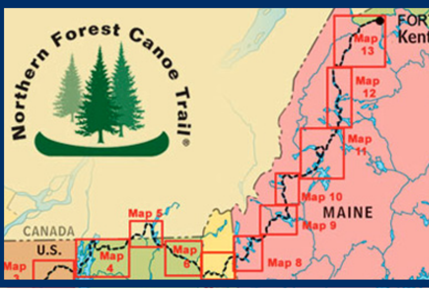
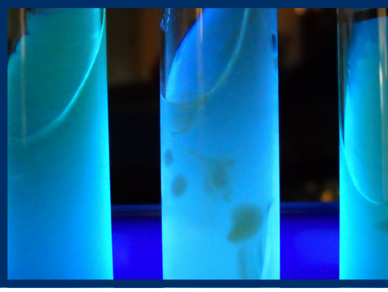
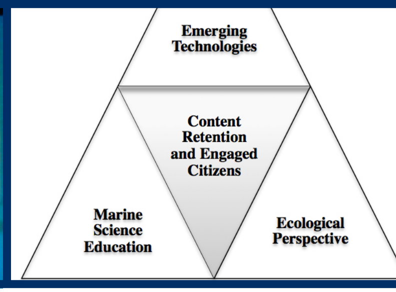


SCIENCE EDUCATION & CIVIC ENGAGEMENT

AN INTERNATIONAL JOURNAL

VOLUME 7 ISSUE 1 · WINTER 2015

Science Education and Civic Engagement: An International Journal
Volume 7 : Issue 1, Winter 2015
ISSN: 2167-1230

Publisher
Wm. David Burns

Editors
Trace Jordan
Eliza Reilly

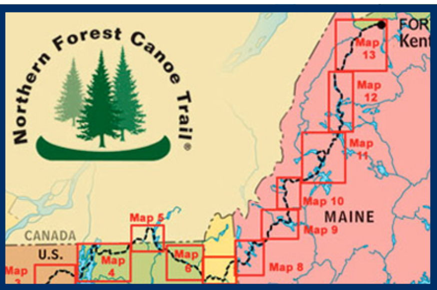
Managing Editor
Marcy Dubroff

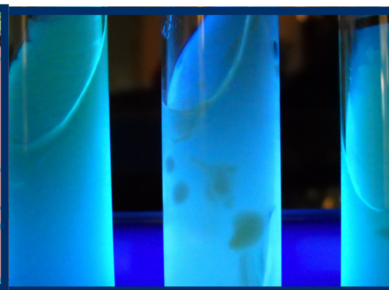
National Center for Science and Civic Engagement
2000 P Street NW Suite 210
Washington, DC 20036
202.483.4600
www.ncsce.net

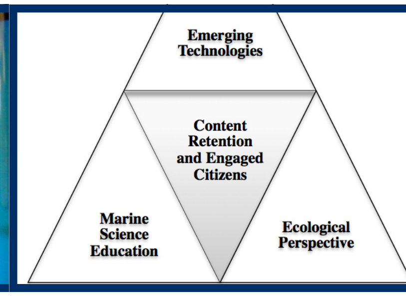
Partial support for this Journal was provided by the National Science Foundation's Course, Curriculum and Laboratory Improvement Program under grant DUE 0618431. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily represent the view of the National Science Foundation or the National Center for Science and Civic Engagement.

SCIENCE EDUCATION
& CIVIC ENGAGEMENT
AN INTERNATIONAL JOURNAL

VOLUME 7
ISSUE 1
WINTER 2015







About the Journal

Science Education and Civic Engagement: An International Journal is an online, peer-reviewed journal. It publishes articles that examine how to use important civic issues as a context to engage students, stimulate their interest, and promote their success in mathematics and science. By exploring civic questions, we seek to empower students to become active participants in their learning, as well as engaged members of their communities. The journal publishes the following types of articles:

- ***Book & Media Reports***
- ***Point of View***
- ***Project Reports***
- ***Research***
- ***Review***
- ***Science Education & Public Policy***
- ***Teaching & Learning***

The Journal is published twice per year in an online format. The official publisher of the journal is Harrisburg University of Science and Technology, home of the National Center for Science and Civic Engagement. Editorial offices for the Journal are located in Lancaster, PA.

WWW.SECEIJ.NET

Contents

From the Editors

The Winter 2015 issue of *Science Education and Civic Engagement: An International Journal* presents five project reports that examine a rich diversity of approaches to embedding science education within a civic context. Three of the articles describe the innovative use of technologies to enhance student engagement and learning.

David Green (University of Miami) and **Jennifer Sparrow** (Pennsylvania State University) explain how they utilized emerging technologies in a marine science course for non-majors, which was organized around the theme of environmental sustainability. The instructors employed a "flipped classroom" approach, along with integration of Geographic Information System (GIS) mapping software, Twitter, podcasting, and several other Web 2.0 tools. These approaches provide students with an opportunity to develop their collaborative and communication skills in the context of real-world learning.

Joseph Liddicoat (City College of New York) and **Peter Bower** (Barnard College) contribute an account of how they adapted the successful Brownfield Action simulation as an online course for non-traditional students. This case study examines the educational creativity that is required to convert classroom-based experiences to a set of effective online activities.

Robert M. Sanford and **Joseph K. Staples** (both at the University of Southern Maine) describe a self-guided, experiential field course based on the Northern Forest Canoe Trail, which extends from upper New York State to Northern Maine. During at least 10 days on the canoe trail, students participate in a Google+ community of paddlers and complete reflective online postings. This course shows how "distance education" does not need to employ traditional pedagogies; instead, it can provide a different type of educational experience.

Charles Greenberg (Murrysville County Library) and his collaborators present a project in which they use a community library as a local hub for the integration of K-8 STEM education into a summer reading program with complementary hands-on activities. They developed and implemented training workshops for librarians, administrators, and volunteers based on national standards in mathematics, science, and English language arts. By using children's literature as used as an entry point for exploring specific math and science concepts, this project demonstrates how literacy and math/science education can be mutually complementary and reinforcing.

Farah Movahedzadeh (Harold Washington College) and her co-authors offer a course that uses the Chicago River as a site of civic engagement. Using the principles of project-based learning, students collect water samples and analyze them for the presence of bacteria. By performing authentic data collection, students developed foundational skills in microbiology within a meaningful context.

In conclusion, we wish to thank all the authors of these reports for sharing their interesting work with the readers of this journal.

— *Trace Jordan*
Eliza Reilly
Co-Editors-in-Chief

RESEARCH ARTICLE

Flipping an Introductory Science Course Using Emerging Technologies

David Green
University of Miami

Jennifer Sparrow
Penn State University

Abstract

Today's faculty members have tools available that enhance the learning experience of modern digital learners. Emerging technologies and innovative teaching practices update the STEM education learning process and facilitate student retention. In today's hybridized educational world, the classroom stretches far beyond the traditional four walls, and students should be producers of content, rather than merely passive acceptors of information. This article explains how several emerging technologies were implemented and tested in a General Education marine science course for non-majors, describes the role of technologies in "flipping" the classroom, and summarizes student feedback on the learning experience. Using the global marine system and specific case study locations, the course covered major oceanography disciplines, critical environmental issues, and socio-economic conditions of urbanized coastal regions. Environmental sustainability was the integrative theme, highlighting the importance of economic growth while emphasizing that environmental responsibility and social well being must be foregrounded in the context of an exponentially growing human population.

Flipping the classroom using emerging technologies supplemented a rigorous schedule of project-based learning, laboratory activities, field excursions, and civic engagement commitments. Pre- and post- SALG surveys (Student Assessment of Their Learning Gains) were used to gauge student perspectives on the course redesign. They demonstrated improvements in knowledge, skills development, and integration of learning. The combination of activity-based, student-centered learning and emerging technologies make today's STEM education classroom an exciting, interactive, and engaging experience by giving these sometimes reluctant students the tools they need to succeed in tomorrow's professional world

Introduction

A scientifically educated citizenry capable of innovation and leadership is a necessity for a functioning democracy. Many of today's learners, however, are ambivalent about science and science education, and they lack understanding of how science relates to their daily lives (Burns 2011; Burns 2012;

Green 2012). While today's learners have been surrounded by technologies in the classroom throughout their entire academic journey, many lack the skills necessary to apply their learning and to produce content and are still passive acceptors of information. Educators now have a responsibility and the opportunity to introduce "high-impact educational practices" into curricular redesigns (Kuh 2008). A host of innovative teaching strategies in STEM education have emerged (Springer et al. 1999; Vatovec and Balser 2009; Brown et al. 2010; Prunuske et al. 2012; Green 2012) that can engage reluctant students, increase critical thinking abilities, foster collaborative relationships in the classroom, and enhance communication skills (oral, written, and digital). Matching appropriate emerging technologies with effective teaching practices (Brill and Park 2008) and gathering feedback on these STEM course redesigns is imperative as we continue to enhance our curricula.

With the advance of academic technologies, many educators have embraced the "hybrid" course design (Garrison and Kanuka 2004; McGee and Reis 2012). Hybrid courses (or blended course designs) are those in which a significant amount of quality online content is used to engage students (McGee and Reis 2012) while providing new teaching opportunities for educators (McGee and Diaz 2007; Brown et al. 2010; Green 2012). Modern learners have been called "digital natives," while today's educators have been named "digital immigrants," but that terminology has generated some debate (Prensky 2001a and 2001b; Toledo 2007; Bennett et al. 2008). Although educators and learners may speak different languages in relation to technology and have different comfort levels regarding its use, it is easy to see the potential of hybrid course design for today's multi-tasking, quick information-seeking, and media-socialized students. Using emerging technologies facilitates activity-based learning and provides students with ownership of the learning environment (Brill and Park 2008; Strayer 2012; Prunuske et al. 2012). Connecting sound pedagogical strategies with suitable technology usage creates a learning environment that matches the needs of modern learners, while providing them with the skills they need to succeed in their professional careers.

Inverting the teaching sequence, or "flipping" the classroom, has gained significant attention in recent years (Lage et al. 2000; Milman 2012; Strayer 2012; Khan 2012; Prober and Khan 2013). Essentially, traditional lecture-type material is provided to students in video or online format before face-to-face sessions. Then, during the face-to-face meetings, students are engaged in social-learning scenarios that promote interactions, engagement, and skills development by applying their knowledge. The role of the instructor changes and, in many ways, resembles an "academic coach" during the learning process rather than an "information presenter." Figure 1 outlines the course design conceptual model used in this curriculum redesign, which employed web-based reusable learning objects that students used before class sessions, so that

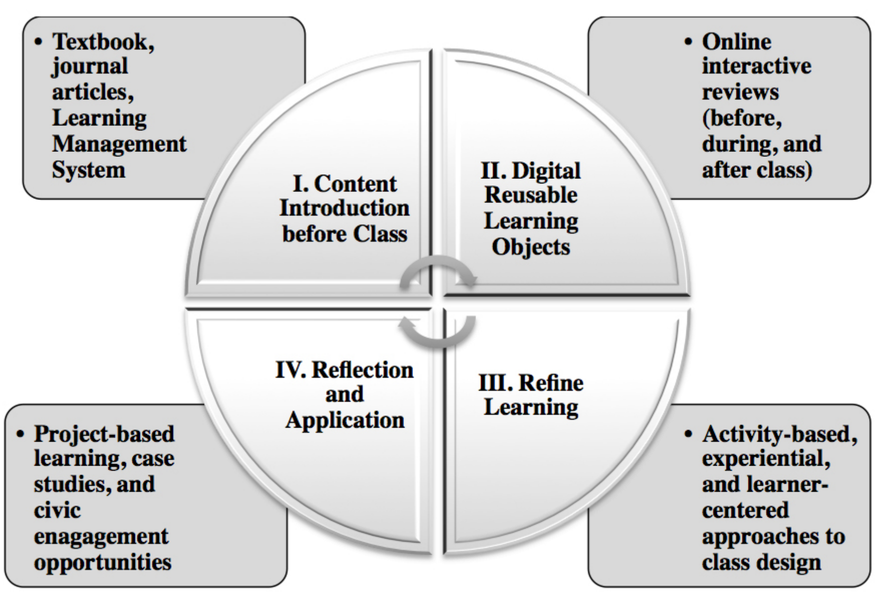


FIGURE 1. A conceptual model of the "flipped classroom" scenario used in the course redesign is depicted. Before attending face-to-face sessions, students are expected to read introductory content, which includes both traditional readings and interactive web-based activities. During face-to-face class sessions, students engage in learner-centered approaches, including activity-based labs and experiential learning opportunities. By implementing combinations of project-based learning, case study analyses, and civic engagement strategies, students apply their learning, demonstrate higher-order thinking skills, and produce content that ultimately benefits the needs of the regional community.

experiential and activity-based learning activities could be conducted during face-to-face sessions. Reflective exercises and activities, like project-based and service-learning activities, are high-impact learning opportunities that promote academic responsibility and civic engagement. Using emerging technologies to "flip the course" provided the curricular flexibility to implement these innovative teaching strategies.

"Marine Systems" is an introductory general education science course for non-science majors that has traditionally been taught as a lecture-based course with embedded laboratory exercises. This paper describes a curriculum redesign that used a "flipped" course model, learner-centered approaches, and embedded service-learning opportunities, and it provides student perspectives on the learning process. The use of emerging technologies in the curriculum facilitated the course delivery, so that students developed an understanding of ecology and its relevance to their daily lives, increasing their civic engagement and awareness (fig. 2). The primary goals of this course redesign were

1. To enhance the educational experiences of non-major science students by engaging in learner-centered approaches and web-based techniques;
2. To demonstrate the potential pedagogical benefits of coupling emerging technologies with innovative teaching practices in a STEM education setting;
3. To assess student perspectives of their learning gains related to their adoption of emerging technology in a "flipped classroom" scenario.

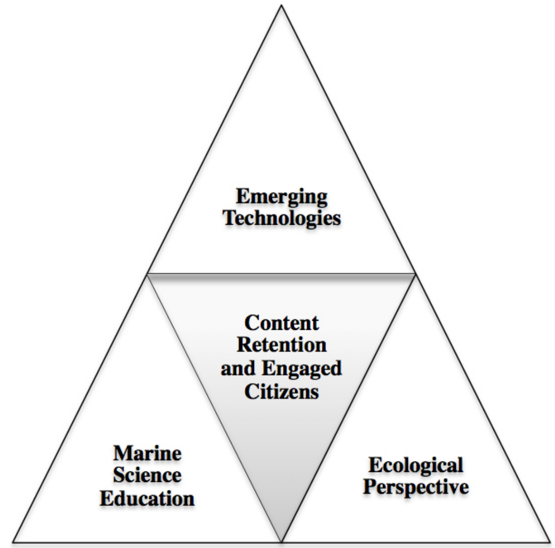


FIGURE 2. By using emerging technologies to facilitate the learning process, students gain an ecological perspective related to the marine science concepts they are introduced to. This helps them retain information and connect it to their daily lives, and, following successful completion of the course and civic engagement activities, they leave as engaged citizens.

Methods

The course redesign began by linking course objectives and learning outcomes to a "Guiding Question" which reads:

> "Given the current degree of human impacts on the marine world, how can tomorrow's generations of all inhabitants continue to benefit from the natural goods and services a healthy marine system provides, if we better understand *our* role as citizens *today*?"

From this follows the "Primary Course Objective" for this course:

> "Students will be able to positively influence both southwest Florida and global communities in making evidence-based decisions regarding human use and impacts of coastal and marine areas / resources."

Lastly, the specific learning outcomes and skills development objectives are

1. To enhance baseline scientific knowledge relating to marine systems and global sustainability by developing critical thinking skills;
2. To gain an understanding of the ecology of regional ecosystems, the natural goods and services provided by these ecosystems, and how human interactions disrupt natural functions;
3. To introduce the concept of environmental sustainability and provide opportunities for students to apply this concept to practical real-life situations in an urbanized society.

Learner-centered Approaches

A variety of learner-centered approaches (experiential learning and project-based learning) were used to enhance student practice, learning, and contributions to the learning environment (fig. 3). Combinations of classroom and field-based learning exercises were used to describe the scientific method, to help explain key oceanographic concepts, and to provide encounters with local estuarine ecosystems. Students were given ownership of academic exercises, while the instructor facilitated, guided, and reinforced crucial learning content. Table 1 explains the calendar of individual learning modules with associated major academic themes and objectives. Multiple sources of information including the textbook, scientific journal articles, lab exercises, and personal observations were used. The textbook provided background information, while journal articles examined current issues and explored topics such as ocean acidification, human impacts, overexploitation of marine resources, and global climate change. Learner-centered laboratory exercises applied textbook concepts and provided a collaborative, activity-based learning environment. A reflective journal provided opportunities for student observations and personal reflections on the learning process. Field excursions engaged student interest by exploring coastal ecosystems and assisted with the understanding of ecosystem structure and function, coastal development, and marine research. The capstone project reinforced all class activities by relating environmental sustainability to the socio-economic and environmental issues previously explored. Civic engagement opportunities helped students leave the course as engaged citizens who are willing to apply their knowledge to meaningful projects that benefit our local informal science education partners.

