet, obesity, and nutrition-related diseases, and of pointing the way toward restoration of the nation’s health and wellness.

## Learning Activity

In this activity, students work in groups to research nutritional ingredients and to design and present their own special recipes to combat one or more of the top nutrition-related diseases. They learn about the role that nutrition plays in their lives and the importance of a healthy, balanced diet and lifestyle. The goal is to learn what biologically constitutes a healthy, balanced meal and to develop a better understanding of the relationships between nutrition, health, and nutrition-related disease. Students also learn about various foods and ingredients: which of these make them healthy, the nutrients they contain, and what specific health problems and diet-related diseases a healthy, balanced meal can combat and why. They also learn about the process by which the body takes in and makes use of food substances.

The objective of the activity is to help students from high school through college (with a background in at least high school biology or chemistry) to understand the nutritional, health, and wellness values of what they eat and how diet can help prevent nutrition-related diseases. In addition, the activity is designed to help them

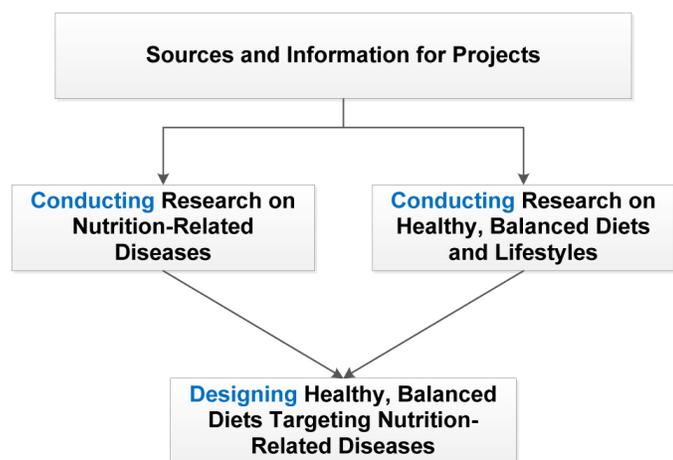
- Understand the nature of nutrition-related diseases and the mechanisms of how these diseases affect the metabolic and other biological activities of the human body
- Understand how the ingredients in food can facilitate the reduction or prevention of nutrition-related diseases

- Apply this understanding toward the choices they make in their daily eating habits and lifestyles.

Throughout the learning activity, instructors reinforce student understanding of the concepts of nutrition, nutrients, biologically balanced healthy meals and diet, and the role that cholesterol, sugar, saturated fat, salt, lack of physical exercise, etc., play in the development of nutrition-related diseases. Instructors also emphasize the importance of lifestyle in shaping and maintaining a healthy body. They emphasize the fact that since the human brain's prime directive is "to eat and defend against the loss of fat," which emerged early in biological evolution, metabolic processes alone might not be enough to successfully influence our state of health, including the maintenance of a healthy body and lifestyle (Hurley 2012 a & b; Freedman 2011).

## Pedagogical Approach

The conceptual basis of the learning activity may be summarized in the following chart:



The learning activity itself is organized and carried out in five phases, as shown in Table 1. Phases One and Two are designed to help students successfully complete Phases Three and Four. Phase Five is related to students' learning outcomes and understanding. At the end of each phase, the students engage in discussion questions that help them move forward in the activity.

**TABLE 1.** Five Phases of Learning Activity

Activity Phases	PART	
PHASE I: Introducing the Learning Activity	1	Informing students what they have to do in order to successfully complete the activity
	2	Discussing the criteria that will be used to assess the designed meals and to evaluate student work
PHASE II: Studying and Evaluating Examples of Existing Healthy, balanced Meals	1	Evaluating two already prepared healthy, balanced meals using given criteria
	2	Discussion of the meals' identified nutritional values for the intended goals
PHASE III: Conducting Research	1	Gathering data and information on diet and nutrition-related diseases
PHASE IV: Designing and Presenting Healthy, balanced Meals	1	Designing a healthy, balanced meal targeting one of the nutrition-related diseases
	2	Presenting the healthy meals in the class and to the Food Policy and Regulation Committee (FPRC)
PHASE V: Evaluating What Students Have Done and Learned	1	The FPRC evaluates students' healthy meals and decides whether or not to endorse the proposed meals for specific nutrition-related diseases
	2	The instructor uses the final decisions of the FPRC and a set of specific questions to reinforce understanding of the intended learning outcomes

In the first phase the students are introduced to what they have to do to successfully complete the activity. Students are also provided with a set of criteria designed to help complete their assignments, assess their designed meals, and understand how their work will be evaluated. Then they are asked to participate in a guided discussion using a set of related

questions to help them advance their understanding of various nutrition-related concepts.

In the second phase students are given a homework assignment which asks them to use the given criteria to analyze and evaluate two examples of balanced healthy meals. Then they engage in discussions about the meals' identified nutritional values for the intended goals. From the homework and the guided discussion, students learn that the choices of food ingredients and the combination of nutrients are very important when designing a healthy, balanced meal and in preventing some of the nutrition-related diseases.

One important discovery made by scientists investigating the disease-fighting powers of foods is that nutrients are absorbed better from food than from pills. It also turns out that foods work synergistically—that is, their health benefits are greater when they are eaten together. For instance, tomatoes, chilies, and garlic—the classic salsa ingredients—deliver more potent health protective powers when they are eaten in combination than when they are eaten alone. This finding reinforces the fact that supplements can never [yet] replicate the benefits of a varied diet (Carleton and Wait 2001, 42-43).

Furthermore, the synergy of multiple nutrients, especially micronutrients, is a very important factor in how food contributes to prevention, reduction, and/or treatment of nutrition-related diseases.

Not only do all nutrients in food work together to make something greater than the whole, the organ systems in your body do the same. We now know that disease isn't usually something that strikes out of the blue and hits an isolated organ. For example, did you know that obesity is a risk factor for age-related macular degeneration (AMD)? Who would guess that being overweight would affect your vision? (Pratt and Matthews 2004, 24)

In the third phase, students engage in research, acquire ideas, and learn biological and nutritional facts and concepts. In the fourth phase the students apply what they have learned in designing their own healthy, balanced meals for specific nutrition-related diseases. Then students present their specialized recipes and (if possible) sample meals in the classroom, along with written papers and presentations of their work.

In the fifth phase, the Food Policy and Regulation Committee (FPRC) (consisting of the instructor, two students, and, if possible, the chef or another staff member from the school cafeteria) evaluates the students' proposed healthy meals for effects on nutrition-related diseases using the specific criteria

provided in Phase One. The FPRC then decides whether or not to endorse the proposed meals. The instructor uses the final recommendations of the FPRC as well as another set of specific questions to guide student discussions reinforcing understanding of the intended learning outcomes.

In summary, by researching nutrition-related diseases, the nutritional values of various food ingredients, and designing specialized meals targeting specific nutrition-related disease, students learn to:

1. Organize their nutritional needs on a day-to-day or weekly basis
2. Make healthy and desirable food choices
3. Learn and reinforce their understanding of the role of food and nutrition in fighting nutrition-related diseases and achieving a healthy lifestyle
4. Understand the roles that the human brain and stomach play in tackling hunger and obesity

## Procedures (Instructor)

### *Before the Presentations*

1. Form a Food Policy and Regulation Committee (FPRC).
2. Hand out the Criteria for the Assessment of the Learning Activity sheet shown in Table 2.
3. Divide the students into groups of 2 or 3 and instruct each group to
  - a. Research one of the nutrition-related diseases, then research nutritional ingredients and design their own recipe for a healthy, balanced meal for a given mealtime and targeting their selected nutrition-related disease
  - b. Prepare a written and oral presentation that includes the research, the nutritional components of the designed meal, the recipe for their meal, and why and how the designed meal is beneficial in reducing and/or preventing their chosen nutrition-related disease(s)
  - c. Present their recipes and (if possible) sample designed meals and assignments to the class
4. At the next class meeting, ask each student to write answers to at least some of the following questions, and then lead the class in a whole-group discussion. Give the students 20-30 minutes to complete the assignment.

- a. What constitutes a “Healthy, balanced Meal” (HBM) and what is the general character and purpose of a given mealtime (breakfast, lunch, and dinner)?
  - b. What is cholesterol? Is it necessary? When and how does cholesterol become a health problem for the human body?
  - c. What is sugar? Is it necessary? When and how can sugar become a health problem for the human body?
  - d. What is an allergy? What is an allergic reaction? What are the symptoms of allergies? What are the most common allergic reactions? What are the main foods that are responsible for 90 percent of all food allergies in the United States? How does “Oral Immune Therapy” work in treating some of the food allergies?
  - e. What is fiber? What is the difference between soluble and insoluble fiber? What is the best way to increase fiber intake?
  - f. What are phytochemicals? What role do they play in achieving a healthy body and lifestyle?
  - g. What is hunger? What is starvation? On average, how long can a person stay alive without food?
  - h. What is fortified food? Why do many believe that it is one of the most effective ways to provide nutrients to some populations that couldn’t otherwise obtain them?
  - i. What are the nutrients most often added to foods?
  - j. What is the leading cause of stroke? What are the stroke risk factors?
  - k. What are the differences between macronutrients and micronutrients? Provide examples.
  - l. What is the difference between a “good carb” and a “bad carb”? What are rich sources of good carbs and rich sources of bad carbs?
  - m. What are trans fats? What are the major sources of trans fats in our diets?
  - n. What are free radicals? What role do nutrients play in the generation of free radicals? How do free radicals affect the human body and health?
5. Once students have answered the questions, discuss them in the classroom and help them select the best answers. Then challenge them to refine their definitions.
  6. At the next class meeting, give students the two proposed Healthy, Balanced Meals shown in Table 3 as a homework assignment to study and critically analyze. These examples will help them design their own healthy, balanced meals for a given mealtime targeting one or more of the top nutrition-related diseases. In this assignment, students are asked to:
    - a. Critically analyze the two examples of Healthy, balanced Meals
    - b. Identify any missing nutrients or substances that are needed to achieve their intended goals
    - c. Provide a justifiable explanation for agreeing or disagreeing that these two meals are nutritionally balanced
    - d. Using the criteria provided in Tables 2 and 3, provide a rating for each of the two proposed balanced meals
  7. Finally, give the students 2-3 weeks to research, design, prepare, and present their specialized meals and their presentations (both oral and written). In addition, set aside time in each class period for the groups to meet and work on their projects. Instruct the groups to:
    - a. Research and prepare a well-supported and evidence-based paper and oral presentation about their specialized meals
    - b. Be prepared to engage in a debate with their classmates and the members of the FPRC on the nutritional value of their specialized meal and why it is suitable for the selected mealtime and the targeted nutrition-related disease
    - c. Have a well-researched handout ready to be distributed to the class before the presentation, as well as an illustrated poster or photos, etc., that help convey the group’s message and support the argument for its designed meal
    - d. Prepare a final written statement for the judges (after the presentation) that can be read to support the usefulness of their specialized meals and their health value to the targeted disease(s)

As mentioned above, the students are provided with a set of criteria that must be used to guide and to assess their designed meal and their oral and written presentations. As shown in Table 2, this set of criteria contains 11 key factors. The criteria are used by both the students and the Food Policy and Regulation Committee. Students use them to prepare their learning assignment and the FPRC uses them to assess student work.

**TABLE 2.** Criteria for the Assessment of Student Projects

- 1. Does the meal address one of the four identified nutrition-related diseases?**
- 2. Does the meal**
  - a. Include more than one ingredient?
  - b. Include vegetables, fruits, grain, etc.?
  - c. Help prevent or reduce the incidence or severity of the targeted disease?
- 3. Is the meal easy to make from available and affordable ingredients?**
- 4. Does the meal contain any of the main eight foods which are responsible for 90 percent of all food allergies in the United States? If yes, does the group**
  - a. Acknowledge that there are allergens?
  - b. Provide a warning and/or state who should avoid them?
  - c. Provide alternative ingredients?
  - d. Provide advice if an allergic person accidentally eats the meal?
- 5. Does the source of ingredients meet the American Health Association's food criteria for saturated fat and cholesterol for healthy people over age 20?**
- 6. Does the meal contain ingredients that should be taken in moderation? If so, does the group bring this to our attention and explain the need for moderation?**
- 7. Does the group identify the type of dish and for which specific mealtime it was designed?**
- 8. Does the group**
  - a. Disclose all the ingredients in the meal?
  - b. Identify the nutritional value of each ingredient?
  - c. Provide a complete recipe for its designed meal?
- 9. Does the group emphasize the relevance of the meal's nutritional value and health benefits for the prevention of one or more of the four nutrition-related diseases?**
- 10. Does the group identify the approximate dollar value of the meal and the time it takes to prepare?**
- 11. Does the group generate a "Card-Fact-Sheet" of ingredients in their specialized meal?**

The students are provided with the following examples to help them start their assignment and as a subject for a homework assignment.

**TABLE 3.** Examples of Proposed Healthy, balanced Meals

**Example One: A Balanced Healthy Oatmeal Breakfast**

**Ingredients:** 1 cup 100% whole oatmeal, ¼ cup dried cranberries, 10-15 chopped almonds (unsalted), ¼ cup raisins, and a handful of chopped walnuts (to taste).

**Directions:** Measure 2 cups of water into a pot. Add the chopped almonds and heat to a boil. When the water boils, take the pot off the burner and add the raisins, cranberries, walnuts, and 1 cup of oatmeal to the mix. Cook on low heat for 3-4 minutes and then remove from heat and let cool. Add a bit of brown sugar to your meal, if desired. (Note: raisins are loaded with sugar and dried cranberries are already sugar sweetened, so sugar is optional. For more protein in this morning meal, a few roasted chickpeas can be added. This meal can be eaten with or without fat-free milk or fat-free soy milk).

**Example Two: A Nutritionally Balanced Healthy Lunch**

This meal consists of fresh lettuce, fresh spinach, cooked skinless chicken or turkey breast, almonds, cranberries, cooked beans (black beans, green peas, or chickpeas), fresh tomatoes, fresh cucumber, and one slice of whole-wheat bread.

**Directions:** Clean and cut up ¼ pound of fresh lettuce and ¼ pound of fresh spinach and mix them in a bowl. Add 8 oz (227 g) of already-cooked skinless chicken or turkey breast strips into the bowl. Then add ¼ cup each of almonds, cranberries, and cooked beans or peas (black beans, green peas, or chickpeas) to the bowl. Cut up and add one fresh tomato and one-half fresh cucumber. If desired, add your favorite reduced-fat or fat-free dressing to the mix. Eat with one slice of whole-wheat bread. If desired, salmon or tuna can be substituted for the chicken or turkey breast.

In addition, as part of designing a balanced healthy meal, students must also complete Table 4 using the ingredients they selected for their design. The students should be advised to be creative with their designed meals and menus by mixing and matching different categories of foods (fruits, vegetables, grains, fish and white meat, and so on) to suit their preferences, objectives, and targeted nutrition-related diseases.