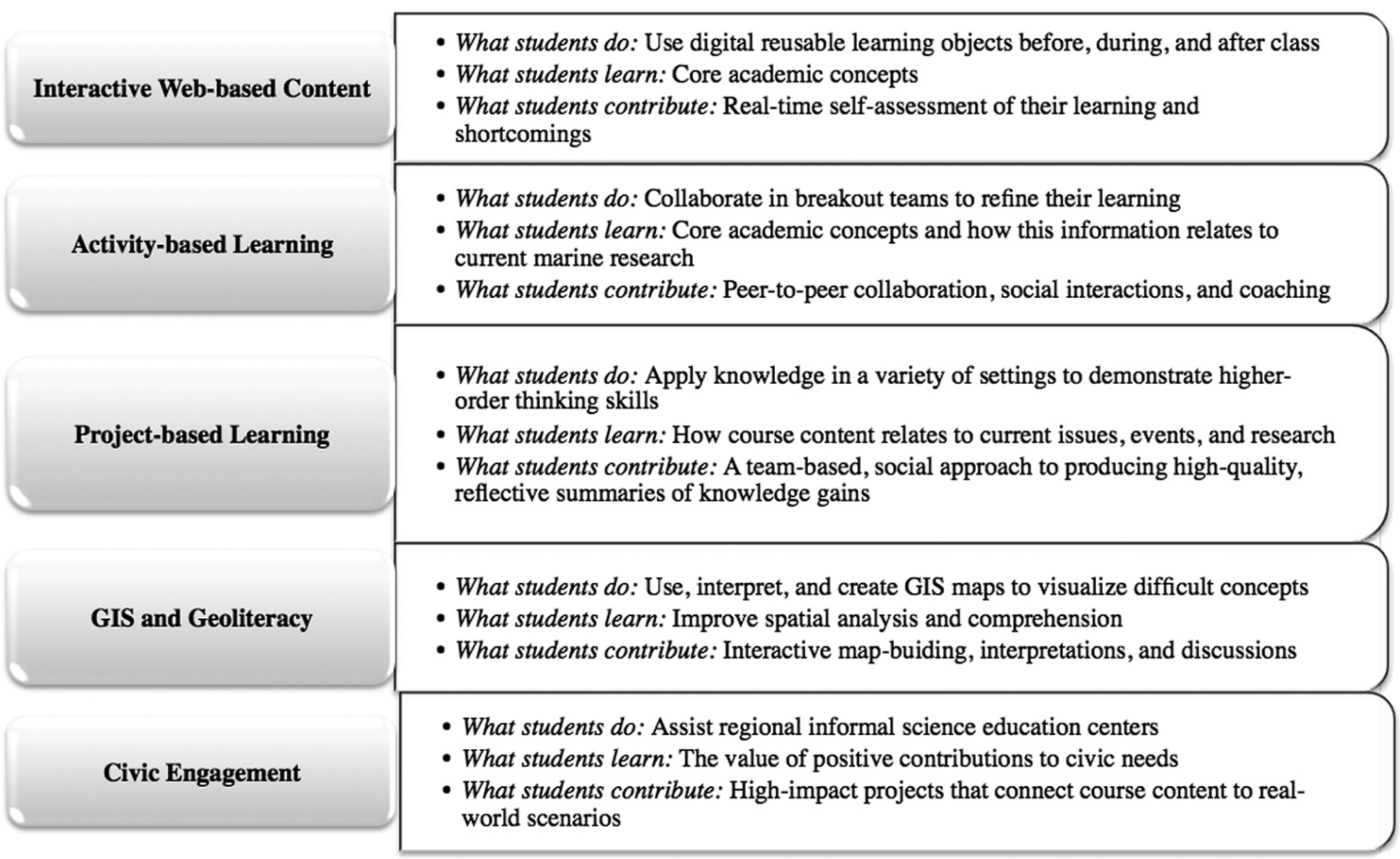


FIGURE 3. Mapping teaching strategies used within the course design to student practice, learning, and contributions to the learning environment.

TABLE 1. Calendar of "learning modules" that explains major academic themes and objectives.

MODULE	THEME	OBJECTIVES
1	Introduction to course	To build a foundation for the course To introduce concepts related to environmental sustainability
2	Thinking like a scientist	To enhance scientific research skills and evidence gathering To review the scientific method To increase communication, collaboration, and critical thinking skills
3	Marine Geology	To understand Earth's dynamic past
4	Marine Chemistry	To introduce seawater properties, ocean acidification, and biogeochemical cycles
5	Physical Oceanography	To explain the coupling of marine and atmospheric processes
6	Marine Ecology	To explain ecosystem structure and functions To provide interactions with regional ecosystems
7	Current issues and human impacts on the marine world	To understand exponential human population growth and consequences for natural goods and services To explore issues related to global climate change and likely impacts To explore environmental sustainability and marine conservation plans To increase geo-literacy skills
8	Civic engagement	To relate course content to students' daily lives To provide service to regional informal science educators To enhance coastal areas for future

Virtual "Oceanographic Research Cruise" Capstone Project

Teams of students "virtually participate" in an oceanographic research expedition that visits a particular location of geological importance on the planet. The task reads: "You have been assigned positions aboard an oceanographic vessel exploring the far reaches of the planet! Your crew will arrive at a marine destination to use as your case study. At this location, your crew will explore and research the factors shaping the region as related to the information you learn in this class. At the end of your 'research cruise,' crews will present at our 'Oceanographic Exploration and Research Collection Symposium!' Collectively, we will explore the globe in its entirety, learning about the marine systems worldwide! You will incorporate concepts related to physical and chemical oceanography, marine geology, and marine ecology into your learning adventure!" The final project is submitted via a student-created webpage that summarizes the team's virtual research expedition. The primary intention is to apply course content and learning in a social setting to a specific location that is unique to each team of students.

Ecosystems Visit Field Study and Formal Lab Report

In class, small groups of students chose a theme to investigate for a field research project. At this point, students brainstormed the parameters of the theme and arrived at a research question, formulating a testable hypothesis and designing an experiment to test their hypothesis. The instructor facilitated discussions and helped students choose gear that was needed for the field studies. Each student group created their own study and all groups worked their way through the scientific method during this project. At a field location, students collected their data and replicated their studies in multiple locations. Students created a formal lab report (complete with Excel graphs, figures, and tables) that summarized their research. Major academic concepts covered in this project included

1. Natural Goods and Services

2. Ecosystem Structure and Function
3. Water Quality
4. Limiting Factors
5. Beach Profiles
6. Flora and Fauna Analyses
7. Estuarine Ecosystems Ecology
8. Intertidal Zone, Beaches, and Dunes Evaluation
9. Coastal Urbanization and Habitat Loss
10. Environmental Sustainability
11. Land Ethic and Wilderness Values
12. Marine Conservation

Students were given ownership of this exercise from start to finish, and they explored the natural world the way a scientist would by applying their previous learning to real-world research opportunities.

Human Impacts Project

Breakout groups were formed, and each group was assigned a topic related to a human impact on the marine environment. Phase I ("Background Explorations—A Literature Scavenger Hunt") included a literature review, where each group located peer-reviewed journal articles related to their topic. From this research, the breakout group synthesized a definition of the impact, explained why it is a problem in the context of an exponentially-growing human population, and described how future decisions should be made differently to improve the situation related to the negative human impact. During Phase II of the project ("From Jigsaw to Podcast"), new groups were formed so that each new group contained students who researched a different human impact during the first phase (similar to a "jigsaw" method of teaching). Students now assumed the role of "expert" for their original topic and they had to teach the new group about that human impact. Once the students had explained their synthesis from Phase I, the new group created an educational podcast script that was three minutes in length and appropriate for an audience of middle-school-aged children. To create the script, students had to summarize all of the human impact topics represented in their new group by answering the following questions:

1. What is the size of the current human population and what is meant by exponential population growth?
2. What are examples of modern-day human influences on the marine world?
3. How and why are these human impacts a problem for the marine world under the context of an exponentially growing human population?
4. Explain what humans can do differently in regard to future decisions made about ocean impacts.

This project helps students critically examine scientific research, use higher-order thinking skills, and produce educational content for a younger generation.

High-impact Learning Opportunities: Service-learning Projects and Civic Engagement

Partnering with regional informal science education centers, students assisted with tasks that met community needs by participating in field-based service-learning projects. These projects allowed students the opportunity to visualize previous human impacts on coastal ecosystems and mitigate the damage. Using "prompt" questions, students reflected on their experience in a written deliverable that connected their service-learning experiences to their learning in the course and personal development. In previous iterations, students also delivered oral presentations with the regional partners in attendance. Serving the needs of the community and learning how to take a leadership role in civic engagement are the primary goals of this high-impact project.

Matching Emerging Technologies to Course Outcomes

A main focus of this course redesign was to match the use of appropriate technologies with non-traditional pedagogical strategies (table 2). Careful thought was given to the choice of technology in the course delivery and to desired outcomes. A description of the chosen technologies follows.

Reusable Learning Objects (RLOs): Traditional lecture sessions were replaced with web-based digital Reusable Learning Objects (RLO's) that were created by the instructor. These highly-interactive presentations with audio, animated figures, text, pictures, and illustrations

TABLE 2. The course redesign focused on matching appropriate emerging technologies with use in the curriculum and to Course Outcomes, so that non-traditional teaching strategies could be employed.

Emerging Technology	THEME	OBJECTIVES
Reusable Learning Objects	Replaces traditional lectures Real-time assessment	To use innovative teaching strategies that engage today's modern learner
GIS Mapping Software	Labs and discussions	To promote geo-literacy by using maps to facilitate comprehension and visualization of difficult concepts
Podcast Creation	Student-produced content to share with younger students	To enhance digital communication skills while learning about current human impacts
Webpage Design	Student-produced content summarizing the application of their knowledge as part of a capstone project	To enhance digital communication skills while applying knowledge to a particular case study location in a collaborative, team-based approach
Online Literature Reviews and Database Searching	Active searches of literature databases to support projects and assignments	To introduce the importance of peer-reviewed literature, the scientific method, and appropriate evidence-gathering strategies that help increase critical thinking skills
Twitter™ Discussions	Engages students outside of the classroom, between face-to-face sessions	To facilitate a social, interactive experience for students outside of the classroom
eTexts, Smartphones, and Tablet Computers	Makes all course content available to students at all times and places	To engage students in the learning process by using entertainment devices as pedagogical tools for content delivery

supplemented the curriculum and enhanced the experience of students by providing an interactive learning environment with real-time assessment and feedback.

GIS Mapping Software: A variety of Geographic Information Systems (GIS)-based learning opportunities were embedded within the course design. Students interpreted patterns they observed and improved their spatial analysis skills. They created their own maps of coastal ecosystems and water quality summaries by using handheld Global Positioning System (GPS) receivers and cloud-based GIS mapping software.

Podcasting: A podcast is an audio or video file that is broadcast over the internet. Following in-depth research on human impacts on the marine world, students created three-minute educational podcasts that are sharable with a younger audience.

Web 2.0 Tools (Weebly, Prezi, Blogs, etc.): Students used free Web 2.0 tools to create their own presentations and webpages. Using these tools, students went from passive acceptors of knowledge to active producers of learning content, which helped them utilize higher-order thinking skills.

Online Database Literature Searches: Students are expected to evaluate evidence and find reputable sources of scientific information. Peer-reviewed literature database searches were required throughout the course and exposed students to discipline-appropriate writing styles and the importance of the peer-review process.

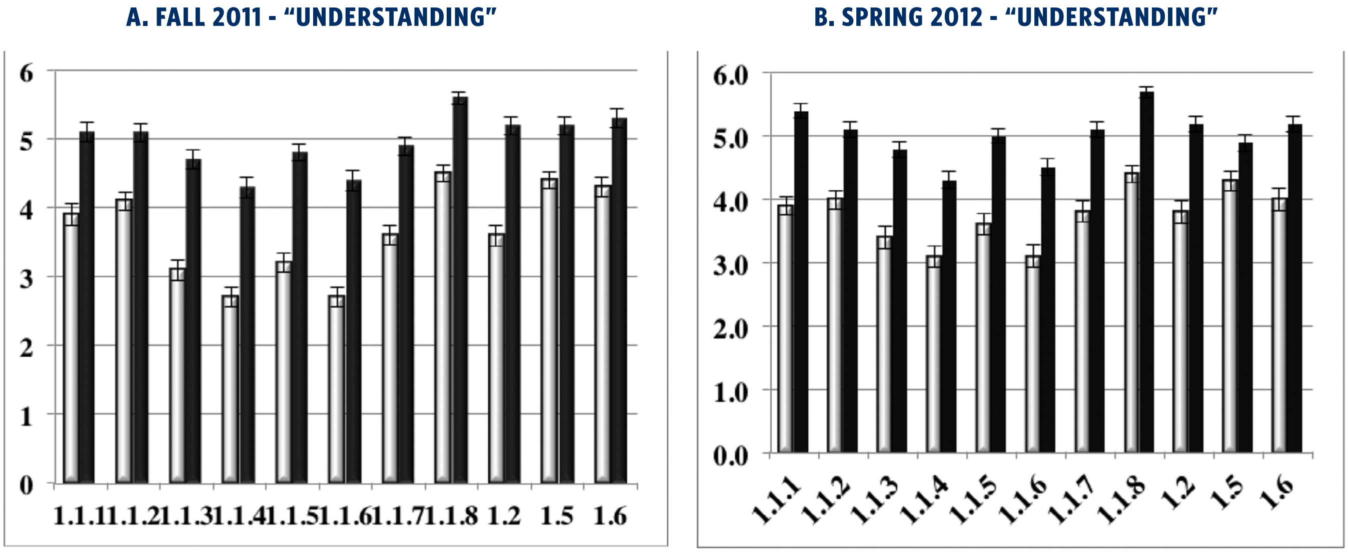


FIGURE 4. Pre- and Post- SALG survey results from two semesters comparing "Understanding of Core Academic Concepts." Question numbers on the x-axis can be cross-referenced with the actual questions in Table 3. Students responded with a 1–6 score, as illustrated on the y-axis (1 = N/A; 2 = Not at All; 3 = Just a Little; 4 = Somewhat; 5 = A Lot; 6 = A Great Deal). Mean and SE are reported ($n_{Fall\ 2011\ Pre}$: 69; $n_{Fall\ 2011\ Post}$: 59; $n_{Spring2012\ Pr}$e: 60; $n_{Spring2012\ Post}$: 58).

Twitter™ Discussions: Twitter™ is a social networking system designed for quick comments and interactions. Students engaged in out-of-classroom discussions that followed face-to-face sessions and introduced upcoming class topics.

eTexts, Smartphones, and Tablet Computers: A variety of hardware choices by students facilitated the learning process. Our classroom was not conceptualized as a four-walled room with desks, but instead reached far beyond the traditional setup and allowed for real-time explorations of internet content and just-in-time teaching moments related to current events. While all course components are currently available for use on a tablet or computer via the learning management system, not all students own such a device, and any hardware choice by the student was acceptable.

SALG Survey and Data Analysis (Methods)

A Pre- and Post- Student Assessment of Learning Gains (SALG) survey was conducted to gain anonymous student perspectives on the course redesign. Students from single course, in each of two different semesters, was included in this analysis. Surveys included questions related to Knowledge, Skills, and Integration of Learning. Mean scores with Standard Errors were calculated for each question and compared across semesters. Table 3 displays the questions used in the SALG surveys. Because students withdraw from classes during the semester, the pre- and post- surveys have slightly different sample sizes. Results from the SALG surveys allowed for omnibus comparisons and cross-semester evaluations. Students were given an opportunity for free-write responses, as well, though those comments are not included in this manuscript.

Results

During the Fall 2011 semester, 77% of students self-reported GPA's > 3.01 and 92% stated they were non-science majors ($n_{Fall\ 2011\ Pre}$: 69; $n_{Fall\ 2011\ Post}$: 59). During the Spring 2012 semester, 52% of students self-reported GPA's > 3.01 and 95% stated they were non-science majors ($n_{Spring2012\ Pre}$: 60; $n_{Spring2012\ Pos}$t: 58).