**TABLE 4.** Criteria for the Assessment of Student Projects

INGREDIENTS	HEALTH BENEFITS OF FOOD	NUTRIENT BENEFITS	POSSIBLE ADVERSE EFFECTS

### During the Presentation:

1. The groups take turns presenting their specialized meals to the class. The members of the FPRC question each group. In addition, the students in the class can ask up to three questions after a group finishes presenting its designed meal. The members of each group take note of the questions that are asked.
2. When all the groups finish presenting their specialized meals, the FPRC can ask more questions of any of the groups. The FPRC must also consider the student questions and answers in their final evaluation.
3. The members of the FPRC wait until the next class meeting before sharing their final decisions with the groups. During this time, if there is a room available in the school, the posters, illustrations, photos, etc. can be made available for all the students to view.

### After the Presentation (For the FPRC)

1. In making their final decisions, the members of the FPRC take into consideration the following:
  - a. The academic quality and integrity of the written paper, the oral presentation, the poster illustration, and/or any additional aids used by the students to help convey their message
  - b. The delivery of the presentations, the articulation of their arguments, the demonstration of the

interrelationship between the ingredients in the meals and their roles in reducing, treating, and/or preventing nutrition-related diseases, as well as the individuals' personal involvement and engagement during the presentations

- c. The type and quality of questions being asked during the process; in addition, the quality of the answers the group provided to questions directed at them (The teachers should also record the types of questions being asked by the groups, the relevancy of the questions to the subject matter and to the point being presented and discussed, and the number of questions being discussed from one group to the other.)
2. Each group is given 2-3 minutes to address the FPRC one more time before the members of the committee read the final decision and recommendations. In these final remarks, the groups must have a written statement that can be read to support the usefulness of their specialized meals for their health value and their relevancy to both their designated mealtime and the targeted nutrition-related disease.
3. Using a scale of 1 to 5 (as seen in Table 5), the Committee makes its recommendations based on the nutritional value of the designed meal, as well as on the meal's effectiveness in reducing or preventing the targeted nutrition-related disease.

*Both the groups and the FPRC use the following criteria for this learning activity.*

**TABLE 5.** Recommendations of the Food Policy and Regulation Committee

LEVEL OF RECOMMENDATION	RECOMMENDATION FOR TARGETED NUTRITION RELATED DISEASE	EXPLANATION AND/OR CLARIFICATION	SUPPORTING EVIDENCE
Level Five	Highly Recommended		
Level Four	Recommended		
Level Three	Recommended with reservations		
Level Two	Lack of sufficient data on the nutritional value of the meal to allow a recommendation		
Level One	Not recommended		

## Discussion Questions

Asking questions can provide information and promote critical thinking that can spark interest in the research done in Phase I, as well as giving students a fresh perspective when needed. The following list of questions can be used at the beginning of each class or at any time during the activity, and can be asked orally or prepared as handouts. Instructors can select any of these questions for use in the activity based on their discipline’s educational objectives and goals. Some of the questions may also be given out for pre-class research by students.

1. Explain the differences among “safety food,” “quality food,” and “comfort food.”
2. According to microbiologist and MD Roberts Desowitz, “The immune system is the body’s doctor, our own personal physician that cures and protects us from a panoply of diseases” (Carleton and Wait 2001, 25). Write a letter to a friend to explain this quote.
3. Which of the four nutrition-related diseases (heart disease, cancer, stroke, and diabetes) has a stronger relationship with the condition of the immune system than the others? Which disease has a weaker relationship than the others? Explain.
4. Differentiate chemically, biologically, and nutritionally between carbohydrates, proteins, and fats/lipids.
5. What is the secret behind the power of oats in bringing cholesterol levels down?
6. Why is spinach not recommended for someone with a tendency toward loose stools or urinary incontinence?
7. Why have we been advised not to eat large quantities of bolted lettuce (lettuce that has gone to seed)?
8. Why should we not worry too much about the total amount of protein we ingest, but rather focus on the healthy sources of the protein and how to increase them in our diet?
9. It has been said that consuming vegetable protein causes less bone loss than animal protein. Why is that?
10. Explain why many scientists believe that breakfast is the most important meal of the day.
11. How should we best eat our food—raw, semi-cooked, or cooked? Explain.
12. In his book *Perfect 10 Diet*, Dr. Michael Aziz (2010) argued that “a healthy diet balances all the macronutrients in a very specific way.” He recommended the balance of 40% carbohydrates, 20% protein, and 40% fat. Do you agree? Explain.

13. Explain how poor nutrition impacts both the physical and mental development of young people.
14. What will happen when your body secretes too much insulin?
15. It has been proposed that everyone should be a "food label sleuth," paying attention to the percentage of calories from fat and the number of grams of fiber. Why is this an important strategy for maintaining a healthy, balanced diet?
16. What are the three main types of carbohydrates and how do they differ?
17. What might happen to the gallbladder of someone whose cholesterol levels are very high?
18. What would you suggest to someone with diabetes to satisfy his or her sweet tooth and why?
19. Explain the significance of the following quote from a health and diet perspective:

The outermost leaves of spinach and cabbage, for example, have the highest levels of vitamin C, and broccoli florets have more C than the stalks. One hundred grams of fresh apples with the skin contain about 142 milligrams of flavonoids, but the same amount of apples without the skin has only 97 milligrams of flavonoids.... Of course, the skin is where the pesticides and potentially harmful bacteria reside, so a careful washing is mandatory. (Pratt and Matthews 2004, 168-169)

## Conclusions

Benjamin Franklin (1706-90) recommended almost 280 years ago: "To lengthen thy life, lessen thy meals" (NIH 2002, 34). Until the twentieth century, complex carbohydrates, starch, and glycogen provided the majority of the metabolic fuel for most people in the world, but this was not the case in the United States during the past century. American diet changed significantly in that time by replacing carbohydrates with fats and protein as energy sources and by replacing complex carbohydrates with sugar (Armstrong 2012, 616).

The food we eat is vital in determining both our current and potential health (Hark and Deen 2005). Traditionally, meals exist to nourish our bodies. In our modern, fast-paced world, the focus of food and meal preparation has changed from nutrition to convenience and speed. Unfortunately, consciously or unconsciously, many of us often eat the wrong

kinds of food. Our diet, often too rich in saturated fats, sugar, and alcohol, has been linked in part to at least 5 of the 10 leading causes of death in the United States: heart disease, cancer, stroke, diabetes, and kidney disease (Hill and Kolb 2007, 459).

This learning activity aims to provide a hands-on method for students to understand the role that nutrients play in their lives. The goal is to teach them what biologically constitutes a healthy meal and to be more aware of the relationship between nutrition and nutrition-related diseases and how nutrition can be used to maintain one's health and well-being. Students learn how to combine ingredients to create a healthy meal, the possible dangers of additives, and the common allergy-inducing foods. By designing and preparing their own meals, students acquire practical lifelong skills that can contribute to achieving a healthy lifestyle.

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## APPENDIX

### *Extra Credit Assignment*

1. Design simple standardized techniques for designing and making healthy, balanced meals for nutrition-related diseases.
2. What are the benefits of getting a good night's sleep of about 7- 9 hours? What are the best ways to help someone sleep more deeply and soundly to achieve a healthy lifestyle?
3. What can be included and what excluded from each proposed healthy, balanced meal for a given nutrition-related disease? Explain.
4. "Today, far too many American children grow up in environments where sedentary lifestyles and an excess of nutrient-poor, calories-dense foods are the norm. If the current trend continues, our children may have shorter life expectancies than we do" (Newsweek, June 26 and July 5, 2010, 22). What solutions would you suggest for dealing with this problem in both the short term and the long term?
5. If the consumers of your healthy, balanced meal also love to drink caffeinated beverages (tea, coffee, chocolate, etc.), which caffeinated beverage do you suggest will BEST complement your meal and the specific nutrition-related disease it addresses? Explain.
6. Many scientists and activists have been talking about the need for a law to protect children's diet and health. Propose a detailed "Child Nutrition Bill" which can be submitted to the U.S. Congress for consideration.
7. Design rules for eating out that help those who would like to have a healthy, balanced diet and maintain healthy eating habits.
8. Conduct research and write a short paper on
  - a. The role that drinking plenty of water plays in weight reduction and a healthy body
  - b. The relationship between aging and diet
  - c. The positive and negative sides of alcohol consumption
  - d. Food and genetic diseases
  - e. Nutrition and longevity (caloric restriction and longevity)
9. We all know that food does not come from packages and cans in the grocery store; it comes originally from farms and people's gardens. Yet, small farms and farmers are disappearing at an alarming rate in many areas of the United States and are being replaced with large agribusinesses. From your perspective, how might this trend affect the type and quality of food large industrial farms produce for public consumption?
10. Which of these four nutrition-related diseases—heart disease, cancer, stroke, and diabetes—has the strongest relationship and which has the weakest relationship with the condition of the immune system? Explain.
11. Cancer, which is one of the nutrition-related diseases, is a disease characterized by the presence of one or more malignant tumors, a mass of neoplastic cells that have the capability of spreading throughout the body. What often causes a normal cell to become a cancer cell? In what ways are cancer cells abnormal cells?
12. Cancers are classified according to the tissues in which they arise. Conduct research to learn more about cancer. Then discuss and differentiate between the common types of cancers.

# Using a Rubric to Standardize Assessment of Quantitative Reasoning Skills in Basic Math Courses

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## Abstract

This paper discusses the design and integration of a scoring rubric to assess quantitative reasoning projects embedded in the basic math courses at LaGuardia Community College. In order to contextualize the basic math skills course material and make it more engaging and relevant to students' interests, LaGuardia's faculty have developed and incorporated PQL (a SENCER-based model) projects into courses such as Pre Algebra, Elementary Algebra, and College Algebra and Trigonometry. Here, we provide an essential tool, the PQL generic rubric, to measure students' success in these projects. The rubric can be used to grade students' work consistently, as well as to provide them with meaningful feedback for improving their learning.

## Introduction

**Overview of PQL:** The Project Quantum Leap (PQL)<sup>1</sup> program at LaGuardia was established in 2007-2009. The primary goal of the PQL program was to adapt the SENCER (Science Education for New Civic Engagements and Responsibilities) approach in basic mathematics courses, allowing students to gain mathematical reasoning skills that they can apply to learn math topics in a relevant context and to solve real-life problems. SENCER, a National Science Foundation initiative for improving STEM education, supports contextualized course material and explores it through "compelling context and civic engagement. It focuses on real-world problems and extends the impact of this learning across the curriculum to the broader community and society" (SENCER, 2009a, 2009c). The aim

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<sup>1</sup> The PQL program was funded by grants from the U.S. Department of Education (Betne 2010). The project, supported by LaGuardia's Center for Teaching and Learning, was expanded in the years 2009–2012, after additional grants from the U.S. Department of Education were received.

of the PQL program is to use the SENCER approach in order to increase students' interest in math and thereby improve student retention and pass rates in developmental math and college gateway level courses.

At LaGuardia, more than 35 percent of the students in basic skills math courses retake the course at least once (Betne 2010). This could perhaps be due to students' perception that the subject is irrelevant and not connected to their lives. Recent studies by Wagstrom suggest that integrating civic/environmental issues into the Pre-Algebra course and teaching mathematics through context of real-world applications improves students' confidence and interest in learning mathematics (Wagstrom 2010). The PQL program at LaGuardia was designed to integrate thematic projects into basic skill math courses and college gateway level courses. Integrating quantitative reasoning skills, such as reading and comprehending of numerical data, into basic math courses seems indispensable, since they have become essential skills in our daily lives. In fact, at LaGuardia, it is one of the core competencies in the General Education curriculum. The PQL projects aimed for enhancement of students' quantitative reasoning skills.

**PQL Faculty development seminar:** A key component of the PQL program was faculty development and course design. In 2007–2009, the math and non-math faculty participants of the PQL professional development seminar designed and piloted the use of class projects for four courses: Introduction to Algebra (MAT 095), Elementary Algebra (MAT 096), College Algebra and Trigonometry (MAT 115), and Elementary Statistics-I (MAT 120). These projects were class activities focused on themes such as Energy and the Environment (MAT 095 and MAT 120), Problems and Issues in Public Health (MAT 096), and Business and Finance (MAT 115). In 2009, the Center for Teaching and Learning published these projects in the form of a Project Quantum Leap Sampler (LaGuardia Center for Teaching and Learning, 2009). Several additional PQL projects were created by the seminar participants in 2012 and were added to the sampler.

Assessment of the PQL program demonstrated an improvement in students' quantitative reasoning skills, confidence, and level of engagement in mathematics, as well as higher passing rates for students who took courses

with PQL (Betne 2010). In Fall 2012, the mathematics department revised the curricula for the MAT 095 and MAT 096 courses, and PQL project activities were integrated as a part of the course material. For Pre-Algebra (MAT 095), the "Instructor's Assessment" grade book category now includes PQL projects, along with tests contributing a total of 15 percent to the course grade. Similarly, for Elementary Algebra (MAT 096) PQL projects are defined as a separate grade book category worth 5 percent of the overall course grade.

**Overview of the PQL assignment rubric:** When the PQL projects were integrated into the courses as graded activities, it became clear that some discussion and standardized approaches for grading the projects needed to be developed.

**Each PQL assignment consists of the following three parts:**

1. *Concept or Theme:* The first part of the assignment includes reading material related to the theme, such as a discussion of environmental issues or problems in public health. Students are required to comprehend the material and understand the problem.
2. *Mathematical Analysis:* In this part of the assignment, students are expected to interpret and analyze the given quantitative information (data) and perform mathematical analysis to produce numerical results.
3. *Conclusion and Reflection:* The final part of the assignment requires students to convert the numerical results obtained in Part 2 into qualitative information and draw meaningful conclusions related to the theme. Students are also asked to reflect on the overall activity to exhibit their understanding of the lesson and to include a summary of their perspective about how mathematical concepts can be applied to solve real-life issues.

Grading PQL projects is complex and challenging. Since the three components of the assignment are inter-related, an examiner needs to carefully evaluate each one of them and ensure that students have exhibited their ability to comprehend the social issues, to apply mathematical reasoning, and to interpret the results in context in order to solve a given problem. When PQL projects were first included in the course curriculum, instructors used either a holistic approach or created their own scale

to assess students' work. Therefore, the assessment of students' work varied based on the instructor's expectations. For example, an instructor might have assigned a fairly good grade for an assignment that exhibited a strong response to the questions related to the overall theme, but contained some inaccuracy in mathematical calculations, while another instructor might have assigned the most credit to accuracy in mathematical calculations, thereby creating a different scale. This could have led to inconsistencies in grading students' work. Moreover, among ourselves, we noticed that there was a discrepancy in overall grades when we graded the same assignments at different times with different performance expectations.