Students responded to questions designed to measure their own perception of their understanding of core academic content (table 3—"Understanding" section). Across semesters, similar trends emerged. Students entered the course at or near the "Somewhat" comfortable level with their understanding of core academic concepts in all measured categories; students in both classes left the course

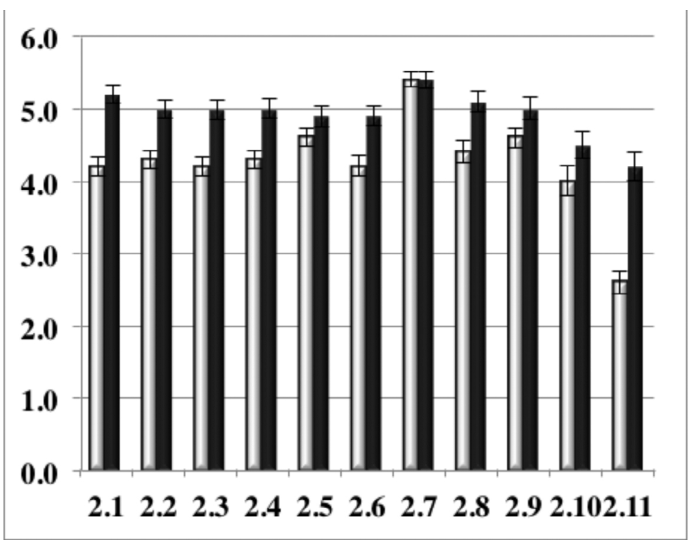
TABLE 3. An overall summary of the SALG Survey questions ($n_{Fall\ 2011\ Pre}$: 69; $n_{Fall\ 2011\ Post}$: 59; $n_{Spring2012\ Pre}$: 60; $n_{Spring2012\ Post}$: 58). Students chose from the following responses for each question:
1: N/A 2: Not at All 3: Just a Little 4: Somewhat 5: A Lot 6: A Great Deal

Number	Question	N Pre total	Mean Pre total	N Post total	Mean Post total
	UNDERSTANDING				
1	Presently, I understand...				
1.1	The following concepts that were explored in this class				
1.1.1	Sustainability	129	3.900	117	5.249
1.1.2	Natural Goods and Services	129	4.053	117	5.100
1.1.3	Marine Geology	129	3.240	117	4.750
1.1.4	Marine Chemistry	129	2.886	117	4.300
1.1.5	Physical Oceanography	129	3.386	117	4.899
1.1.6	Chemical Oceanography	129	2.886	117	4.450
1.1.7	Marine Biology / Ecology	129	3.693	117	4.999
1.1.8	Human impacts on the marine environment	129	4.453	117	5.650
1.2	The relationships between those main concepts	129	3.693	117	5.200
1.3	How ideas we explored in this class relate to ideas I have encountered in other classes within this subject area	129	3.953	117	4.550
1.4	How ideas we explored in this class relate to ideas I have encountered in classes outside of this subject area	129	3.707	117	4.602
1.5	How studying this subject helps people address real world issues	129	4.353	117	5.051
1.6	How civic engagement activities help connect course content to real-world scenarios	129	4.160	117	5.250
1.7	Please comment on how civic engagement activities (podcast scripts for middle schoolers, Bunche Beach salt flats service and reflection) impacted your learning.	.	.	.	.
	SKILLS				
2	Presently, I can...				
2.1	Find articles relevant to a particular problem in professional journals or elsewhere	129	4.200	117	5.200
2.2	Critically read articles about issues raised in class	129	4.300	117	5.000
2.3	Identify patterns in data	129	4.247	117	5.000
2.4	Recognize a sound argument and appropriate use of evidence	129	4.347	117	4.950
2.5	Develop a logical argument	129	4.553	117	4.999
2.6	Write documents in discipline-appropriate style and format	129	4.200	117	4.999
2.7	Work effectively with others	129	5.353	117	5.350
2.8	Prepare and give oral presentations	129	4.493	117	5.050
2.9	Read and interpret maps	129	4.600	117	5.050
2.10	Use GPS handheld devices to collect data	129	4.233	117	4.649
2.11	Interpret GIS images	129	2.879	117	4.448
2.12	Explain the skills this class helped you develop.	.	.	.	.
	ATTITUDES				
3	Presently, I am...				
3.1	Enthusiastic about the subject	129	4.474	117	4.301

TABLE 3 (CONTINUED). An overall summary of the SALG Survey questions ($n_{Fall\ 2011\ Pre}$: 69; $n_{Fall\ 2011\ Post}$: 59; $n_{Spring2012\ Pre}$: 60; $n_{Spring2012\ Post}$: 58). Students chose from the following responses for each question:
1: N/A 2: Not at All 3: Just a Little 4: Somewhat 5: A Lot 6: A Great Deal

Number	Question	N Pre total	Mean Pre total	N Post total	Mean Post total
3.3	Interested in taking or planning to take additional classes in this subject	129	3.467	117	3.651
3.4	Confident that I understand the subject	129	3.753	117	4.600
3.5	Confident that I can do this subject	129	4.653	117	4.600
3.6	Comfortable working with complex ideas	129	4.253	117	4.601
3.7	Enthusiastic about activity-based learning	129	4.821	117	4.800
3.8	Enthusiastic about project-based learning	129	4.353	117	4.650
3.9	Willing to seek help from others (teacher, peers, TA) when working on academic problems	129	4.914	117	4.900
3.10	Please comment on your present level of interest in this subject.	.	.	.	.
3.11	Please explain how project-based learning impacted your learning in this class.	.	.	.	.
	INTEGRATION OF LEARNING				
4	Presently, I am in the habit of...				
4.1	Connecting key ideas I learn in my classes with other knowledge	129	4.407	58	4.700

A. FALL 2011 - "SKILLS"



B. SPRING 2012 - "SKILLS"

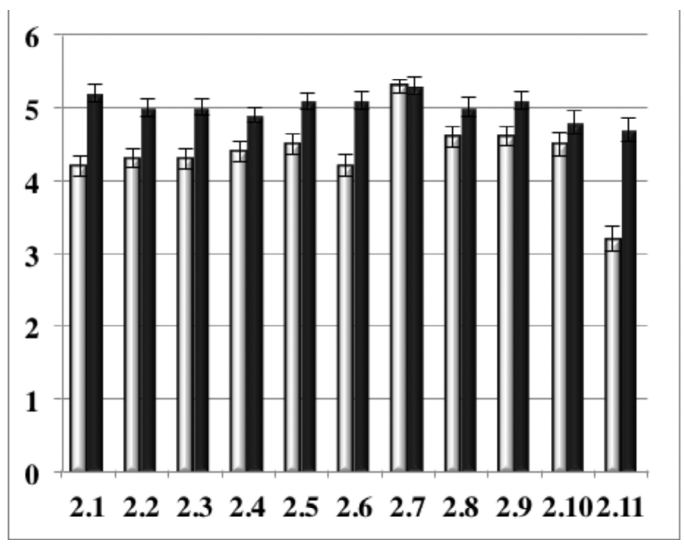
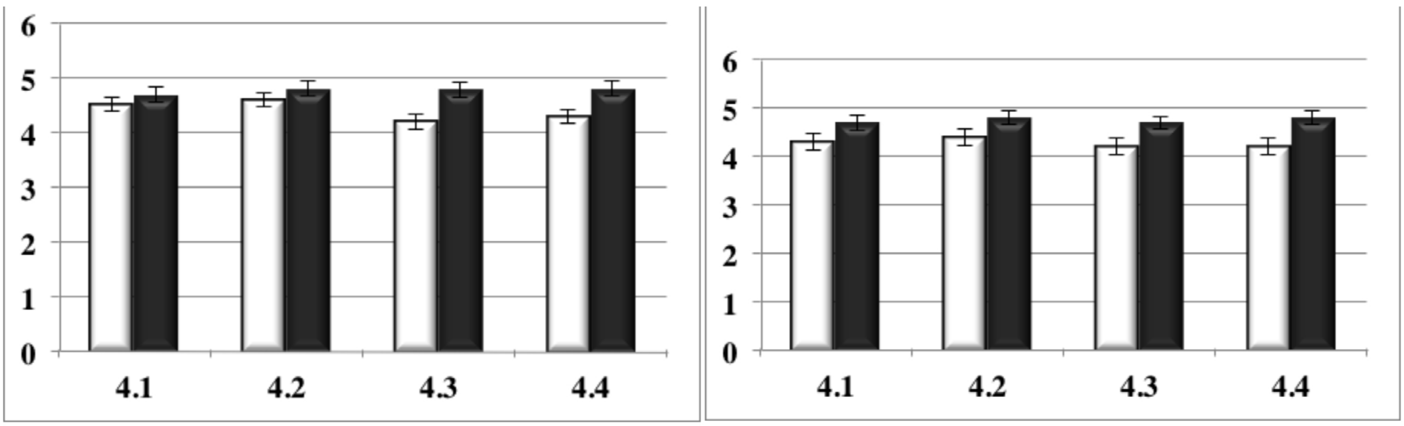


FIGURE 5. Pre- and Post- SALG survey results from two semesters comparing "Skills Development." Question numbers on the x-axis can be cross-referenced with the actual questions in Table 3. Students responded with a 1–6 score, as illustrated on the y-axis (1 = N/A; 2 = Not at All; 3 = Just a Little; 4 = Somewhat; 5 = A Lot; 6 = A Great Deal).
Mean and SE are reported ($n_{Fall\ 2011\ Pre}$: 69; $n_{Fall\ 2011\ Post}$: 59; $n_{Spring2012\ Pre}$: 60; $n_{Spring2012\ Post}$: 58).

FIGURE 6. Pre- and Post- SALG survey results from two semesters comparing "Integration of Learning." Question numbers on the x-axis can be cross-referenced with the actual questions in Table 3. Students responded with a 1–6 score, as illustrated on the y-axis (1 = N/A; 2 = Not at All; 3 = Just a Little; 4 = Somewhat; 5 = A Lot; 6 = A Great Deal). Mean and SE are reported ($n_{Fall\ 2011\ Pre}$: 69; $n_{Fall\ 2011\ Post}$: 59; $n_{Spring2012\ Pre}$: 60; $n_{Spring2012\ Post}$: 58).

A. FALL 2011 - "INTEGRATION OF LEARNING" **B. SPRING 2012 - "INTEGRATION OF LEARNING"**



feeling "A Lot" to "A Great Deal" more comfortable with their own understanding of core academic concepts (fig. 4).

Students responded to questions designed to measure their own assessment of "Skills Development" (table 3—"Skills" section). Across semesters the data indicated that students entered the course at or near the "Somewhat" comfortable level with their perceptions of skills development; students in both classes left the course feeling "A Lot" to "A Great Deal" more comfortable with their own perceptions of skills development (fig 5). One specific skill ("Work Effectively with Others") displayed no change in the pre- and post- surveys in either the Fall 2011 or Spring 2012 semesters (fig. 5).

Embedded within this course were opportunities for civic engagement, GIS exercises to enhance geospatial analysis skills, and collaborative learning experiences for students. The omnibus dataset (table 3) reveals that students showed a strong increase in their understanding of how civic engagement activities help connect course content to real-world scenarios ($Mean_{Pre}$ = 4.160 vs. $Mean_{Post}$ = 5.250). GIS and geoliteracy skills were enhanced as students demonstrated a strengthened skillset related to their abilities to interpret GIS images to identify patterns ($Mean_{Pre}$ = 2.879 vs. $Mean_{Post}$ = 4.448). Student attitudes remained neutral toward activity-based learning ($Mean_{Pre}$ = 4.821 vs. $Mean_{Post}$ = 4.800). However, student perspective related to project-based learning displayed an increase ($Mean_{Pre}$ = 4.353 vs. $Mean_{Post}$ = 4.650).

Helping students integrate their new knowledge is an important goal in a general education course and is a key factor in matching teaching strategies to student practice, learning, and contributions to the learning environment (fig. 3). Students were asked if they were in the habit of connecting key ideas they learn in their classes with other knowledge, of applying what they learn in classes to other situations, of using systematic reasoning in their approach to problems, and of using a critical approach to analyzing data and arguments in their daily lives (table 3—"Integration of Learning" section). Learner perspectives showed an increase in each of these four categories related to the student integration of learning (fig. 6 and table 3 – "Integration of Learning" section).

Discussion

Spatially and technologically, tomorrow's classroom will be very different from today's, and the academic tools used in it may not yet even exist (McGee and Diaz 2007; Green 2012; Bolduc-Simpson and Simpson 2012). Yet we currently have many opportunities to engage modern learners with a variety of innovative strategies (Kuh 2008) and learner-friendly technological devices. We must continue to evaluate and assess the incorporation of emerging technologies into curricula redesigns, to ensure their academic soundness and their effectiveness in increasing student engagement. Entry-level STEM courses, like the one described in this article, provide us with the opportunity to transform the science education experience for reluctant learners (Green 2012).

Brundiers et al. (2010) stated the importance of embedding "real-world learning opportunities" into general education courses with an environmental sustainability focus. Overall, students responded favorably to project-based learning in this course redesign. When performing their own assessments, students clearly indicated an increased confidence in their learning gains. Increased skills development (critical thinking, communication, collaborative learning, and social interactions), which contributes to career and professional readiness, was demonstrated, as was an increase in integrating course content by connecting information gained in this course to other knowledge. Likewise, students perceived an increase in their ability to connect their knowledge gains from this class to other situations. In using the scientific method as a guide, students verified that they now are beginning to use systematic reasoning in their approaches to problem solving. Consistent with previous studies, students associated with this course redesign began to understand how civic engagement activities help connect course content to real-world scenarios that made course material relevant to them (Jacoby 2009; Green 2012).

While this course redesign was successful in many ways, it is important to recognize that not every student responds favorably to an inverted classroom design supported by technology. Most students are accustomed to note-taking during a traditional lecture, and any alteration to this structure makes some students uncomfortable. While these changes may not excite a student (as indicated in SALG Attitudes question about activity-based learning), other data presented in this paper show that learning did indeed take place. It is equally important to recognize that not all students learn in the same way, and some may not respond positively to non-traditional teaching strategies. This, however, is true of any teaching method, and it remains the responsibility of the instructor to adjust, assist, and guide each individual learner in the classroom, as needed. The instructor must also remember that learning happens at different paces, and that some students respond slowly to independent learning strategies that differ from their traditional classroom experiences, especially if they lack self-motivation. There are access issues with technology that must be understood by the instructor (i.e. costs, lack of ownership, etc.). Some students lack digital skills, and we must not assume that all have the same knowledge and experience when it comes to using digital tools, software, and hardware. Indeed, Toledo (2007) states that not all students are interested in a technologically-immersed learning environment, regardless of age or exposure. While the challenges listed here are not prohibitive, they must be understood for a successful course redesign aimed at increasing student engagement in the learning process.

In this study, emerging technologies proved to be an effective complement to the curriculum. Student responses generally showed an increase in learning and an increased confidence in subject matter as a result of the flipped classroom model that used emerging technologies as a teaching supplement. Classrooms tended to be lively, with animated students who were actively producing content. This is a much different scene from a traditional classroom with slideshows, dimmed lights, and quiet students taking notes. Thanks to the increased opportunities for one-on-one interactions during the face-to-face class time, struggling students were identified early in the learning process and assisted with their skills development and knowledge gains. This is consistent with Prunuske et al. (2012), who stated that they were able to spend more classroom time assisting students with higher-order learning development.

Using an inverted classroom delivery model required that the role of the instructor be modified into that of an academic facilitator, one who actively guides, rather than one who spouts information from the front of the room. Because self-motivated students were essential to the success of the course, there were challenges. "Borderline chaos" was tolerated in this active-learning scenario, yet the student energy was harnessed and used in a positive manner. Typically, breakout groups of students worked independently while the instructor circulated through the classroom. As a result, there was less reliance on slideshows and formal lectures. Instead, discussions, interactive exercises, and activity-based learning opportunities were emphasized, to promote student engagement and concept retention. Students must still be provided with proper guidance that includes "cognitive presence, teacher presence, and social presence" (Garrison and Cleveland-Innes 2005). Extra time and care should be given by the instructor to explain the new teaching methods, why they are important to the students, and what the learning outcomes are. Innovative teaching methods aside, best practices in teaching must be continued, which means that, regardless of pedagogical strategies, traditional study skills still need to be emphasized for proper learner development. (Brill and Park 2008; McGee and Reis 2012).

Many students have some underlying interest in the course on the first day, yet these same students may have had earlier experiences in science classes that alienated them. Some arrive with preconceived notions about what science is and isn't. This interrupts their learning until the instructor can find ways to break through these barriers and reach the learner. Connecting textbook material with real world scenarios, case studies, and interactive exercises promotes stronger interest in the learning process and provides students with ownership of the class. Service-learning projects make students feel a sense of pride and accomplishment by directly serving the needs of regional organizations. Reaching reluctant learners and exciting them about science is an embraceable challenge that can be accomplished through the right mix of teaching methods and curricula design (Strayer 2012).

Learner-centered approaches to teaching were employed that relied upon innovative web-based techniques. By matching appropriate emerging technologies with learning outcomes in a STEM education classroom for non-science majors, reluctant students were reached and excited; these students were able to connect course content to other classes and to their daily lives, making their experience relevant and worthwhile. Gaining insight from students about the academic experience by understanding their perspectives is important as faculty experiment with new teaching strategies. To promote best practices in teaching, assessing learning gains and demonstrating student successes is an important follow-up for faculty members who experiment with non-traditional teaching methods and approaches. The incorporation of emerging technology into the course redesign allowed students to engage in a variety of learner-centered approaches designed to increase their knowledge, skills, and integration of learning. While students were neutral in their feelings toward activity-based learning, they displayed an increase in their enthusiasm toward project-based learning, which indicates that a successful social and collaborative learning environment was established with this course redesign. Student spatial skills were enhanced through the use of GIS mapping exercises and academic content was connected to their daily lives via a service-learning project at a coastal salt marsh, indicating student uses of higher-order thinking skills (Bloom 1956; Fink 2003). Our current students are our future decision-makers and leaders. It is vital to give them the tools they need to be well-rounded professionals who are educated and technologically advanced, and who approach their lives with ecological perspectives. As faculty members, it is our responsibility to ensure the teaching strategies we employ are as advanced and innovative as possible. Taking the time to understand the student perspective on innovative course redesigns can enable us to enhance the learning environment for all and might just help us save some of those reluctant science students.