This experience led us to create an analytical scoring rubric for PQL projects. We realized that it is critical to have clear learning goals and an efficient evaluation tool in order to be consistent in grading. Assessments that are tailored both to course goals and to institutional goals for students' learning could play a crucial role in producing the desired results (Burns 2012). Assessment and grading of students' PQL project work was important in order to provide meaningful feedback to students and to clarify performance expectations. We chose to create an analytical rubric (Mertler 2001) for scoring the individual parts of the project, since scoring each individual part of the assignment was crucial in finding the overall grade. We

### GENERIC RUBRIC FOR PQL ACTIVITIES <sup>2</sup>

Scale	1 - Beginning	2 - Developing	3 - Competent	4 - Good	5 - Excellent
<b>Understanding information and data; ability to interpret quantitative information</b>	Minimal understanding of information and/or incorrect use of the data; not capable of interpreting quantitative information	Some understanding of information and occasionally uses data correctly; some confusion with interpretation of quantitative information	Understands most of the information and use of data is mostly correct; reasonable interpretation of quantitative information	Understands information and use of data is correct; interprets quantitative information correctly	Understands information, uses data confidently, accurately, and efficiently; flawless interpretation of data
<b>Ability to apply math concepts; using formulas; performing mathematical analyses</b>	Applies math concepts incorrectly; uses formulas incorrectly; incorrect math analyses	Some grasp of math concepts but not always applied correctly; errors with formulas; many numerical errors	Use of math concepts is mostly correct; use of formulas is correct; several errors in mathematical computation	Math concepts used correctly; formulas are correct; mathematical computations exhibit minor or insignificant errors	Math concepts used correctly; use of formulas is correct, proficient, and even elegant; math analyses are perfect
<b>Conclusions and/or reflection on the activity</b>	Inappropriate conclusions or blank responses	Weak or vague conclusions or blank responses	Reasonable conclusions and/or reflection; demonstrates relevance of math in approaching social issues	Insightful conclusions and/or thoughtful and focused reflections	Precise and well-established conclusions and/or great insight into use of math when approaching social issues
<b>Presentation (language use, look and feel, citations)</b>	No effort to write carefully or to create thoughtful presentation; no citations	Some effort to write carefully but many errors; no attempt to follow a logical sequence; few or no use of references and citations	Some errors but follows a logical sequence; little attempt to enhance the project with graphics, etc.; occasional use of references and citations	Good, careful, and logical writing; attempts to enhance presentation with graphics or additional comments; provides citations to references but may not format citations correctly	Well-written and logical; enhances presentation with graphics and comments; citations of references are present and correctly formatted

<sup>2</sup> The rubric was originally developed by the author and then revised and edited with support from Ros Orgel of the Center for Teaching and Learning at LaGuardia. This preliminary version of the rubric was presented by the author during the SENCER MidAtlantic Regional Meeting held on November 11, 2011 at Metropolitan College of New York with Dr. Sreedevi Ande from LaGuardia Community College.

used the three components of the PQL project (mentioned above) as criteria for grading. We used a fourth criterion, Presentation Skills, for assigning bonus points to encourage students to perform better.

Since grading requires precision (Allen 2010), our objective was to provide scoring guidelines to faculty for grading PQL projects. In order to evaluate student's assignments consistently, we designed the following assessment rubric. We were careful to keep in mind the need to give and receive more meaningful feedback on students' learning, in order to help them understand the concepts more deeply. Our discussion of the usefulness of the PQL Rubric to assess students' learning is based on our experiences.

**Application of PQL Rubric to PQL activities:** In the following examples, specific parts of the projects are discussed to show how each criterion of the rubric can be applied to assess the PQL assignment. We have also provided general guidelines for using the rubric to assess any PQL project.

**1. Understanding information and data; ability to interpret quantitative information:** For assessing students' work under this criterion, we give the following example of a PQL project:

*"Carbon Emission" – a PQL project for MAT 095 (Betne 2009)*

In this activity students need to understand the concept of simple average and weighted average. Based on a chart given in the assignment, they are required to obtain the average carbon emissions per person for the seven regions. In order to do this, they will have to find the weighted average. A conceptual error can occur if a student ignores the population of each region and calculates only a simple average. In this case, we can refer to the first row of the rubric to evaluate a student's work on the scale of 1-5.

**2. Ability to apply math concepts; using formulas; performing mathematical analyses:** The following example of the activity demonstrates the use of this criterion for examining students' work:

*"Projected Deaths for Selected Causes to 2030" – PQL project for MAT 096 (Gbedemah 2009).*

In this activity a graph of projected global deaths due to HIV/AIDS starting from year 2000 is given. It is assumed that the graph starting from 2010 can be described as a square root function of the type  $H(t) = a\sqrt{t+b}$ , where  $a, b$  are constants and,  $H(t)$  represents the number of projected global deaths (in millions) in year ( $t$ ) after 2000. Students are required to use the given data points to find values of unknowns  $a$  and  $b$  in the equation. The second row of the rubric could be helpful to evaluate a student's work when mathematical errors are exhibited. For example, students may compute values of the constants  $a$  and  $b$  inaccurately or make numerical errors in evaluating the function  $H(t)$  for a given  $t$ .

**3. Conclusions and/or reflection on the activity:** The following example illustrates how this criterion can be applied for assessing the PQL project:

*"Rising Gas Prices Crisis: How Fast and Why?" – a PQL project for MAT 115 (Meangru 2009)*

In this activity, students are asked to reflect on the increase in the gasoline prices and its impact on daily life. The activity includes questions such as, "In what way did you connect the math to a real situation?" "What factors do you feel may be responsible for this crisis?" A well-established conclusion should address these questions based on the math the student has learned. In this particular problem, a summary should show how the knowledge of the average rate of change helped the student to understand the severity of the gasoline crisis. It could also include an extract or a supporting argument based on the mathematical equations that the student learned in the activity. One can refer to the guidelines listed in the third row of the rubric to judge the student's insight into the topic and for understanding the relevance of math.

**4. Presentation:** We found that awarding students a few bonus points for a detailed and outstanding explanation of work, with appropriate citations, greatly motivated and inspired them to engage with the content and to learn more.

## Results and Discussion

During the Spring 2012 semester, in order to train faculty on the use of the rubric, we asked participants of the PQL professional development seminar to pilot test the rubric by assessing two anonymous samples, PQL projects that were exemplars of different levels of performance. We asked participants to use the scale 1-5 of the rubric to score independently each component of the project and then average the scores of all components to report the overall score for the entire assignment. Out of eleven faculty participants who responded, nine of them assigned identical scores for sample A while for sample B, eight participants gave identical ratings, thereby indicating the high inter-rater reliability of the rubric (see Table 1 below). We then discussed the differences in the ratings and asked raters to explain their judgments. This helped us to establish the standards and to gauge usefulness of the rubric. We agreed that the majority of our remedial math students needed be at the level of 3 or higher.

**TABLE 1.** Number of faculty and ratings for sample assignments

Score ( on Scale 1-5)	1	2	3	4	5
Sample A		2		9	
Sample B		8	3		

We presented the PQL Rubric during the departmental basic skills workshop at the beginning of Fall 2012 semester and shared it with all faculty teaching basic skills math courses. The instructors were also provided with a handbook giving them guidelines for implementing the PQL approach in basic skill math classrooms. We observed that during Fall 2012 more of the faculty piloted the use of the rubric in their classes to assess the PQL projects. To test further the usefulness and applicability of the PQL Rubric and its three components, we ran an anonymous survey to receive feedback from the instructors on the use of PQL handbook and rubric. About 61 percent of the faculty who responded to the survey reported that they used the PQL handbook and about 44 percent of them said that they used the PQL Rubric to assess the PQL projects. About 11 percent of the survey respondents used the PQL Rubric along with their own judgments or some other method of grading. One faculty

member responded that the PQL Rubric was used for estimation of overall grade, while another reported no knowledge of this resource.

It is evident that the PQL Rubric was useful in examining students' PQL project work in a consistent manner. Since each assignment had quantitative reasoning components, it was easy to use the PQL Rubric to grade that part of the project. It also gave the instructor a fairly good estimation of the score and judgment about the overall proficiency that students exhibited through their work. Although several faculty members piloted the use of PQL Rubric in their classes and reported its usefulness in gauging students' learning, we realize that much more research still needs to be done to fully validate the PQL Rubric we have developed.