Acknowledgements

A SENCER Post-Institute Implementation Award and an FGCU General Education Council Course Redesign Faculty Award helped fund this project. The authors wish to thank Douglas Spencer, Jessica Rhea, Mike Savarese, Donna Henry, Elspeth McCulloch, Aswani Volety, and the "Tablet Computer Teaching Cell" at FGCU. Terry Cain, Lee County Parks and Recreation, and the Conservation 2020 Program assisted with civic engagement projects and field excursion logistics. Finally, many thanks to the "Students-as-Partners" who make this work possible and worthwhile! This study was completed at Florida Gulf Coast University before the lead author moved to the University of Miami.

About the Authors

David Green is an Instructional Designer for the Academic Technologies department at the University of Miami, where he is responsible for consulting with, guiding, and supporting faculty in the design and delivery of technology-enhanced courses and co-curricular activities. He is responsible for helping to design, develop, and implement the "Cane Academy," which is a new initiative at the UM Miller School of Medicine to "flip the classroom" using short instructional videos coupled with companion assessment exercises. As a SENCER Leadership Fellow, he authored a SENCER Model Course and has retrofit multiple university-level classes using the SENCER approach to pedagogy, assessed student response and engagement to the course redesigns, and helped recruit new faculty members to the program.

Jennifer Sparrow is the Senior Director for Teaching and Learning Technology (TLT) at Penn State University. TLT works to help PSU faculty take advantage of information technology to enrich the educational experiences of their students and to champion the creative and innovative uses of technology for teaching, learning, and research. She was previously Senior Director of Networked Knowledge Ventures and Emerging Technologies at Virginia Tech. For more than 15 years, she has championed the use of technology to engage students in the learning process. She has a passion for working with faculty to explore new technologies and their potential implementations in teaching and learning. She loves working with faculty who are willing to push the boundaries of the leading edge of technology in teaching, learning, and research. Her current projects involve the convergence of technologies and learning spaces to create interactive and engaged learning opportunities. Jennifer's conversations around technology focus on increasing digital fluency for students, faculty, and life-long learners.

References

Bennett, S., K. Maton, and L. Kervin. 2008. "The 'Digital Natives' Debate: A Critical Review of the Evidence." British Journal of Educational Technology 39 (5): 775–786.

Bloom B.S. 1956. Taxonomy of Educational Objectives, Handbook I: The Cognitive Domain. New York: David McKay Co., Inc.

Bolduc-Simpson, S., and M. Simpson. 2012. "Social Places in Virtual Spaces: Creating a Social Learning Community in Online Courses." Distance Learning for Educators, Trainers, and Leaders 9 (3): 33–42.

Brill, J.M., and Y. Park. 2008. "Facilitating Engaged Learning in the Interac-tion Age: Taking a Pedagogically-disciplined Approach to Innovation with Emergent Technologies." International Journal of Teaching and Learning in Higher Education 20 (1): 70–78.

Brown, M., M. Auslander, K. Gredone, D.P.J. Green, B. Hull, and W. Jacobs. 2010. "A Dialogue for Engagement." EDUCAUSE Review 45 (5): 38–56.

Brundiers, K., A. Wiek, and C.L. Redman. 2010. "Real-world Learning Opportunities in Sustainability: From Classroom into the Real World." International Journal of Sustainability in Higher Education 11 (4): 308–324.

Burns, W.D. 2011. "But You Needed Me: Reflections on the Premises, Purposes, Lessons Learned, and Ethos of SENCER—Part 1." Science Education and Civic Engagement: An International Journal 3 (2): 5–12.

———. 2012. "But You Needed Me: Reflections on the Premises, Purposes, Lessons Learned, and Ethos of SENCER—Part 2." Science Education and Civic Engagement: An International Journal 4 (1): 6–13.

Fink, L.D. 2003. Creating Significant Learning Experiences. San Francisco: Jossey Bass.

Garrison, D.R., and H. Kanuka. 2004. "Blended Learning: Uncovering Its Transformative Potential in Higher Education." Internet and Higher Education 7 (2): 95–105.

Garrison, D.R., and M. Cleveland-Innes. 2005. "Facilitating Cognitive Presence in Online Learning: Interaction Is Not Enough." The American Journal of Distance Education 19 (3): 133–148.

Green, D.P.J. 2012. "Using Emerging Technologies To Facilitate Science Learning and Civic Engagement." Science Education and Civic Engagement: An International Journal 4 (2): 18–33.

Jacoby, B. 2009. Civic Engagement in Higher Education: Concepts and Practices. San Francisco: Jossey-Bass.

Khan S. 2012. The One World School House: Education Reimagined. New York: Twelve.

Kuh, G.D. 2008. High Impact Educational Practices: What They Are, Who Has Access to Them, and Why They Matter. Washington, D.C.: Association of American Colleges and Universities.

Lage, M.J., G.J. Platt, and M. Treglia. 2000. "Inverting the Classroom: A Gateway to Creating an Inclusive Learning Environment." The Journal of Economic Education 31 (1): 30–43.

McGee, P., and V. Diaz. 2007. "Wikis and Podcasts and Blogs! Oh My! What Is a Faculty Member Supposed To Do?" EDUCAUSE Review 42 (5): 28–40.

McGee, P., and A. Reis. 2012. "Blended Course Design: A Synthesis of Best Practices." Journal of Asynchronous Learning Networks 16 (4): 7–22.

Milman, N.B. 2012. The Flipped Classroom Strategy: What Is It and How Can It Be Used?" Distance Learning for Educators, Trainers, and Leaders 9 (3): 85–87.

Prensky, M. 2001a. "Digital Natives, Digital Immigrants Part 1." On the Hori¬zon 9 (5): 1–6.

———. 2001b. "Digital Natives, Digital Immigrants Part 2: Do They Really Think Differently?" On the Horizon 9 (6): 1–6.

Prober, C.G., and S. Khan. 2013. "Medical Education Reimagined: A Call to Action." Academic Medicine 88 (10): 1407–1410.

Prunuske, A.J., J. Batzli, E. Howell, and S. Miller. 2012. "Using Online Lectures To Make Time for Active Learning." Genetics Education 192: 67–72.

Springer, L., M.E. Stanne, and S.S. Donovan. 1999. "Effects of Small-group Learning on Undergraduates in Science, Mathematics, Engineering, and Technology: A Meta-analysis." Review of Educational Research 69 (1): 21–51.

Strayer, J.F. 2012. "How Learning in an Inverted Classroom Influences Cooperation, Innovation, and Task Orientation." Learning Environments Research: An International Journal 15: 171–193.

Toledo, C.A. 2007. "Digital Culture: Immigrants and Tourists Responding to the Natives' Drumbeat." International Journal of Teaching and Learning in Higher Education 19 (1): 84–92.

Vatovec, C., and T. Balser. 2009. "Podcasts As Tools in Introductory Environmental Studies." Journal of Microbiology and Biology Education 10: 19–24.

PROJECT REPORT

CCSS/NGSS Pilot for Library Summer Reading Club:

Informal K-8 STEM Learning as a Bridge for Formal Scholastic Learning

Charles B. Greenberg
Murrysville Community Library

Nancy R. Bunt
Math & Science Collaborative

Jamie K. Falo
Murrysville Community Library

Michael Fierle
Math & Science Collaborative

Barbara Lease
Math & Science Collaborative

Corinne Murawski
Math & Science Collaborative

Gabriela Rose
Math & Science Collaborative

Cynthia A. Tananis
Collaborative for Evaluation and Assessment Capacity (CEAC), University of Pittsburgh

Keith Trahan
CEAC, University of Pittsburgh

Dana Winters
CEAC, University of Pittsburgh

Abstract

The applied research pilot project of this report seeks to advance K-8 STEM learning by bridging in-school, scholastic learning sessions with informal, out-of-school, summertime learning at public libraries. Professional library programming for children and families around reading and learning is already an integral component of meeting community needs, especially during the summer months when skills can be lost. Annually, and nationally, public libraries have been sharing a themed set of guidelines and activities for Summer Reading Clubs, and activities for K-8 Summer Reading Clubs. The pilot program has been designed to professionally train librarians, administrators, and volunteers for orienting these children, their parents and guardians, to STEM learning in particular, based on scholastic Common Core State Standards (CCSS) in mathematics/English language arts, and Next Generation Science Standards (NGSS). This report describes the activities and progress in the first year of the two-year pilot, including results from an external evaluation.

Introduction

Public Library of the Conflicted Civic Mind

If a community is fortunate enough to have its own public library, that library is often openly associated with civic pride, and, at least within the core body of the library's users and supporters, with a genuine love of books and reading. For some modern-day cynics, nevertheless, the public library is perceived as only a side street of the new main road paved for the Internet. This paper will demonstrate that such a perception is false; we will show how libraries can reinvent themselves to an even larger educational purpose, one that is integral to scholastic STEM learning, and one that can better withstand cynical views.

The Murrysville Community Library is a non-profit corporation, with a Board of Directors, with its own Articles of Incorporation, with an annual budget plan, and with a strategic plan; it is no different from any other corporation, but because it serves at the pleasure of the community, the conflicting views between user and non-user, book-lover and cynic, impact annual funding and viability. In the state of Pennsylvania, where we serve in the southwest corner, there are 445 such public libraries and twenty-nine Districts into which the libraries are grouped regionally (PDE 2012). Districts sometimes correspond with counties.

On Building a New Model [1]

In our District of twenty-four libraries, the Westmoreland Library Network (WLN™), we are in the midst of piloting a new model, one that is intended to eventually overcome not only cynical perceptions, but complacency as well, and to fill a societal educational void (Greenberg and Falo 2014–15). This is really the goal of the pilot project. It integrates a summertime, K-8 educational library experience—based on Common Core State Standards in mathematics/English language arts and Next Generation Science Standards—with formal, standards-based, scholastic learning (NGSS 2014; PA Common Core 2012; Widener 2014). The two-year pilot is about bridging fall/winter/spring scholastic semesters with enhanced and more purposeful, standards-based summer programming. This paper is a report on the first year's activities and progress, including an external evaluation by the Collaborative for Evaluation and Assessment Capacity (CEAC), University of Pittsburgh School of Education.

Background

Library Strengths and Addressing a Weakness

In Pennsylvania, public libraries are well-established, stable resources for information access, reading for pleasure, and informal learning. They operate with a common core of information services. Library Directors and some other staff are trained at the level of a university M.S. Public libraries adhere to specific state library codes, and they operate under the state's Pennsylvania Department of Education, the Office of Commonwealth Libraries. However, while skilled in reading literacy, staff is rarely trained in STEM subject matter or pedagogy. The two-year pilot project in progress seeks to advance student interest in or disposition towards STEM, along with actual learning and understanding of STEM concepts, by building library staff capacity to include STEM in its programming and to make more connections with CCSS and NGSS standards. It seeks to reach across a full spectrum of learning groups in one large PA county/District, with rural to suburban to urban population, and also to be comprehensive with respect to gender, race, ethnicity, and economic means.

Summer Reading Club as Central to the Vision

Many public libraries in all fifty states already participate in an organized Summer Reading Club activity, using a nationally themed set of guidelines and activities structured by the Collaborative Summer Library Program (CSLP 2014). For 2014, the designated theme was "Science: Fizz, Boom, Read!," a first-time explicit focus on science in twenty years of theme-setting. The pilot is designed to take advantage of the established and ongoing reading program and its popularity, as well as the favorable theme. It is doing this by training library staff and key programming volunteers in advance of summer to orient children, parents, and guardians to CCSS/NGSS learning, under the banner of the Summer Reading Club. The collaborating trainers, who otherwise train scholastic teachers and administrators in their usual role, are Mathematics & Science Coordinators from southwestern PA's Math & Science Collaborative (MSC), of which more will be said below. Those who are trained then become trainers for all participants, hopefully leading to the lifelong standards-based learning for all that is needed throughout our society.

MSC Trainers and Library Trainees

For eleven counties, 138 public school districts and non-public schools, MSC stands as the area's comprehensive catalyst for advancement of K-12 STEM learning. MSC's multifaceted STEM program, by which 1250+ teachers and administrators have received training over about twenty years, has: (1) sustained a teacher culture of lifelong professional learning by the internal sharing of best practices and external enrichment; (2) taught teachers to take more personal responsibility for lifetime professional learning; (3) institutionalized a complex array of professional communication and training networks for teachers, administrators, and institutions of education; (4) established the MSC as a leading proponent for CCSS and NGSS standards. In 2012, the MSC earned the prestigious Carnegie Science Center's Leadership in STEM Education Award in recognition of its exceptional impact. It is well positioned to repurpose its usual teacher-training model for use in the public library world.

Key trainees include Library Directors, Children's Librarians, volunteers, and Board Directors. The Directors are important for building administrative support for the initiative; in 2014 four Directors from the Murrysville Community Library (MCL) Board and/or its fundraising MCL Foundation Board participated. The two Boards work closely, even sharing a Strategic Plan; two trainees serve on both Boards. For this first year, Murrysville Community Library was targeted as the particular focus for training, rather than the WLN District as a whole, although participants came from ten libraries in all. In 2015 the emphasis will shift to the WLN District as a whole. MCL's Library Director and Youth Services Coordinator participated fully.

MCL is a particularly good starting point for the pilot because of its depth of experience and recognized skill in children's programming. The MCL offers numerous special programs for patrons of all ages, both on-site and off, some seasonally. The Children's Library was recognized as the 2009 statewide winner of the prestigous PA Library Association's David J. Roberts EXCEL Library Service Award. Furthermore, the MCL consistently draws about 900 youngsters annually for its Summer Reading Club, which is significant in a service area of about 28,000 people.

Specific Goals and Hypotheses

The project's specific goals are (1) to incorporate STEM learning in nationally themed K-8 Summer Reading Club programming in public libraries, as well as other children's programming during the year, as informed by curriculum grade-level standards; (2) to bridge grade-level learning during the otherwise low-STEM-content, out-of-school summer months; (3) to make volunteers and family members a part of the learning, so that children and their families realize enrichment in both the library and home settings. The year-one parental experience is limited to on-site observation and/or child engagement at home; more direct training may be possible when staff members are better prepared as trainers themselves.

The research and development hypotheses are that: (1) in-school student STEM learning can be advanced, given continuity, and sustained by repurposing in-school MSC practices to out-of-school children's programming in public libraries; (2) all children can learn science and mathematics; (3) awareness and knowledge of 21st-century skills for lifelong, "life-wide," and "life-deep" STEM experiences can be fostered in public library settings for family groups.

Methods

Workshops

Eight half-day training workshops were conducted from January through April 2014. Each was led by a pair of staff members from the MSC, most often paired as two Science Coordinators or two Math Coordinators. The workshops included explanative discussion by the Coordinators, hands-on activities, and extensive interactive discussion. The hands-on activities were connected to children's literature that served as the pathway to important mathematics and/or science processes and content.

For example, one session focused on number and shape patterns. The MSC facilitator read aloud the story "The Grapes of Math" (Tang 2004). Trainees then worked in small groups to solve a particular riddle from the story. Each trainee group shared its riddle and solution strategy with the other trainee groups. The ensuing plenary discussion focused on the following essential questions:

- What mathematical or scientific concepts/ideas did the riddles (or activity) illuminate?
- What insights/ideas did the activity leave with you?

TABLE 1. Some Workshop Topics and Resources Used

Topic(s)	Type	Resources in Notes[2]	Featured CCSS/NGSS
Archimedes displacement	Science	The Inquiry Project 2011	5-PS1: Matter and Its Interactions
Density and buoyancy	Science	Home Experiments 2012	5-PS1: Matter and Its Interactions
Density and heat energy transfer	Science	Yang 2007	HS-PS1: Matter and Its Interactions; HS-PS3: Energy
Friction	Science	Robertson 2014; Keeley 2013; Cole et al. 1998	3-PS2: Motion and Stability: Forces and Interactions
Species adaption	Science	Keeley and Tugel 2009	MS-LS4: Biological Evolution: Unity and Diversity
Center of gravity	Science	FOSS	K-PS2: Motion and Stability: Forces and Interactions
Color and chromatography	Science	ICE 2012	1-PS4: Waves and Their Applications in Technologies for Information Transfer; 2-PS1: Matter and Its Interactions
Water Cycle	Science	Project WET 2009	5-ESS2: Earth Systems
Mean, median and mode	Math	Munsch 1992; Math Solutions 2009	6.SP.B.5: Summarize Numerical Data
Patterns	Math	Tang 2004; MARS 2003	4.OA.5: Number and Shape Patterns
Engineering design	Eng	EIE 2014	3-5-ETS1: Engineering design

- With which standards of mathematical practice (or science and engineering practices) and English language arts capacities did the riddles most require you to engage? Why?
- What are the implications for planning your summer reading program? How might you use a task/story/activity like this in the summer reading program?