In the future, we would like to determine whether providing the rubric to the students along with the project assignments would have any effect on their performance on the project. We plan to compare the performances of the math students who are given the PQL Rubric as a guideline for their PQL project with those who do not get the rubric. We also plan to administer the SALG assessment tool (SENCER 2009b) to gauge the effectiveness of the use of rubric. Further, we need to make this PQL Rubric assessment tool available to the greater community of faculty and students, get their feedback, revise the tool to suit their needs, and measure its impact on students' learning.

## Conclusions

We noticed several potential advantages of having faculty use a standardized rubric format for evaluating students' PQL projects. First of all, a standard rubric can provide uniform measures of quality to assess students' work, as opposed to using a holistic approach or using different grading scales devised by individual faculty members for each of their assignments. The use of rubrics provides consistency in grading, thereby ensuring greater accuracy in the measurement of learning gains and enhancing the reliability and validity of the assessment. Secondly, the use of rubrics allows the instructor to grade the assignment in parts, making grading easier and more efficient. Furthermore, using a rubric helps clarify to students the expectations of their performance on projects. Since the

instructor can provide detailed feedback on their progress for each part of the assignment, students can better understand how well they are learning and how they can improve.

Moreover, examining students' work and scoring assignments using the rubrics could allow the faculty to create or revise assignments, so that students are able to demonstrate their proficiency as expected. Instructors could even tailor their pedagogy according to the levels of learning that they want to measure. Finally, the standardized PQL Rubric could be helpful for measuring students' learning, not only in the mathematical aspect of Quantitative Reasoning, but also in interdisciplinary core competencies such as Research and Information Literacy, Critical Thinking across the Curriculum, or Communications Skills. Recently, Grawe et al. (2010) viewed Quantitative Reasoning in the context of writing skills, and they have developed a rubric to assess quantitative reasoning in students' written arguments.

We believe that the PQL Rubric presented here is not limited to only PQL projects but could be applied to any mathematical assignments that are designed using the SENCER approach. We hope that this work will provide valuable insight into students' learning and may even lead to development of more powerful assessment tools in the future.

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# Integrating SENCER into a Large Lecture General Education Chemistry Course

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## Abstract

Students in a large lecture general education chemistry course at Southern Connecticut State University (SCSU) were required to design their own SENCER-based research project. The students were tasked with researching chemical topics found anywhere within the campus/local community, resulting in projects that were extremely diverse. These projects ranged from students researching the feasibility of opening an on-campus can/bottle redemption center to students exploring the disposal procedures of supplies in the art department. The SENCER-SALG assessment tool was used to evaluate the success of the projects and showed that the majority of students reported a gain in their understanding of the multidisciplinary nature of societal issues and in their perception of how studying chemistry helps people address real world issues.

## Introduction

One of the major obstacles to the implementation of anything novel into the course curriculum of a large lecture class (the size of the course as currently taught at SCSU is approximately 130 students in one large lecture hall) is the substantial amount of organization and assessment required. The class size, coupled with the lack of funding for teaching assistants make the proper implementation and assessment of novel coursework a monumental task. In addition to the large lecture sizes, the motivation of “general education” students in required lecture courses has always been a significant obstacle to learning (Glynn et al. 2005; Ward and Bodner 1993).

Recently, SCSU transformed its general education program (referred to as all-university requirements [AUR]) into its new Liberal Education Program (LEP). Because one of the main requirements of the LEP is that the courses involve some relevance to contemporary societal issues, the teaching approaches advocated by Science Education for New Civic Engagements and Responsibilities (SENCER) are an ideal way to integrate community issues into a science course

(Burns 2011). Another required component of a LEP science course is that the students understand the nature of scientific inquiry (Natural World: Area of Knowledge and Experience).

In an effort to keep the students motivated while integrating these new key elements into the curriculum, a flexible, modular SENCER project was developed where students could, with minimal guidance, develop a project related to their own interests. Although there was still a significant amount of grading involved in properly assessing a SENCER project in a class of this size, the SENCER-SALG (Student Assessment of Learning Gains) survey helped to minimize the workload on the instructor as well as to evaluate the project.

## Methods

During the Fall 2012 semester a SENCER project was introduced into the curriculum for the CHE 101—Chemistry in Contemporary Issues—course at SCSU. The course is offered either as a day class or as a night class. While the day lecture class has a much larger enrollment (128 students) than the night class (32 students), both courses integrated the modular SENCER research project into the curriculum. The students were taught about the SENCER ideals and the SENCER project during the first class, and were asked to divide themselves into groups of four. They were then given a project description, including a grading rubric for each module. This description included an outline and an approximate timeline of due dates throughout the semester. The SENCER-SALG assessment tool was utilized to evaluate how much the SENCER project assisted their learning. In an effort to alleviate any student concerns about group work, individual group participation was self-evaluated twice throughout the course.

### Group Formation/Project Proposal

In this initial part of the project, the students worked in groups of four to develop a SENCER-based project involving chemistry and the local and/or campus community. The students were asked to submit a group narrative outlining their projects, with a focus on the purpose, civic connection, and science connection. The students were also asked to perform the baseline survey for the SENCER-SALG assessment. In the documents provided to the students about the project proposal, several examples of a possible SENCER project were offered, such as

1. Exploring the science of recycling on campus
2. Exploring the science of community gardens
3. Exploring the campus shuttle bus program and its impact on the environment
4. Exploring the energy consumption of buildings on campus

### Module 1: Background Investigation/ Planning and Preparation

After receiving instructor approval for their topic, each group began to work on the first portion of their project. In module 1, each group was tasked with submitting a two-page report summarizing their progress. The report consisted of three sections: a summary (with references) of their background research, a summary of their research plan, and a summary of the chemistry topics involved in the project. Each student was asked to submit an individual student response, the purpose of which was to evaluate their fellow group members' abilities to work within the group based on how much each student contributed to the project and what each one did.

### Module 2

Upon completion of module 1, each group began the research component of their project. In this module, the students were required to submit a copy of their data and any calculations done, as well as any graphs or charts produced to summarize their data. In addition, the students were asked to submit a data analysis summary and a brief conclusion statement.

### Module 3

In the last module of the SENCER project students were asked to submit a final written report (3-5 pages) of their project. The report consisted of a(n)

1. *Title Page* – Project title, group members, and an outline of the report
2. *Introduction* – Short paragraph(s) that outline the issue and the goal of the project
3. *Main Body* – Organized summary of all the relevant data and a discussion of the results that lead the reader to the conclusion
4. *Conclusion* – Summary of the conclusions of the project including a discussion of related topics and possible future work
5. *Bibliography* – Complete documentation of all sources used in the report

6. *Data and Calculation Appendices* – Copies of all raw data collected and calculations required for the report
7. *Response Appendix* – Description of a short action plan that the group would recommend as a result of their project; an example might be a memo to an administrator recommending a corrective action.

## Results

The SENCER project implemented in this course was utilized as a way to build into the curriculum a connection between the chemistry content presented in the course and the issues/needs of the local and university community. The majority of the reports that the students produced focused on environmental chemistry/science. This was expected because of the somewhat obvious connections between chemistry and the environment as well as the topic of the course textbook (Schachter and Edgerly 1999; Middlecamp et al. 2012). (Table 1)

Predictably, because they were provided with several project topic examples, the students produced a large number of projects centered around recycling on campus (4 projects), shuttle bus pollution (3 projects), and energy consumption of buildings on campus (7 projects) (35 percent of the 40 graded SENCER projects). In addition to the students who used the examples provided as project ideas, the students also produced a large variety of projects with 25 different themes.

Three particularly notable projects stand out among the 40 submitted for this course. (Table 2) Two of these noteworthy projects are good examples of students with similar majors coming together and developing a project wherein they take advantage of their common interests to investigate a chemical topic, and impact the campus community in the process.

Project #3 was an interesting collaboration of students majoring in Communication Disorders. While the students initially struggled to decide on a topic, they ultimately decided to study tobacco. The students learned a great deal about the large number of chemicals in cigarettes and discovered that there had been some research done on the effects of tobacco use on people with communication disorders, and they developed a brochure where they could inform SCSU students about the harmful effects of tobacco on communication disorders. The students then handed out their brochures on campus to the SCSU student/faculty population to inform the campus community about their project. Project #4 looked at

**TABLE 1.** SENCER Group Projects and Topics

Project #	Project Description:
1	Quantifying Sodium in Foods on Campus
2	Gatorade versus Water Hydration
3	SCSU Tobacco Trends on Campus
4	Chemistry in Oil Paints/Solvents and their Waste Disposal
5	What Are the Easiest Elements to Find in CT?
6	Recycling: Student Opinion vs. Fact
7	Chemistry of Crimes on Campus
8	Single Stream Recycling
9	Community Gardens
10	The Dihydrogen Monoxide Hoax
11	Composting on Campus
12	Indoor Swimming Pool Water Study
13	From Soil to Wine
14	Garbage on Campus
15	Redemption Centers on Campus
16	Organic vs. Nonorganic Foods
17	Plastic vs. Reusable
18	Going Green with Solar Panels
19	Polystyrene: A Threat to the Environment
20	SCSU Shuttle Buses
21	Coffee Consumption
22	Mold in Dorms?
23	Campus Gazebos
24	Fountain Drinking Water
25	Air Conditioning Conservation

**TABLE 2.** Notable SENCER Projects

Project #	Project Description:	Short Explanation
3	SCSU Tobacco Trends on Campus	Communication Disorders majors studying the effect of tobacco on speech
4	Chem./Waste Disposal in Paints/Solvents	Art majors studying the chemistry of oil paints and their proper waste disposal
15	Redemption Centers on Campus	Students researching the feasibility of an on-campus redemption center where students could add bottle deposits to their accounts

the disposal procedures used (or not used) for various creative works made in the Art Department. These students were amazed to find the general lack of awareness among art majors of the importance of properly disposing their various chemical waste products.

Project #15 was one of the most ambitious projects taken on by any of the students in CHE 101. These students looked into the chemistry behind recycling aluminum cans and plastic bottles. They called up several local recycling centers and asked about the costs of on-site recycling machines. One of the most interesting aspects of their proposal was the ability to add the bottle deposits to the students' campus accounts. The students even estimated the costs of a staff member for the proposed center. The students then surveyed the SCSU student body about the likelihood that they would utilize an on-campus recycling center. The group members then wrote an eloquent letter to the administration outlining their findings.

During the development/implementation of the SENCER project into the CHE 101 curriculum, we thought that leaving the project topic open for students to develop would allow them to devise a project based on their common interests and truly take ownership of it. While this did happen, it happened to a much smaller degree than was originally expected (4/40 projects; 10%). We suggest this is because of the large lecture class enrollment coupled with a general lack of instructional time available to devote to forming well-organized SENCER groups involving students with similar majors or interests. (Currently, the course lecture time is limited to two hours per week for the semester.) Ideally, instructor familiarity with the project will allow for better organization, and this would result in better groups in future semesters. Despite the lack of groups composed of students with common interests and majors, the students expressed their satisfaction and general approval of the project. (See SENCER-SALG student comments below.)

## STUDENT COMMENTS

*"The labs helped me understand and retain what we were learning. The group project helped me appreciate the subject."*

*"I enjoyed the SENCER project."*

*"The SENCER project really helped me to bring up my grade. I really enjoyed the project and the group work went really well."*

*"The group project was a lot of fun. It was a good way to work on something to help the university."*

*"I like the SENCER project, it helped me apply the concept to the world and the people."*

When the project was originally designed, we assumed the students would enjoy cooperative learning and be prepared for working together (Shibley and Zimmaro 2002; Felder and Brent 2007). Additionally, in order to encourage student enthusiasm and participation, students were informed about the benefits that the cooperative project would have on their learning and appreciation of chemistry (Bowen 2000; Kogut 1997). Even with our initial assumptions/information, we believed that some students might be reluctant to work in a group. In an effort to preclude any issues with group work, the SENCER project evaluation did take the students' group work into account. This was accomplished by allocating 10 points of the overall project grade for group evaluations. Despite this, a few students still commented on the SENCER-SALG about their displeasure working in groups with their classmates. (See student comments below.)

## STUDENT COMMENTS

*"I do not like working in groups. Everyone has lives outside of class and to get together to work on this project seemed difficult."*

*"Group activities can be frustrating."*

*"Good idea for a group project but it was very difficult to stay in contact and work together and with our schedules."*

After analyzing the few negative group work SENCER-SALG student comments, as well as informal questioning of students, we theorize that the students were dissatisfied because of two factors: The students needed further specific instruction about how to work effectively in groups, and SCSU's large commuter student population (~75%) was resistant to spending additional time

on campus for group work. In an effort to alleviate this, two changes will be implemented:

- 1) In order to quell frustrations about scheduling group meetings with commuter students, students will be asked to create Facebook or Twitter accounts to facilitate group interactions.
- 2) Additional course time will be devoted to instruction on how to effectively work together as a group, and there will be additional group work assignments outside the SENCER project.

While one instructor found the size of the large lecture class to be a significant obstacle to assessing the large number of student projects, by allowing the students the flexibility to develop their own project as well as utilizing a modular approach, the faculty workload was manageable and the students produced a large number of unique projects, increasing the impact on the local campus community as well as the students' general interest in the project.

## SALG-Survey

The SENCER-SALG was utilized to analyze the students' learning gains and the students' assessment of how the group project fit into their learning. The relatively low N (86) can partially be explained by student attrition. It also appears that some students simply did not complete the SALG and were willing to take a small point deduction. In future semesters, to rectify the low response rate additional points in the grading rubric will be allocated for completion of the survey. (See selected SALG question analysis below.)

**Question:** *How much did the SENCER group project help your learning in this course?*

The students reported that the SENCER group project was somewhere between little and moderate at helping their learning in this course. (N = 86; Mean = 2.6; Std. Dev. = 1.29) While this is lower than expected, the question did have the highest standard deviation among all the questions asked on the post-project SALG assessment. A more detailed look at this question revealed that 44 percent of the students ranked the SENCER project as little or no help at

helping their learning. The other 56 percent ranked the SENCER project as either moderate, much, or a great help to their learning in this course. The statistical mode (31 percent) for this question was a response of the project being a moderate help to their learning. (N = 27)

**Question:** *As a result of your work in this class, what gains did you make in your understanding of the multi-disciplinary nature of social issues and the importance of science in solving these issues?*

The students reported that they made a moderate gain in their understanding of the complexity of societal issues and their relation to science. (N = 86; Mean = 3.3; Std. Dev. = 1.07) A more detailed look at this question revealed that 24 percent of the students ranked their gains in understanding as little or none. The other 76 percent of students ranked their gains in understanding as moderate, good, or great. The statistical mode (33 percent) for this question was a response of a good gain in their understanding of the multi-disciplinary nature of social issues. (N = 28)

**Question:** *As a result of your work in this class, what gains did you make in your understanding of how studying this subject area helps people address real world issues?*

The students reported that they made a moderate gain in their understanding of how studying this subject area helps address real world issues. (N = 85; Mean = 3.3; Std. Dev. = 1.09) A more detailed look at this question revealed that 20 percent of the students ranked their gains in understanding as little or none. The other 80 percent ranked their gains in understanding as either a moderate, good, or great gain. The statistical mode (35 percent) for this question was a response of a moderate gain in their understanding of how studying this subject area helps people address real world issues. (N = 30)

The SENCER project aimed at integrating a relevance to contemporary societal issues into the course. The last two SALG questions discussed above were focused on assessing this particular aspect of the course. Both questions revealed that the majority of students (76 percent and 80 percent, respectively)

reported a moderate, good, or great gain in their understanding of both the multi-disciplinary nature of societal issues and of how studying chemistry helps people address real world issues. This result demonstrated that the integration of this SENCER project into the CHE 101 curriculum helps meet one of the key requirements for placing a course in the Liberal Education Program at SCSU.