Additional examples of the mathematics and science content of the exercises are summarized in Table 1.

The number of workshop attendees ranged from ten to twenty-two, averaging eighteen. In total, there were thirty-four unique attendees for the purposes of the external evaluation to be discussed below, of which thirty-one were library trainees. The additional three were community leaders with a stake in the outcome (Mayor, Superintendent of Schools, and Assistant Superintendent); these three attended part of one workshop each. The Program Officer and a Board Director from the lead funding agency participated at part of one workshop. The number of workshops attended by library trainees ranged from one to eight, but each workshop was sufficiently illustrative of CCSS/NGSS learning that a trainee could get the main points in one session. In general, additional sessions served to reinforce learning with new math and/or science process/content connections to children's literature, to be applied during the coming Summer Reading Club.

A Venn diagram from Michaels (2013, 59), showing the CCSS/NGSS standards for mathematical practice, science and engineering practices, and English language arts capacities, was used repeatedly as a thumbnail point of reference. The trainers discussed the fuller descriptions for each set of practices as well. They provided all trainees with more extensive written content in three-ring binders, to which ongoing reference was made. These standards describe the proficiencies being targeted for the trainees, mirroring those exhibited by a mathematically and scientifically literate individual. At every workshop, the appropriate standards were discussed in the context of exemplary, hands-on exercises, each of which was done typically in groups of three or four. The intent was always to help the trainees understand the processes and proficiencies of mathematics and science, including how to reason in a professional way, and how to communicate in an informed way. Thus, the training was about more than just mathematical and scientific content, although that too was embedded in the exercises.

External Evaluation

The MCL contracted with the University of Pittsburgh's Collaborative for Evaluation and Assessment Capacity to evaluate the 2014-2015 program. Two surveys were constructed to examine the effect of the program on the students and the library staff, administrators, and volunteers who participated in the training, particularly with regard

TABLE 2. Examples of Survey Questions

Questions to Training Participants **Scale: 1=Strongly Disagree, 2=Disagree, 3=Uncertain, 4=Agree, 5=Strongly Agree**
As a result of the math and science professional development,
I better understand math and science concepts.
I better understand how children think about math and science.
I am better able to answer children's math and science questions.
I am more confident in my ability to further children's math and science knowledge through appropriate resources.
I can better help children appreciate the value in learning math and science.
I am more confident in my ability to provide math and science programming.
I can better assist families in helping their children understand or learn about math and science.
I feel motivated to seek further information and training regarding math and science.
Questions to Children **Scale: 1=Disagree, 2=I do not know, 3=Agree**
After participating in the *Science: Fizz, Boom, Read!* summer reading program,
I am more interested in science.
I want to read more books about science.
I want to attend more programs about science.
I understand science better.
I talk more about science with my friends and family.
I will use the library to learn more about science.
I will ask the librarian questions about science.
I am more interested in television shows about science.
I am more interested in science experiments.
I am more interested in jobs in science.

to how their familiarity and understanding of mathematics and science concepts progressed. Training participants were contacted via email to complete the participant survey, while parents of children who participated in the program were asked, via email, to provide the survey to their children and to assist them in its completion. Survey responses addressed the following evaluation questions:

Q1: Do participating library staff, volunteers, and/or third parties develop or extend their knowledge and understanding of STEM content and learning engagement strategies?

Q2: Do participating library staff, volunteers, and/or third parties develop or extend their application of STEM content and learning engagement strategies?

Q3: Do child and adolescent learners engage with STEM concepts and processes in their involvement in the Summer Reading Club and/or their use of the library during summer months?

Q4: Do child and adolescent learners exhibit more positive perceptions of and attitudes toward STEM concepts and processes as a result of their involvement in the Summer Reading Club and/or their use of the library during summer months?

Input data were analyzed using basic descriptive statistics for scaled responses. Qualitative analysis strategies were used for open-ended responses. Sample survey questions are shown in Table 2.

Results

Of the 34 workshop participants who were surveyed by the CEAC, 68% (n=23) responded, all of them library staff/administrator/volunteer trainees (Winters and Wade 2014). As for parents and children who participated in the program, about 6% (n=61) of the total of participants responded to the survey. The key findings from the report are as follows:

Key Findings for the Training Participants

(1) Roughly half of the training participants (57%, n=12) had never received any prior professional development in mathematics and/or science.

(2) More than two-thirds of respondents (71%, n=15) strongly agreed or agreed that they are better able to answer students' questions about various STEM concepts and assist families in helping their children to learn and understand math and science.

(3) A large majority (81%, n=17) indicated greater confidence in their ability to select more appropriate resources to improve children's knowledge of mathematics and science.

(4) A large majority of respondents (86%, n=18) indicated that as a result of the training they better understood how children think about mathematics and science.

(5) Nearly all respondents (90.5%, n=19) indicated that as a result of the training program they could better help children appreciate the value of learning math and science.

(6) Nearly all open-ended responses indicated that respondents could better help students to appreciate the value in learning mathematics and science as a result of training participation.

Key Findings for the Students

(1) Gender and grade level seemed to be non-factors for student enjoyment of Summer Reading Club; however, girl respondents indicated a greater interest in science than boy respondents as a result of participating in the *Science: Fizz, Boom, Read!* program (girls: 80%, n=24; boys: 61%, n=19).

(2) More than three-quarters of student respondents (77%, n=47) had previously participated in library programs.

(3) Over half of the students (54%, n=32) indicated that, as a result of participating in *Science: Fizz, Boom, Read!* they understood science better.

(4) Almost three-quarters of student respondents (73%, n=43) indicated an increased interest in science as a result of the *Science: Fizz, Boom, Read!* program.

(5) Over half of student respondents (51%, n=30) indicated that they would use the library to learn more about science. Of these 30 students, 53% (n=16) indicated that they were more inclined to ask librarians questions about science.

(6) A large majority of student respondents (81%, n=48) stated that they wanted to attend more programs about science and were more interested in science experiments as a result of the *Science: Fizz, Boom, Read!* program.

Discussion and Summary

Although the above results represent only the earliest product of what is perceived to be a multiyear and ongoing growth process, they are entirely positive and encouraging. Both trainees and students affirmed the multiple benefits to their relationships with STEM from the experience. The responses are consistent with the earlier brief report of Greenberg and Falo (2014–15), made before CEAC's external evaluation was done. Certain early outcomes are noted in that report. The most important are these: (1) children's librarians from multiple libraries began immediately to plan together for the year's Summer Reading Club, which they had not done before; (2) librarians expressed appreciation for having had identified for them STEM children's books of high value and credibility; (3) as a given, for the first time, there is now an ongoing working collaboration among scholastic trainers and librarians (as evidenced now by the co-authorship of the present report).

In the second-year Summer Reading Club 2015 timeframe, the K-8 theme is known to be *Every Hero Has a Story*. This theme is not explicitly science-based, as was the year-one theme, but it does still serve as a framework for introducing STEM content. Indeed, every theme can be made to include STEM content. In this case, some of the heroes will actually be scientists, mathematicians, or engineers. Some will be non-scientists who use STEM. For example, a fireman hero learns to extinguish fires using chemical combustion principles. Similar strategies can be applied generally for topics yet unnamed in subsequent years. In that way, as librarians gain knowledge and skills, they will continue to create programs and provide informed resources that encourage patron interaction with STEM concepts, even while continuing to promote reading skills and language arts.

In 2014, a first step was taken to introduce the pilot and its intent to the Superintendent of Schools and the Assistant Superintendent for Murrysville. This was done through their participation as trainees and by off-site exchanges. Each participating library will need to make this an ongoing effort.

Finally, returning to the question of whether the public library has become just a side street to the main Internet thoroughfare: it has not, or at least it should not have done so, for one main reason. The Internet is a place to find everything, both information that is informed, correct, and professionally referenced, and information that is not. This goes to the matter of quality of information, and consistency with respect to quality, and, in the case of STEM subjects, adherence to the scientific approach itself. Thus, the Internet has an inherent weakness. Anyone can add information to it, and do so without rules as to quality, and no one is responsible for showing the reader or user how to differentiate. With proper training, the same is not true of public libraries; a well- trained and present staff can make the difference, for using both the local collection and the Internet. The first year of this project has shown that staff consciousness has been raised in respect to choosing quality STEM resources for collection-building and programming, including Summer Reading Club programming. This outcome alone convinces us that we are on the right track with this project.

Our goal for the second year of sponsored training is to expand participation within our District to a broader population of staff members, administrators, and volunteers, including both new and repeat participants. We have also arranged to have at least one participant from a contiguous District attend a training session, with the purpose of possibly expanding the program to her District. Ultimately, depending on outcomes, we imagine at least a statewide presence for STEM training, with goals similar to those of this pilot.

References

CSLP®, Collaborative Summer Reading Club. 2014. "Fizz Boom Read™," http://www.cslpreads.org (accessed October 17, 2014).

Greenberg, C.B., and J. Falo. 2014–15. "CCSS/NGSS Pilot for Summer Reading Club 2014–2015." Math & Science Collaborative Journal 20: 28–29. http://www.aiu3.net/uploadedFiles/Teaching_and_Learning/Math_and_Science_Collaborative/2014-2015%20Journal%20(complete).pdf (accessed January 14, 2015).

Michaels, Sarah. 2013. "What's Common Across the Common Core (ELAS and Math) and the Next Generation Science Standards?" Presentation of NSTA WEB Seminars: Live Interactive Learning @ Your Desktop. http://learningcenter.nsta.org/products/symposia_seminars/NGSS/files/ConnectionsBetweenPracticesinNGSS-CommonCoreMathandCommonCoreELA_2-12-2013.pdf (accessed January 14, 2015).

NGSS, Next Generation Science Standards. 2014. http://www.nextgenscience.org/next-generation-science-standards (accessed January 14, 2015).

PA Common Core. 2012. http://www.pa-commoncorestandards.com (accessed January 14, 2015).

Pennsylvania Department of Education. 2012. Office of Commonwealth Libraries. "Library Statistics." http://www.portal.state.pa.us/portal/server.pt/community/library_statistics/8696 (accessed January 14, 2015).

Tang, G. 2004. The Grapes of Math. New York: Scholastic Paperbacks.

Widener, A. 2014. "A New Standard." Chemical & Engineering News 92(35): 43–45.

Winters, D.M., and K.T. Wade. 2014. "Librarian/volunteer and Student Surveys for Murrysville Community Library's CCSS/NGSS Pilot for Summer Reading Club." Collaboration for Evaluation and Assessment Capacity (CEAC). September Report, School of Education, University of Pittsburgh.

Notes

1 The authors thank the Community Foundation of Westmoreland County (affiliated with The Pittsburgh Foundation) for its lead support in the project. They also are grateful to the following key supporters: the Community Foundation of Murrysville, Export, and Delmont; PPG GIVE Award; the Lulu Pool Trust, managed by First Commonwealth Bank; Mr. Lakshmi Gupta.

2 Cole, J., A. Ruiz, and B.Degen. 1998. The Magic School Bus Plays Ball: A Book About Forces. New York: Scholastic Paperbacks.

EIE, Engineering is Elementary. 2014. "The Engineering Design Process." http://www.eie.org/overview/engineering-design-process (accessed January 14, 2015).

FOSS, Full Option Science System. "Investigation 1: Balance." http://www.lyvemedia.com/delta/grade/2/balance_and_motion/investigation_1/balancemotion_inv1_background.html (accessed January 14, 2015).
Home Experiments on scifun.org. 2012. "Dancing Raisins." http://scifun.chem.wisc.edu/homeexpts/HOMEEXPTS.HTML (accessed January 14, 2015).
ICE, Institute for Chemical Education. 2012. "Is Black Really Black?" and "The Mystery Pen." http://ice.chem.wisc.edu/SSC/SSC_Color.pdf (accessed January 14, 2015).
Keeley, P., and J. Tugel. 2009. Uncovering Student Ideas in Science, Volume 4: 25 New Formative Assessment Probes for Grades K-2. Chapter 15. Arlington, VA: NSTA Press.
Keeley, P. 2013. Uncovering Student Ideas in Primary Science, Volume 1: 25 New Formative Assessment Probes for Grades K-2. Chapter 14. Arlington, VA: NSTA Press.
MARS, Mathematics Assessment Resource Service. 2003. "Buttons." http://www.cfn609.org/uploads/4/6/9/6/4696562/task_-_buttons_mars2003-05.pdf (accessed January 14, 2015).
Math Solutions. 2009. "Literature-Math Connection—Moira's Birthday." http://mathsolutions.com/documents/Moiras_Birthday_i34.pdf (accessed January 14, 2015).
Munsch, R. 1992. Moira's Birthday. Toronto: Annick Press.
Project Wet International Foundation. 2009. Discover Floods Educators Guide: 9. "Incredible Journey." http://www.apfm.info/education/kids/WET_Discover_Floods_Ed_Guide.pdf (accessed January 14, 2015).
Robertson, W. 2014. "Science 101: What Causes Friction?" Science & Children (May–June). 60–62.
Tang, G. 2004. The Grapes of Math. New York: Scholastic Paperbacks.
The Inquiry Project: Seeing the World Through A Scientist's Eyes. 2011. "What Causes the Water Level to Rise?" http://inquiryproject.terc.edu/curriculum/curriculum4/4_mineralmaterials/inv4_1 (accessed January 14, 2015).
Yang, L. 2007. "A Cool Glass of Water: A Mystery." http://sciencecases.lib.buffalo.edu/cs/files/melting_ice.pdf (accessed January 14, 2015).

About the Authors

Charles B. Greenberg is retired Corporate Fellow and Manager of Flat Glass New Product Development for PPG Industries, Inc., with expertise in glass, solar control, thin films, switchable materials, and photocatalysis for self-cleaning. He earned a B.S. from Rutgers University and a Ph.D. and M.S. from the University of Illinois, all in Materials Science/Engineering. Since retirement in 2002, he has been dedicated to several special K-12 to senior learning initiatives relating to STEM and has served on various education and library Boards/Councils. For purposes of the present article, he is a Director and Immediate Past President of the Murrysville Community Library Board (4130 Sardis Road, Murrysville, PA 15668), as well as the Westmoreland Library Network's Treasurer, Immediate Past President, and representative on the Math & Science Collaborative Steering Council. cbgreenberg@earthlink.net

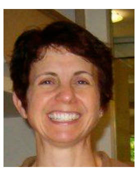
Nancy R. Bunt is Program Director of southwestern Pennsylvania's Math & Science Collaborative, headquartered at the Allegheny Intermediate Unit. She also served concurrently as MSC's Principal Investigator for a $20 million Southwest Pennsylvania Math Science Partnership funded by the NSF and the PA Dept. of Education. She has led the Collaborative in the coordination of efforts to focus K-16 and informal learning resources on strengthening the teaching and learning of mathematics and science for all 138 K-12 school districts in the 11 counties surrounding and including Pittsburgh. Bunt is a certified teacher and administrator who has worked in urban and suburban settings in Pennsylvania and in Europe. She earned her undergraduate degree from the University of Michigan, and her masters and doctorate from the University of Pittsburgh. nancyrobiebunt@gmail.com

Jamie K. Falo has been Library Director for the Murrysville Community Library in Murrysville, PA since 2011, following nine years as Library Director for the Mount Pleasant Public Library in Mount Pleasant, PA. She earned her B.S. and M.L.I.S. from the University of Pittsburgh. Jamie is an active member of the Pennsylvania Library Association (PaLA), serves in various positions of governance for the Westmoreland Library Network, and serves on the Franklin Regional School District Act 48 Committee. Jamie presented a poster about aspects of this paper at the 2014 PaLA Southwest Regional Summer Reading Club Conference. jamie.falo@wlnonline.org

Michael Fierle is certified in Secondary Mathematics Education, Supervisory-Mathematics, and K-12 Principal. He completed his undergraduate studies at Indiana University of PA, and then attended the University of Pittsburgh where he earned his M.Ed. by completing the Administrative and Policies Studies program.