## Conclusions

It will take several semesters to assess the overall success of the integration of a SENCER project into the curriculum of this class. Nevertheless, after the project was taught for just one semester, several questions on the SENCER-SALG revealed that the project was already successful at instilling a relevance to contemporary societal issues into the course. Furthermore, the majority of students asked (56 percent) ranked the SENCER project as a moderate, good, or a great help to their learning in this course. This SENCER project demonstrated that a large lecture class—while difficult to manage especially for one instructor—could be a venue for students to integrate their personal interests into chemistry, not only to enhance their understanding of course content but also to improve their understanding of chemistry's place in society. This project also provides a working model for instructors to integrate SENCER ideals into a large lecture-based chemistry class for non-majors while providing an enhanced experience for students studying general education chemistry. In future semesters additional instructional time will be allocated to teaching students about working in groups in an effort to improve that aspect of the course.

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# Energizing STEM Education at a Community College

## SENCER and Harold Washington College

**Dennis Lehman, Ph.D.**

*Harold Washington College*

Harold Washington College has been a participant in the National Science Foundation funded program *Science Education for New Civic Engagement and Responsibilities* (SENCER) since 2001. SENCER works to improve undergraduate science education and stimulate civic engagement by teaching basic science content through complex and unresolved public issues. Sustained participation in SENCER, through both the summer institutes and regional meetings, has had a significant impact on Harold Washington College's curriculum, an impact which is most evident in two important areas: notable improvements in faculty development and the establishment of new learning communities that have demonstrably boosted student retention rates.

Harold Washington College, named for the first African-American mayor of Chicago, is one of the seven campuses of the City Colleges of Chicago and is located in a downtown commercial area of Chicago. The student body is predominantly female members of ethnic and racial minorities. The college's mission is to provide students with opportunities for academic advancement, career development, and personal

enrichment. As with most community colleges, preparation for transfer to four-year baccalaureate institutions and workforce preparation are important academic priorities, and the college's curriculum is explicitly student-centered.

Harold Washington College was one of the first community colleges to participate in a SENCER Summer Institute, and faculty from our math, science, humanities, social science, and English departments have attended one or more of the annual Summer Institutes. The discussions and ideas emerging from these experiences have produced a range of new curricula and have led to the establishment of several highly successful learning communities.

There are two major reasons for SENCER's success at Harold Washington College: a very dedicated and creative faculty, and very strong administrative support. Support from the president, academic vice-president, deans, and chairs allowed the faculty to try new and innovative curriculum that improved retention and success rates in many of the SENCER courses. Another contributing factor, and a notable feature of Harold Washington's College's other SENCER

programming, is the number of disciplines and departments that are involved in the planning, development and implementation, and there are two examples that are particularly illustrative of this.

Thanks to the involvement of John Hader, Professor of English and former Associate Dean for Academic Affairs, SENCER found a very receptive community in the Department of English, Speech, and Theatre. The department is by far the largest at HWC with 30 full-time faculty, many of whom were interested in using the intersection of contemporary science-based issues and civic engagement as a way of stimulating critical thinking in the many composition courses offered each semester. Additionally, the faculty saw the SENCER approach as an innovative solution to engaging students early in their college experience and interesting them in STEM related careers. The Urban Asthma learning community, which was the first program to be developed and implemented at HWC following the SENCER model, targeted students from pre-credit English and Reading courses and from underrepresented groups who were candidates for possible careers in STEM based professions. The first cohort consisted of 20 students who were eventually enrolled in four general education courses; English, Reading, Biology and Social Science, all organized around the theme of urban asthma. All the students in the cohort were either diagnosed with asthma themselves, or had a close friend/relative with asthma, ensuring that the students had a strong personal stake in the issue. Community partners for the project included the Chicago Lung Association and the Chicago Chapter of the Sierra Club and students collaborated on civic projects related to their learning, including participating in a day-long training session offered by the Lung Association for “asthma inter- venter,” writing to members of the state legislature in support of clean air legislation, and the creation of public poster presentations on urban asthma.

English department faculty presented the results of Urban Asthma initiative at the 2007 National Center for Science and Civic Engagement’s (NCSCE) Capitol Hill Symposium in Washington, D.C. Subsequently, HWC’s English faculty delivered a presentation on “Learning Communities” at the 2007 SENCER Summer Institute at the University of Southern Maine.

English department faculty have continued their strong engagement with SENCER, spearheading the development and implementation of an HIV/AIDS curriculum for a

section of English 101/English 197, and collaborating with faculty from the Departments of Mathematics, Social Science, and English, Speech, and Theatre in developing a SENCER cohort for fall of 2008 called “Focus on the Environment.”

Chris Sabino, Professor of Mathematics at Harold Washington College, has also been a key to the success of SENCER at Harold Washington College, particularly in the development of learning communities organized around *Childhood Obesity and Sleep*. The *Childhood Obesity* cohort, which ran for three semesters, consisted of a Math 98 (a developmental Elementary Algebra course), English 100 (a developmental Composition course) and Child Development 107 (an Applied Science course with a notable focus on health and nutrition). This was an interesting experiment given that two of the three courses were designed as “developmental.” Though the cohort did not boast statistically significant increases in success rates, it did boast statistically significant increases in retention. In addition, the cohort instructors were able to find creative ways to merge their disciplinary content and help the students apply their knowledge and put it to immediate use.

The *Sleep* cohort was more challenging, and consisted of a Chemistry component (Introductory Chemistry), a Psychology component and an optional Mathematics component (College Algebra), in which I served as the instructor. Because the mathematics component was optional, it was more difficult to integrate the disciplinary content with the civic issue. Nonetheless, students still developed a strong sense of community and retention was above average for those students who elected the mathematics course.

Although learning communities have been the primary vehicle for SENCER in regard to mathematics, my experience has led me to believe that the SENCER approach would thrive outside of a learning community structure, either with an individual course or sequence of courses, organized around a civic or social problem. The groundwork has certainly been laid at Harold Washington College, especially in some of the multi-section courses, and we have strong models of success from other community colleges in the SENCER project, such as Metropolitan State. This gives us hope that we can achieve the same level of success.

We do know from our own experience that SENCER courses address a major concern of our students in regard to courses, such as math, that are not directly contributing to their major, and that is the question of how the math they are learning can be used in “real life.” Though we cannot take

a completely utilitarian approach to college learning, we must acknowledge (as a community of math educators) that it is the opportunity to put learning to immediate use that sparks student motivation and creates the interest in further study. SENCER courses explicitly invite students to put scientific knowledge and scientific method to immediate use on matters of pressing interest to them. This enables them to make their own connection between a particular problem and the scientific and mathematical knowledge they need to fully engage with it.

As noted earlier, Harold Washington College is greatly indebted to the National Science Foundation and the National Center for Science and Civic engagement for the opportunity to participate in SENCER for the last decade. SENCER's curricular strategies, and its institutes, meetings, and resources, have had a measurable impact on student retention and faculty development at Harold Washington College and have supported the institution as it strives to fulfill its mission of student-centered learning and civic empowerment.

## About the Author

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of the City Colleges of Chicago campuses. He is a past Distinguished Professor at Harold Washington College. He was also a visiting professor in chemistry at Northwestern University and a lecturer

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