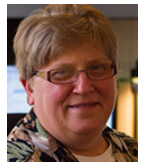
His teaching experience includes eight years as a middle/high school mathematics educator in various school systems in PA and VA. As a Mathematics Coordinator with the Math & Science Collaborative for the past ten years, he has provided direct math professional development to school districts and educators throughout southwestern PA, as well as support for regional STEM Professional Learning Communities (PLCs). Michael.Fierle@aiu3.net

Barbara Lease has been in education for 24 years and is currently a Science Coordinator with the Math & Science Collaborative. Barbara earned a B.S. in biology from Allegheny College, did graduate work at the University of Pittsburgh in human genetics, and was certified as a biology teacher through Seton Hill University. Previously, Barbara worked as biology and mathematics instructor for Mater Dei College in Ogdensburg, New York, as a professional development coordinator at the Carnegie Science Center, Pittsburgh, and as a secondary science teacher in the Pittsburgh area's Penn Hills School District. barbara.lease@aiu3.net



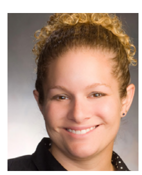
Corinne Murawski is a Mathematics Coordinator with the Math & Science Collaborative and a mother of two daughters, ages 4 and 9. Corinne earned her undergraduate degree from Penn State University, and her Masters degree in Education Policy Studies and a K-12 Supervisory Certificate from Duquesne University. Previously, Corinne worked as a district-level administrator for supervision of mathematics/computer science; as a curriculum, textbook, and cognitive tutor developer; and as a classroom teacher in mathematics and science. Corinne has worked with the University of Pittsburgh to supervise pre-service mathematics teachers, and she has also taught undergraduate and graduate courses both face-to-face and online. corinne.murawski@aiu3.net

Gabriela Rose is a Science Coordinator for the Math & Science Collaborative at the Allegheny Intermediate Unit in Pittsburgh, PA. In this position she is working with science teachers and administrators to implement rigorous inquiry-based science instruction with the goal of preparing all students for college and career in the 21st century. Before coming to the Allegheny Intermediate Unit, Gabriela taught middle school science. Gabriela holds certification for Biology 7–12, Middle Level Science, K-12 Principal, and Supervisor for Curriculum and Instruction. Gabriela earned her undergraduate and graduate degrees in biology and physical education at the Free University of Berlin, and a Master of Science in Ecology from the University of California at Davis. gabriela.rose@aiu3.net



Cynthia A. Tananis founded the Collaborative for Evaluation and Assessment Capacity in the School of Education at the University of Pittsburgh and serves as its Director and as an Associate Professor in the School Leadership Program. Her expertise focuses on using participative evaluation designs with involved stakeholders, helping people make sense of and benefit from the evaluation process through collaboration, and linking evaluation studies and school reform policy. She holds a B.S. in Education and an Ed.D. in Policy, Planning, and Evaluation Studies, both from the University of Pittsburgh. tananis@pitt.edu

Keith Trahan serves as the Assistant Director of CEAC. Keith has been lead evaluator for a variety of programs in the areas of K-12 math and science reform and school leadership, IHE STEM curriculum, instruction, and learning, IHE international education, and community-based human services. He holds a B.A. in Government and a B.A. in Sociology from McNeese State University, an M.A.T. from Charleston Southern University, and a Ph.D. from the Social and Comparative Analysis in Education Program at the University of Pittsburgh. kwt2@pitt.edu



Dana Winters serves as Senior Evaluator for CEAC. Dana has experience leading evaluations throughout PK-16 formal education, large-scale STEM and literacy reform initiatives, informal education, and community-based non-profit evaluation. Dana has a B.A. in Sociology and Political Science from Saint Vincent College and a M.A. in Student Affairs in Higher Education from Indiana University of Pennsylvania. She is currently a doctoral student in the Social and Comparative Analysis in Education Program at the University of Pittsburgh. dmw67@pitt.edu

PROJECT REPORT

Brownfield Action Online– Using Technology to Extend Access to Non-Traditional Students

Joseph Liddicoat
City College of New York, City University of New York

Peter Bower
Barnard College, Columbia University

Introduction

Brownfield Action (BA) is a SENCER Model that is a web-based, interactive, three-dimensional digital space and learning simulation in which students form fictitious geotechnical consulting companies and work collectively to explore problems in environmental forensics. Created at Columbia University's Barnard College in conjunction with Columbia's Center for New Media Teaching and Learning, BA has a 12-year history of use at Barnard as a full semester activity in a two-semester Introduction to Environmental Science course. Each year more than 100 non-science majors take BA as an option to satisfy the College's undergraduate science requirement. The pedagogical methods and design of BA are grounded in a substantial research literature focused on the design, use, and effectiveness of games and simulation in education (Bower et al. 2011). The variety of ways in which the BA simulation is used at Barnard and nine other educational institutions in the United States is described in Bower et al. (2014).

Although BA is web-based, there are components that are done in the classroom to complement the online instruction. The components include making topographic, bedrock, and groundwater maps; laboratory experiments to determine the porosity and permeability of sediment; and observation of the migration of a contaminant plume in a sand tank designed for that purpose. In this report we describe how we taught BA online to non-traditional students who use the course to satisfy an elective science requirement at the City College of New York (CCNY). The CCNY learning management system (LMS) is Blackboard 9.1, but any LMS can be used when teaching BA online. The course combined mainly asynchronous instruction, in which the students accessed course material and learned it outside the classroom at their leisure, and in-class instruction evenly spaced during the semester, when all of the students were present. It was in the classroom that students did laboratory experiments with equipment that would not be available away from the College. Examples of equipment that makes the learning experience meaningful to the students are sediment sieves for mechanical separation of regolith (sand) into different sizes or fractions, a triple-beam balance for measuring the mass of each sand fraction, a permeameter to measure the permeability coefficient needed in the calculation of the velocity of groundwater flow using D'Arcy's Law, and a sand tank commercially obtained and designed to demonstrate the migration of a contaminated plume in groundwater.

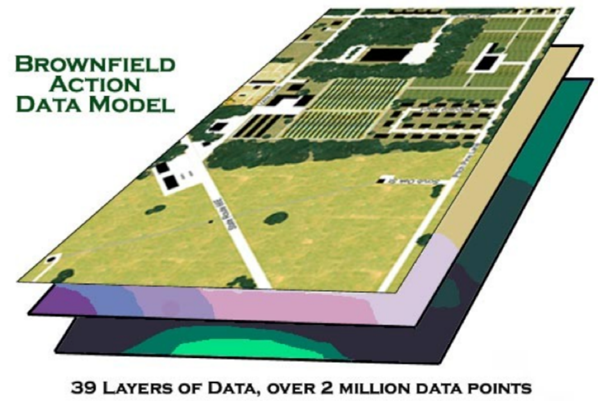


FIGURE 1. In the Brownfield Action simulation, data can be obtained for surface and bedrock topography, water table, water chemistry, soil characteristics, and vegetation as well as data from tools like soil gas, seismic reflection and refraction, metal detection and magnetometry, ground penetrating radar, and drilling.

Course Design

We used the constructionist approach (Murphy et al. 2005) to teaching BA as an asynchronous online course. An advantage of teaching BA asynchronously rather than having real-time (synchronous) communication between students and us is that it allowed the students to collapse time and space, to access the classes anywhere, and to get immediate feedback between themselves and us. Furthermore, we prefer authentic learning (Donovan et al. 1999) that involves the students in an investigation of a relevant issue such as a brownfield because it applies well to someone who lives in a large metropolitan area such as New York City. We are mindful that the success of the course depends much on structuring assignments so that the students see where the tasks they do help to lead to the eventual goal of the course, which is the drafting of an Environmental Site Assessment Phase I Report. We are fortunate to have more than a decade of experience developing and teaching face-to-face the assignments used in BA. Texts for the course are Jonathan Harr's *A Civil Action* and Rachel Carson's *Silent Spring*, which are accompanied by questions that direct the reading for each class.

Course Content

For faculty who intend to teach BA online, we offer here the lessons we developed for the course at CCNY. Each class consisted of a *Lesson, Assignment, Discussion, Questions* for reading assignments, and *Resource*, which was a PowerPoint presentation. The answers to the reading questions were known only to us and were not shared between students online. Student performance was assessed by weekly assignments and an Environmental Site Assessment Phase I Final Report.

During the first week of the course there were two three-hour classes when the students met with us on campus to make and interpret maps that are required for BA. Four additional classes during the semester when the students were together with us were when laboratory experiments were done to measure the porosity and permeability of regolith (sand), observe the contaminant plume in the sand tank model, and write the Environmental Site Assessment Phase I Report that was a requirement of the course. What follows is a description of the classes that can be used or adapted by other instructors when teaching BA online.

Class 1 consisted of a *Lesson* that described a brownfield and the design of the course. Because scale and a map of the region to be explored and topographic, bedrock, and water table maps are important in an environmental investigation of the kind that is done in BA, there was an explanation of the maps with all of the students present. The *Discussion* was for the students to write a paragraph telling their classmates and us something about themselves. As part of the biography, the students used the letters of their first name to describe traits they have. This activity served as an informal means of introducing the students to each other. An *Assignment* to be shared with everyone was for each student to select a park or similar site in his or her neighborhood and compute the area of that site. The intention of the assignment is to reinforce the concept of scale by comparing the area of the neighborhood site with the area of the base map (about 160 acres) and to Governor's Island in New York Harbor, which was of similar area and a familiar locality to the students. *Questions* the students saw online about Chapter 1 in *Silent Spring* and *A Civil Action* were to be answered and sent to us before the next class;

the biography using the letters of the first name was sent to everyone in the course. The *Resource* was a PowerPoint presentation about scale and the fictitious township that the students would investigate in the search for a brownfield. The class concluded with a video that described why an environmental site assessment is required for a parcel of land that a developer is considering buying; in this case, the land would be used to construct a mini-mall at the site of a former factory in Moraine Township, which is the fictitious township in the BA simulation.

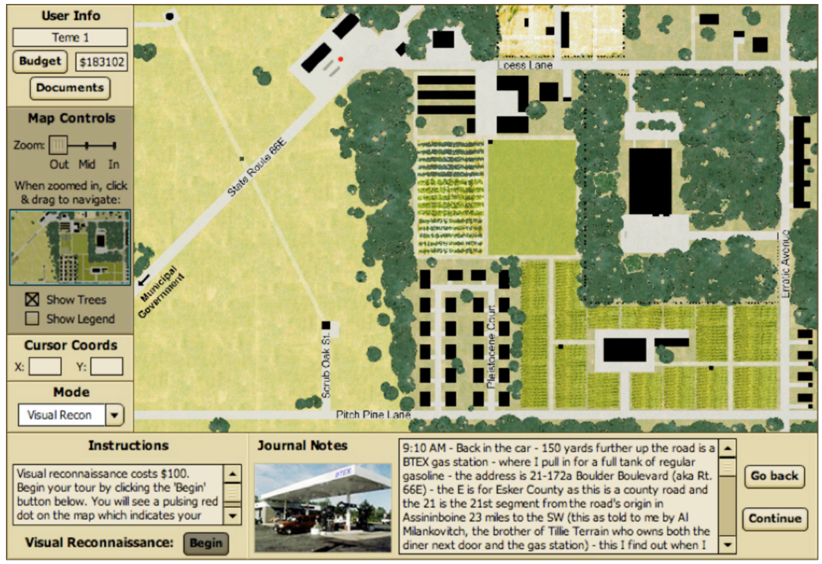


FIGURE 2. The buildings and vegetation map, which covers the "field of play " in the Brownfield Action simulation, in the Visual Reconnaissance mode that provides information about the BTEX station.

The *Lesson* in Class 2 was devoted to a visual reconnaissance of Moraine Township. Because the reconnaissance is of about 160 acres, the task was divided among the students with each one assigned a sector of 20 acres. The *Assignment* required each student to report on the physical appearance of the landscape and position of buildings and roads in the sector. Students then combined the reports in the *Discussion* for use in a storyboard that would be a reference throughout the investigation. *Questions* about Chapter 2 in *Silent Spring* and *A Civil Action* were to be answered within seven days and sent only to us. The *Resource* was a PowerPoint presentation that had photographs and results of the regolith sieving lab that was done in Class 1.

The *Lesson* in Class 3 was for each student to locate and describe a brownfield in his or her neighborhood, and to report it to the entire class in the *Discussion*. The *Assignment* was to summarize the information that was learned in the visual reconnaissance of Moraine Township and to identify possible sites that required examination. This information also was to be communicated to the entire class in the *Discussion*. *Questions* about Chapter 3 in *Silent Spring* and *A Civil Action* were to be answered within seven days and sent only to us. The *Resource* was a PowerPoint presentation that had photographs of an abandoned gas station in Manhattan that is a brownfield. The photographs gave the students an example of what might be a brownfield in their neighborhood.

Interviews with residents in Moraine Township have the potential to provide information that will be valuable in the search for a brownfield. Those interviews are possible in the BA simulation, and the *Lesson* in Class 4 was to have each student make several interviews from 20 possible ones. The *Assignment* was for each student to report the results of the interviews in the *Discussion* that was shared with everyone, and to add the responses to the storyboard for the investigation. *Questions* about Chapter 4 in *Silent Spring* and *A Civil Action* were to be answered within seven days and sent only to us. The *Resource* was a PowerPoint presentation containing information about how to conduct an interview in the BA simulation.

The students met with us in the classroom for Class 5. The *Lesson* was to introduce a plume (dye) into a sand tank designed to show how a contaminant moves from a point source in a well to a region of reduced confining pressure (pond). The *Assignment* was to calculate the rate of the groundwater flow using D'Arcy's Law and to share the result in the *Discussion*. Questions about Chapter 5 in *Silent Spring* and *A Civil Action* were to be answered within seven days and sent only to us. The *Resource* was a PowerPoint presentation that showed the sand tank and explained the demonstration that was done with it. The class concluded with a showing of the CBS 60 Minutes interview with Anne Anderson, whose young son died from leukemia and who is a central character in *A Civil Action*.

Information from the interviews that were made in the *Lesson* for Class 4 and shared in the *Discussion* that week revealed that there might be subsurface pollution at the BTEX station that is located in the northwestern part of Moraine

Township. The *Lesson* for Class 6 was to make a Soil Gas Sampling Analysis (SGSA) along a transect from the BTEX station to the municipal well that provides drinking water to the residents of Moraine Township. The SGSA survey is a geophysical method of detecting whether there is gasoline floating on the surface of the water table. The *Assignment* was for each student to make a measurement at a selected point along the transect and report the result in the *Discussion* for everyone to use. *Questions* about Chapter 6 in *Silent Spring* and *A Civil Action* were to be answered within seven days and sent only to us. The *Resource* was a PowerPoint presentation about the SGSA procedure, costs, and certification that is required before a measurement is made.

Because there was a positive SGSA result from the surveys in Class 6, the *Lesson* for Class 7 was to locate the underground storage tanks (UST) at the BTEX station. This is possible by doing a Magnetometry Metal Detection (MMD) investigation to locate the tanks before they are excavated. The *Assignment* was for each student to do the MMD survey in a square 10 feet on a side on the topographic map and to report the results to everyone in the *Discussion*. *Questions* about Chapter 7 in *Silent Spring* and *A Civil Action* were to be answered within seven days and sent only to us. The *Resource* was a PowerPoint presentation about the MMD procedure, cost, and required certification before making the measurement.

After locating the USTs with the MMD survey, the tanks were excavated in Class 8. The *Lesson* for Class 8 was for each student to excavate the site he or she explored in Lesson 7. The *Assignment* was to expose the USTs and for ones that are leaking (LUSTs) to report the results in the *Discussion* for each student to add to the base map of Moraine Township. *Questions* about Chapter 8 in *Silent Spring* and *A Civil Action* were to be answered within seven days and sent only to us. The *Resource* was a PowerPoint presentation about how to excavate an UST, the cost involved in doing that, and the certification required before excavation is begun.

In the *Lesson* for Class 9, the students were asked to review information that was obtained from the visual reconnaissance of Moraine Township, from interviews with business owners and their employees and from residents and government officials, the SGSA and MMD surveys, and excavations at the BTEX station. The *Assignment* was to draw conclusions from the information as it applied to the LUSTs at the BTEX station and to share the conclusions with classmates and us in the *Discussion*. A second *Lesson* in Class 9 was to do a Ground Penetrating Radar (GPR) survey of the septic field at a former factory that is suspected to be the point source of the radioactive isotope tritium in the municipal water supply. As with the SGSA and MMD surveys, the sites for the GPR survey were assigned to different students. The *Assignment* was to report the findings of the survey to everyone in the course and to share it in a *Discussion*. *Questions* about Chapter 9 in *Silent Spring* and *A Civil Action* were to be answered within seven days and sent only to us. The *Resource* was a PowerPoint presentation about how to do a GPR survey, the cost, and certification required before the survey is begun.

The students were back in the classroom for Class 10 where the sand tank was used for the *Lesson* about the migration of a plume of vegetable dye from a point source to a region of reduced confining pressure, which is a pond. The *Assignment* was to calculate the rate of flow of the plume using D'Arcy's Law and to share the answer with classmates in the *Discussion*. A laboratory activity was to measure the permeability coefficient of the regolith with a permeameter. *Questions* about Chapter 10 in *Silent Spring* and *A Civil Action* were to be answered within seven days and sent only to us. The *Resource* was a PowerPoint presentation about the use of the permeameter to obtain the permeability coefficient that is one of the factors in D'Arcy's Law.

The *Lesson* for Class 11 was about radioactivity and the radioactive isotope tritium. The abandoned factory that will be the site of the proposed shopping center used tritium in the manufacture of some of its products. Because tritium is present in the drinking water used by residents in Moraine Township, it is important to find its source. Using the porosity and permeability constant of the regolith and the slope of the water table, the *Assignment* was to calculate the time in years that it would take for tritium to move in the groundwater from the factory to the municipal well. The answer to this assignment was shared in the *Discussion*. *Questions* about Chapter 11 in *Silent Spring* and *A Civil Action* were to be answered within seven days and sent only to us. The *Resource* was a PowerPoint presentation about radioactivity and nuclides, especially of tritium and its decay product, a beta particle.

The *Lesson* for Class 12 was an examination of reports about the quality of the drinking water in Moraine Township. The *Assignment* was to summarize the information that is relevant for the Environmental Site Assessment Phase I Report that is a requirement of the investigation. Each student shared his or her interpretation of the reports with classmates using the *Discussion*. *Questions* about Chapter 12 in *Silent Spring* and *A Civil Action* were to be answered within seven days and sent only to us. The *Resource* was a PowerPoint presentation showing a Water Report and providing information about how to interpret the Report.

The *Lesson* for Class 13 was to test the groundwater in Moraine Township by obtaining water samples from drill wells. Drilling was done along a transect where there was a suspected plume of hydrocarbon contamination from the LUST at the BTEX station, and along a transect from the septic field at the abandoned factory that used tritium as an energy source in the manufacture of some of its products. The *Assignment* was for each student to drill at a site along the transect and to report the results in the *Discussion*. *Questions* about Chapter 13 in *Silent Spring* and *A Civil Action* were to be answered within seven days and sent only to us. The *Resource* was a PowerPoint presentation that had instructions and guidelines about drilling so that money would not be spent unwisely at this phase of the investigation.

The *Lessons* for Classes 14 and 15, which were done in the classroom, were devoted to the writing of the Environmental Site Assessment Phase I Report that was a requirement of the investigation. The *Assignments* were for each student to draft a part of the report and share it with the entire class in the *Discussions*. Questions about Chapter 14 and 15 in S*ilent Spring* and *A Civil Action* were to be answered within seven days and sent only to us. The *Resource* for Class 14 was a PowerPoint presentation with the instructions for the writing of the report. The *Resource* for Class 15 was a PowerPoint presentation that summarized the phases of the investigation and had instructions about completing the investigation, along with recommendations to be given to the prospective property owner regarding the environmental quality of the land being considered for the mini-mall. The course ended with a video that showed the two brownfields in Moraine Township and a three-dimensional simulation of their movement to the municipal water well from the BTEX station and from the abandoned factory that used tritium.

Summary

In order to preserve the integrity of BA when it is taught online, it should be framed as a "hybrid" course, as it is important that the students meet together with the instructor for some of the classes. The asynchronous part of the course allows students to collapse time and space; to access the classes anywhere; to get immediate feedback, tutoring, and coaching; and to receive real-time interaction between themselves and the instructor. For anyone who teaches an online course or intends to teach one, a resource that we found to be useful is *The Complete Step-by-Step Guide to Designing & Teaching Online Courses* by Joan Thormann and Isa Kaftal Zimmerman (2012).

References

Bower, P., R. Kelsey, and F. Moretti, 2011. "Brownfield Action: An Inquiry-based Multimedia Simulation for Teaching and Learning Environmental Science." Science Education and Civic Engagement 3 (1): 5–14. http://seceij.net/seceij/winter11/brownfield_acti.html (accessed December 19, 2014).

Bower, P., R. Kelsey, B. Bennington, L.D. Lemke, J. Liddicoat, B. Sorice Miccio, A. Lampousis, D.M. Thompson, B. Greenbaum Seewald, A.D. Kney, T. Graham, and S. Datta, 2014. "Brownfield Action: Dissemination of a SENCER Model Curriculum and the Creation of a Collaborative STEM Education Network." Science Education and Civic Engagement 6 (1): 5–21. http://seceij.net/secei/winter 14/brownfield_acti.html (accessed December 19, 2014).

Carson, R. 2002. *Silent Spring*. Boston: Houghton Mifflin Harcourt.

Donovan, M.S., J.D. Bradsford, and J.W. Pellegrino, eds. 1999. How People Learn: Bridging Research and Practice. Washington, D.C.: National Academy Press.

Harr, J. 1996. A Civil Action. New York: Vintage Books.

Murphy, K., S.E. Mahoney, C.Y. Chen, N. Mendoza-Diaz, and X. Yang. 2005. "A Constructionist Model of Mentoring, Coaching, and Facilitating Online Discussions." Distance Education 26 (3): 341–355.

Thormann, J., and I.K. Zimmerman. 2012. The Complete Step-by-Step Guide to Designing & Teaching Online Courses. New York: Teachers College Press.

About the Authors

Joseph Liddicoat is an Adjunct Professor at the City College of New York where he teaches the Core Science curriculum and elective science courses, one of which is Brownfield Action. Retired from Barnard College, he has been part of the development of Brownfield Action with Peter Bower and others for nearly 15 years. He received his A.B in English Literature and Language from Wayne State University in Detroit, MI, which is his home town, and graduate degrees in Earth Science from Dartmouth College (A.M.) and University of California, Santa Cruz (Ph.D.). City College of New York, Center for Worker Education, 25 Broadway, 7th Floor, New York, NY 10004; jlidddicoat@ccny.cuny.edu.

Peter Bower, conservationist and educator, is a Senior Lecturer in the Department of Environmental Science at Barnard College/Columbia University, where he has taught for 29 years. He has been involved in research, conservation, and education in the Hudson River Valley for 35 years. He is the creator of the Brownfield Action selected as a National SENCER Model Curriculum in 2003 and is a SENCER Fellow. This innovative curriculum includes a web-based, interactive, digital space and simulation, in which student "consulting companies" explore and solve problems in environmental forensics (see www.brownfieldaction.org). He has also developed and taught courses in field methods, environmental law, environmental hazards and disasters, waste management, energy resources, and the Hudson River ecosystem, among others. He is a recipient of Barnard College's Emily Gregory Award for excellence in teaching. He has also served as acting executive director of the Black Rock Forest Consortium in Cornwall, New York, where he managed and directed the staff and facilities of a 3,785-acre forest and oversaw its research, educational, and conservation activities. He is the former Mayor of Teaneck, New Jersey, where he served on the City Council, Planning Board, and Environmental Commission for eight years. He received his B.S. in geology from Yale, M.A. in geology from Queens, and Ph.D. in geochemistry from Columbia. pb119@columbia.edu.

Supplemental Course Material

A. Class PowerPoints:
https://serc.carleton.edu/download/files/65107/ClassPowerpoints.zip

B. Class Lessons:
https://serc.carleton.edu/download/files/65104/ClassLessons.zip

C. Class Discussions (Forums):
https://serc.carleton.edu/download/files/65101/ClassDiscussions.zip

D. *Silent Spring* Questions:
https://serc.carleton.edu/download/files/65110/SilentSpringQuestions.zip

E. *A Civil Action* Questions:
https://serc.carleton.edu/download/files/65098/ACivilActionQuestions.zip

Link to Brownfield Action

http://brownfield.ccnmtl.columbia.edu

PROJECT REPORT

Life in and Around the Chicago River: Achieving Civic Engagement through Project Based Learning

Farahnaz Movahedzadeh
Harold Washington College

Adrienne Linzemann
Harold Washington College

Elsa Quintero
Harold Washington College

Jose Aveja
Harold Washington College

William Thompson
Harold Washington College

Margaret Martyn
Harold Washington College

Abstract

By the year 2016, the Environmental Protection Agency (EPA) aims to make the Chicago River an area designated for primary contact recreational use, where people can swim in the water without being harmed by waterborne pathogens from raw sewage contamination (EPA 2011). In recent years, recreational use of the Chicago River has been increasing. Currently only three of the Chicagoland area's water reclamation plants disinfect their wastewater (Oh 2012). The focus of this research project was to determine the coliform count and identify the bacteria within the Chicago River. This mission was performed by undergraduate students enrolled in a microbiology research course centered on project-based learning (PBL) at Harold Washington College (HWC). This endeavor allowed students to learn basic laboratory skills currently used in the field of microbiology and apply them in a real-world scenario. In addition, the students learned the value of collaborative learning and research, along with its outcomes. The results of this project can serve to engage the public by educating them about the pollution in the Chicago River, an invaluable resource shared by many locals and tourists in the Chicagoland area.

Introduction

If there is magic on this planet, it is contained in water, and the Chicago River is a testament to that (Eiseley 1959). The Chicago River has played a critical role in the history of Chicago and continues to be utilized to this day. As has been often repeated, the city of Chicago owes its existence to the Chicago River, and the river owes its present form to Chicago. Geographically speaking, had it not been for the river's location between Lake Michigan and the Des Plaines River, Chicago would never have become one of the nation's central transshipment points (Hill 2000). Since that time, the Chicago River has come a long way from being a cesspool to today's recreational hot spot.

In the nineteenth century, city sewers drained into the Chicago River, which emptied into Lake Michigan. This posed a health hazard, as the lake supplied the city's drinking water (Brown, 2002). In 1900, the completion of the Sanitary and Ship Canal reversed the flow of the Chicago River to direct sewage away from the lake, and after 1922, water treatment plants were established. Today, the Chicago River is used for recreational purposes where tourists hop aboard tour boats and water taxis. Some residents kayak on the river despite the fact that it sometimes receives bad press due to its polluted ecosystem. The EPA's goal is to designate the Chicago River as an area safe for primary contact recreation use by 2016, meaning that people will be able to enjoy direct contact between their skin and the water without being harmed by waterborne pathogens from raw sewage contamination (EPA 2011). Moreover, Mayor Rahm Emanuel has launched a development project for the Chicago Riverwalk, attracting residents and tourists alike to enjoy activities along the main branch of the river. However, only three out of seven of the Chicagoland area's water reclamation plants currently sanitize their wastewater before pumping the effluent back out into the river (Oh 2012).

The main goals of this research are to:

1. Show the impact of learning that resulted in civic engagement through project-based learning conducted by undergraduates.

2. Demonstrate the ability of two-year college students, when given the opportunity, to engage and conduct critical research such as the investigation of water quality in the Chicago River, and to supply results and outcomes that could make a difference in the quality of life around the river. Such work is at the core of civic engagement.

3. Investigate the water contamination level in the Chicago River by determining the coliform count and bacterial identification. Coliforms are gram-negative bacteria that originate from the large intestines of warm-blooded animals and are therefore used as an indicator of fecal contamination. If coliforms are found in water, other pathogenic bacteria may be present as well. Pathogens commonly found in wastewater effluents include *Escherichia coli*, *Streptococcus*, *Salmonella*, *Shigella*, *mycobacterium*, *Pseudomonas aeruginosa*, *Giardia lamblia*, and *enteroviruses* (North Carolina Department of Health and Human Services 2011).

This investigation was carried out as part of an interdisciplinary microbiology research course that was designed and taught based on Project-Based Learning (PBL) methods. There is no doubt that the ways we teach and engage students in learning affect students' attitudes toward, and performance in, college-level courses. Educating our students within the classroom about science, technology, engineering, and mathematics (STEM) is not enough. Science is not simply what students learn from textbooks or from a traditional passive learning environment. Students need to be taught how science is practiced, because it is through science and math that our world is rapidly evolving, with new discoveries being made through inquiry and experimental research. Teaching students scientific concepts through engagement in scientific inquiry and empirical research enables them to understand how math and science fields play a critical role in our society and in our everyday life. When students experience this through hands-on learning and empirical research, their creativity and intellectual boundaries are expanded, and their problem- solving skills and cognitive abilities improve and advance. It has been shown that students learn more effectively when they are engaged in hands-on learning experiences directed by students themselves (Brickman et al. 2009).

PBL has the potential to be a highly effective teaching method that fully engages students and leads them to success in mastering the course material. It greatly increases student motivation to learn course material, due to the impact of connections made outside of the conventional classroom setting. It is an alternative approach to education that encourages students to seek solutions to challenging and relevant problems and to bridge the gap between school and the real world (Doles 2012). In addition, the PBL method allows the student to retain the course material for a longer period of time than the methods employed in a traditional course. A study performed by Cherif, Movahedzadeh, Adams, and Dunning on why students fail in college-level courses, presented at the Higher Learning Commission (HLC) conference in 2013, revealed that lack of motivation is among the most common factors that contribute to student academic failure (Cherif et al. 2013). Lack of motivation was also recognized by many faculty members as one of the root causes of student failure (Cherif et al. 2014). When students realize the significance of the subject being taught and how it relates to their lives, they are more likely to become motivated and engaged. A PBL environment may also change the attitude a student has towards a course or career path (Chang et al. 2011). This is significant, especially because it has been documented that 50 percent of students seeking an associate degree require remediation, while 20.7 percent of those seeking a bachelor degree require remediation (The State of College & Career Readiness 2013).

PBL is an innovative and promising teaching method that imparts to students the skills needed to compete and succeed in STEM field jobs. PBL teaches students important skills such as critical thinking, collaboration with others, taking responsibility for their learning, and time management, among others. PBL is a key learning methodology that prepares students with the skills that are required by employers in STEM fields. Today employers expect professionals not only to hold strong technical skills, but also to be able to work well in teams, manage their time efficiently, multitask, and effectively communicate information gathered from a variety of sources (AACC 2010). Students in PBL classrooms learn and continuously exercise these important skills. Positive outcomes have been revealed at universities such as Southern Connecticut State University (SCSU), where students in a general chemistry course completed a project of their choice related to chemistry. The majority of the students had a positive sense of having gained an "understanding of the multidisciplinary nature of societal issues" and how chemistry aids in addressing real-world issues (Webb 2013). Similarly, this research project revealed the important role biotechnology plays in our society as a means of addressing issues such as water contamination.

We are rapidly moving forward with advancing technology, but there is a lack of skilled and qualified personnel adequately equipped with knowledge in using such advancements. If we are quickly developing innovative technology through research and development, and the demand for skilled workers, such as lab technicians, is ever increasing, then why are students not being taught the skills employers are looking for or the skills necessary to succeed in STEM field jobs? As we will show, PBL methodology grants students opportunities to learn to be self-directed in their education and to acquire the skills they need.

The research project discussed in this paper incorporated the use of current microbiology techniques for students to investigate water contamination in the Chicago River. Integrating PBL in science courses can inspire students to pursue science-related careers. Moreover, these types of projects can positively impact students and encourage them to engage pressing issues in their community and educate the public about such issues. The results of this research call for civic engagement, because the Chicago River is a dynamic resource that is shared and utilized by countless residents of Chicago for various purposes. Given support and minimal resources, students at the community college level are able to actively participate and flourish in research that both recognizes and addresses matters concerning their society and their environment.

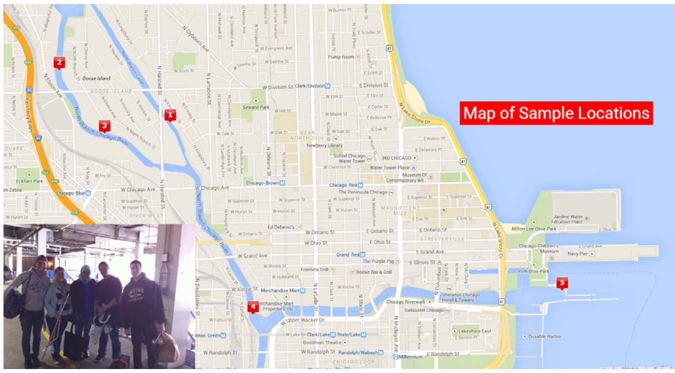
Materials and Methods

Undergraduates were tasked with planning and implementation in all of the aspects of this course, including but not limited to the design of and participation in sampling, testing, research, and synthesis of information.

Sample collection

Water samples were obtained on two separate occasions under two diverse weather conditions. Samples were taken from one location, under the Wabash Avenue Bridge, during inclement weather when torrential rains precipitated the opening of the locks leading from the Chicago River into Lake Michigan due to flooding (April 18, 2013). Water samples reflecting dry weather and normal river conditions were collected at five sites along the Chicago River (fig. 1) on a separate day approximately two weeks later (May 3, 2013). In selecting the sites for the testing samples, covering a large area along the river across multiple neighborhoods where residents use the river in various ways was desired. Samples were collected using a one-liter graduated pitcher attached to an eight-foot pole. Two water samples per location were collected from approximately six feet below the surface, poured into collection bottles, and taken to the microbiology lab at Harold Washington College (HWC) for analysis.

FIGURE 1. Map of five locations from which water samples were collected



Bacterial Count

To determine coliform counts, serial dilutions of 1:1, 1:10, 1:100, and 1:1000 were made from the samples taken during dry normal conditions as they more accurately reflect the ongoing contamination of the Chicago River. MacConkey's agar plates were inoculated with 100 µL of each dilution. After incubation at 37° C for 24–48 hours, colony-forming units (CFUs) were determined. Final results represent the average of both samples per location as shown in table 1. While the applied approach may differ from the methods utilized by the Metropolitan Water Reclamation District (MWRD) plants, the way we submitted the report of the colony count is the standard method and comparable to theirs.

Culture Identification

Bacterial differentiation began by inoculating 100 µL of each non-diluted sample onto the following media: MacConkey's agar, blood agar, Eosin-methylene blue agar (EMB), and triple sugar agar (TSA). After overnight incubation at 37° C, gram negative colonies were selected and isolated to inoculate into nutrient broth for further testing.

Biochemical Identification of Isolates

In addition to the IMViC tests, the following biochemical tests were performed for bacterial differentiation: glucose broth (with and without oil), lactose broth, nitrate broth, gelatin agar, starch agar, spirit blue agar, phenylalanine deaminase, methyl red/ Voges Proskauer, esculin hydrolysis, urea hydrolysis, oxidase and catalase production. To confirm the identification, Enterotube Multitest System (BD BBL, USA) was used for each sample and incubated at 37° C for 24–48 hours. Results from all tests were determined (table 1) using the Bergey's Manual of Determinative Bacteriology (1994).

Results

Testing the water in the Chicago River led to the isolation of coliforms like *Pseudomonas aeruginosa* (fig. 2, originating from flood water sample), *Escherichia coli* and opportunistic pathogens like *Enterobacter agglomerans* and *Serratia odorifera* (table 1). Since the presence of coliform bacteria was suspected, a series of biochemical tests was designed to investigate the fermentation and oxidation properties of the isolates. The bacteria were first tested for their ability to ferment lactose, since bacteria commonly found in water, such as E.coli, are lactose fermenters. The inoculated MacConkey agar plates displayed smooth, round, pink colonies which denoted lactose fermentation. All the results were confirmed using Enterotube Multitest System. Based on the series of biochemical tests performed, the resulting physiological characteristics were matched to the isolated enterobacteria (table 1).

Bacterial counts obtained by the undergraduates conducting this project are comparable to bacterial counts obtained by the MWRD after weekly testing of effluent wastewater released from both its O'Brien Water Reclamation Plant and Calumet Water Reclamation Plant between 2005 and 2010 (MWRD 2011). The bacterial count obtained from Site 3 had a higher count than the highest recorded at the Calumet Water Reclamation Plant (120,000 CFUs /100 mL), yet lower than the highest count recorded at the O'Brien Water Reclamation Plant (200,000 CFUs /100 mL) (MWRD 2011). Site 5, where the lowest number of CFUs were recorded by undergraduates, had a count above the minimum CFUs reported at

FIGURE 2. *Pseudomonas aeruginosa* Photo selected as "Picture of the Day" for the American Society for Microbiology website (www.asm.org) September 30, 2014

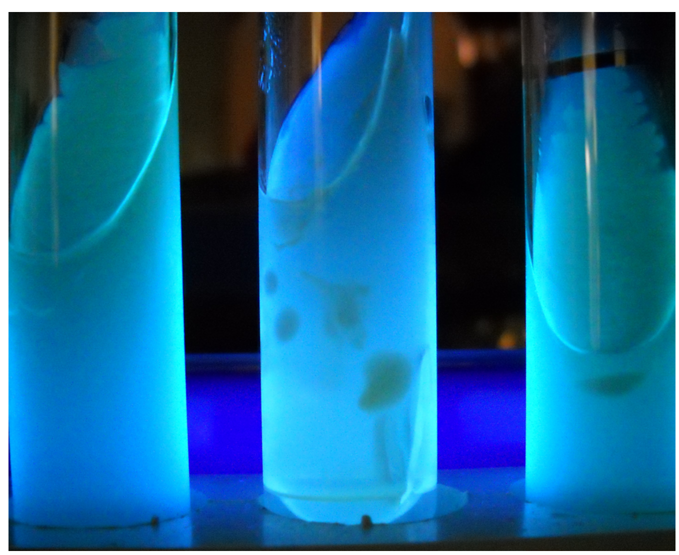


TABLE 1. Results of the water samples collected along the Chicago River.

Water Samples	Location	CFU on MacConkey Agar Plate	Bacterial Identification
Site 1	Goose Island East Side	84,000 /100 mL	***Escherichia coli***
Site 2	Goose Island Northwest Side	21,500 /100 mL	***Enterobacter agglomerans; Escherichia coli***
Site 3	Goose Island West Side	144,300 /100 mL	***Enterobacter gergoviae; Enterobacter agglomerans; Serratia odorifera***
Site 4	Wolf Point	62,000 /100 mL	***Escherichia coli***
Site 5	Locks (near Lake)	6,000 /100 mL	***Enterobacter sp.***
Site 6	Wabash Street Bridge	No CFU Count performed	***Pseudomonas aeruginosa***

the O'Brien Water Reclamation Plant (660 CFUs /100 mL) (MWRD 2011). All sites where students obtained samples are located approximately eight to ten miles downstream from the O'Brien Water Reclamation Plant.

While a total of six sites were randomly selected for this investigation, no specific reports have been found regarding these sites. The implication of the findings is that there is urgent need to make the river safe as a recreational place for Chicago residents.

Discussion

As evidenced by the results, this research focuses on what students can and do achieve when given the opportunity to learn through PBL and undergraduate research. It also demonstrates the ability of undergraduate students at the community college level to give back to society. The central point is the impact of the learning that resulted from this type of civic engagement conducted by undergraduates, including what they could contribute to help the community in making informed decisions related to safety and the quality of the river. This project was part of an interdisciplinary course in which faculty and students at Harold Washington College pursued work on various aspects of the Chicago River. The Chicago Waterways Project, as conducted, provided students with the opportunity to discover by themselves what civic engagement and community service are all about.

The evaluation of students' feedback revealed that appreciation for the project's role in highlighting the significance of the Chicago River and appreciation for being part of something special were the major themes identified. Serving and giving back to the community was another key topic they mentioned. The average retention rate at HWC is 67 percent, in this course a retention rate of 88 percent was achieved. Upon assessment of the members of the microbiology section within this interdisciplinary class, 100 percent of the participants had either successfully transferred as a science major to a four-year institution or had been accepted in professional career programs. The success of this small model has tremendously encouraged us to use PBL with a civic engagement purpose in larger-scale future classes.

As part of this interdisciplinary research project at HWC, the result of this study was presented as a poster that was visited by members from the seven City Colleges of Chicago and the general public. The result was also presented orally to the attendees at the national conferences of the American Association of University Administrators (AAUA) and the Association of American Colleges and Universities (AACU) (Martyn and Movahedzadeh 2014; Martyn et al. 2013).

Given that the EPA aims to make the Chicago River an area designated for primary contact recreational use by 2016, the research project described in this paper had a significant purpose: to enable students from a microbiology research course with a PBL emphasis to develop and complete a project that investigated the contamination of the Chicago River. Through this process, the students were inspired and empowered, recognizing that they had an important role to play both in contributing to the collective body of research focused on the Chicago River's ecosystem and in increasing citizens' awareness of existent public health concerns. The outcome of this research brought valuable results to the populace and invaluable skills to the students, enabling them to demonstrate the intrinsic value of civic engagement.

The water samples collected revealed the presence of enterobacteria in the Chicago River. These bacteria are coliform bacteria, indicating that fecal contamination is likely. Contamination in the water could be due to the fact that currently only three out of seven of Chicago's water reclamation plants disinfect their wastewater before pumping the effluent back out into the area waterways. Furthermore, it is worth noting that none of these three disinfecting plants sit adjacent to the Chicago River or serve the City of Chicago directly; thus these plants' contribution of clean water to the river is not as significant as that of the contaminated sources. The Chicago River is a resource widely used for recreation by local residents and guests visiting Chicago. It is troubling to discover and report such a high number of CFUs. To add some perspective, consider standards applied along the shore of Lake Michigan, another source of recreational water use in Chicago. The Illinois Department of Public Health's regulations contain a maximum standard for fecal coliform bacteria at 500 CFUs /100 mL at area beaches (Illinois Department of Public Health 2015). It is imperative to pay attention to the state of the river's water quality, as new development along the beautified pedestrian walkways attract residents and tourists alike.

Through this research project, students acquired and improved upon skills currently employed in the microbial research/clinical setting. Nevertheless, the skills learned in this project go beyond the mastery of technical skills and practices in the laboratory. This project provided students a chance to further develop skills that will be useful in their future professions and daily lives, such as responsibility, critical thinking, self-motivation, collaboration, and communication. The concepts presented in the classroom and applied in the field fostered a more profound understanding and a greater appreciation of the biological sciences and how they can be applied directly to help address real world issues.

This research project revealed the significant role that technology plays in our society when utilized to address critical problems such as water contamination. It also attests to the importance and the value of civic engagement in college education. Students participating in this PBL course developed a profound personal attachment to effecting positive change in both the environment and their communities. A similar example can be found in a PBL based calculus II course at Roosevelt University, where semester-long projects have been incorporated into the course curriculum. The project topics vary from HIV/AIDs to wealth distribution, and include the mathematical topics being taught in the course. These projects have allowed the students to "understand the quantitative aspects of civic issues using models that rely on calculus for their construction" (González-Arévalo and Pivarski 2013). In addition, students gained an enhanced appreciation of mathematics and its applications in other fields (González-Arévalo and Pivarski 2013). PBL enables students to increase their knowledge while challenging them to think critically and teaching them to design and direct a project of their own. This work unifies the students' initiative to direct their own learning and to accept responsibility for their education. At HWC, PBL had previously been successfully integrated in a biotechnology lab course where students demonstrated a high level of performance and satisfaction (Movahedzadeh et al. 2012). Moreover, students indicated that this experience supported their cognitive development and self-confidence and stimulated the idea of continuing their education beyond the associate degree level (Movahedzadeh et al. 2012). With minimal funding and support, students can be enriched with hands-on knowledge that breaks the traditional forms of teaching. PBL could be used as an effective vehicle guiding students to civic engagement while obtaining the skills needed to succeed in their higher learning and in their future professions through an active connection with their environment.

Interesting results were found testing the water of the Chicago River. Coliforms like *E. coli*, *Pseudomonas aeruginosa*, and the opportunistic pathogens *Enterobacter agglomerans* and *Serratia odorifera* were isolated. Students found it imperative to instruct river enthusiasts and the broader community at large of the existence of coliforms and ways to reduce the risk of infection due to exposure from opportunistic pathogens. Simple precautions recommended to avoid water-borne illness when swimming or playing in or on the water include proper hand washing, showering before and after water exposure, refraining from recreational activities in water that is stagnant with dead fish, refraining from digging in or stirring up the sediment while taking part in water-related activities in shallow and warm freshwater areas, and promptly tending to any wounds, cuts, or abrasions suffered in or near the water (North Carolina Department of Health and Human Services 2011).

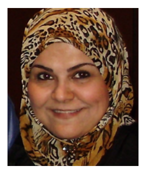
The Chicago River has received bad press due to the polluted status of its ecosystem. These findings reveal the importance of seeking solutions to improve the water quality of the Chicago River. This is vital, especially since recreational activities are on the rise along the Chicago River. The solution could be disinfecting the wastewater from all seven reclamation plants before pumping the effluent back into the waterway system. We propose that there should be a collaborative effort that includes students from the City Colleges of Chicago. Instead of wasting materials on lab exercises divorced from real-world applications, students would prefer to assist in efforts aimed at continually improving and monitoring the standards of our communal waterway, having already demonstrated their willingness and competence to do so. Our laboratories are capable of contributing to the success of these efforts.

The primary goal of this research project was to engage students in the learning process and to create an educational environment where meaningful learning was not only possible, but would actually occur. Students explored conceptual meanings and implications throughout the learning processes contained in this PBL course. Furthermore, students gained vital experience by participating in the Chicago Waterways Project, where they applied what had been previously learned exclusively in the didactic classroom. This learning experience was further enriched when students tackled the problem of contamination in the Chicago River, an issue that must be addressed due to its potential to affect public health. It is hoped that this research will motivate students and the public to take action in the restoration of the river. Involving college students in research projects such as these reveals to them the impact they can have on society and how important their participation is in addressing these issues. PBL demonstrates to students that the scholastic subjects they may deem uninteresting or useless play an integral role in addressing the problems of society, in this case, the quality of the Chicago River. With encouragement and minimal financial resources students can gain a world of knowledge beyond the classroom and thrive by applying that knowledge to engage the issues in the world around them.

Acknowledgements

Research reported in this paper was supported by *The City Colleges of Chicago Annual Plan* funding under award number 12-450.

About the Authors



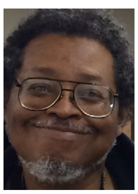
Farah Movahedzadeh, Ph.D., is an associate professor and currently the co-Chair of the Department of Biological Sciences at Harold Washington College in Chicago, Illinois (fmovahedzadeh@ccc.edu). She received a doctorate degree in Clinical Lab Sciences from Medical Sciences University of Iran, and a Ph.D. in Molecular Biology and Microbiology from the University College of London (UCL) and the National Institute for Medical Research (NIMR). She was elected as a SENCER Leadership Fellow in 2012. Her skills and areas of expertise include molecular biology, microbiology, clinical lab sciences, hybrid/blended teaching, and project-based learning. She also actively pursues her research on essential genes as drug targets for tuberculosis at the College of Pharmacy in the University of Illinois at Chicago. She has published research articles in both basic science and in pedagogy and scholarship of teaching.

Margie Martyn, Ph.D., is the Interim President at Harold Washington College, one of the City Colleges of Chicago. Previously, Dr. Martyn served as Vice President of Academic Affairs for Harold Washington College. She earned a B.S. from Michigan State University, an MBA from Baldwin-Wallace College, and a Ph.D. in Instructional Technology with a minor in Computer Science from The University of Akron. Dr. Martyn has experience as a faculty member, teaching both graduate and undergraduate courses in adult learning, computer literacy, mathematics literacy, liberal arts and sciences, management, telecommunications, and networking. She has published articles on the impact of technology on student learning outcomes and engagement.

Adrienne Linzemann is currently enrolled in the associate degree nursing program at Truman College in Chicago, Illinois (alinzemann@student.ccc.edu). She intends to continue her nursing education after graduation. Her interests include microbiology, health promotion, and travel.

Elsa Quintero received her Bachelor of Science in Biology from the University of Illinois at Chicago in 2012. She is currently pursuing a bachelor's degree in Medical Laboratory Science at Rush University.

Jose Aveja continued his education at Northeastern University in Chicago, Illinois. He is an avid photographer drawn to ornithology.



William Thompson is a senior lab technician in the Department of Biological Sciences at Harold Washington College in Chicago, Illinois (wthompson@ccc.edu). This year he begins his 35th year of service with the City Colleges of Chicago. He is passionate about biology, microbiology, and clinical lab sciences.

References

AACC, American Association of Community Colleges. 2010. Fact Sheet. http://www.aacc.nche.edu/AboutCC/Documents/Archive/factsheet2010.pdf (accessed January 24, 2015).

Brickman, P., C. Gormally, N. Armstrong, and B. Hallar. 2009. "Effects of Inquiry-based Learning on Students' Science Literacy Skills and Confidence." International Journal for the Scholarship of Teaching and Learning 3 (2): 1–22.

Brown, J.L. (2002). Reversal of the Chicago River, Civil Engineering, no. 72: 110-111. Retrieved from: Academic Search Complete, EBSCOhost

Chang, C., W. Chen, S. Lou, and K. Tseng. 2011. "Attitudes towards Science, Technology, Engineering and Mathematics (STEM) in a Project-based Learning (PBL) Environment." International Journal of Technology and Design Education 23: 81–102.

Cherif, A., G. Adams, F. Movahedzadeh, M. Martyn, and J. Dunning. 2014. "Why Do Students Fail? Faculty's Perspective." Collection of Papers from the Annual Conference published by the Higher Learning Commission. http://cop.hlcommission.org/Learning-Environments/cherif.html (accessed January 24, 2015).

Cherif, A., F. Movahedzadeh, G. Adams, and J. Dunning. 2013 "Why Do Students Fail?" Higher Learning Commission: A Collection of Papers on Self-Study and Institutional Improvement 29: 35–51.

Doles, K. 2012. "What is Project-Based Learning?" Frontline. PBS. July 17, 2012. Television. http://www.pbs.org/wgbh/pages/frontline/education/fast-times-at-west-philly-high/what-is-project-based-learning/ (accessed January 24, 2015).

Eiseley, L. 1959. The Immense Journey. New York: Vintage Books.

Environmental Protection Agency (2011). Summary of EPA's Actions on Illinois' New and Revised Water Quality Standards for the CAWS and LDPR. (2011). http://www.epa.gov/region5/chicagoriver/pdfs/caws-summary-20120510.pdf

González-Arévalo, B., & Pivarski, M. (2013). The Real-World Connection: Incorporating Semester-Long Projects into Calculus II. Science Education and Civic Engagement 5:1: 17-24. http://seceij.net/seceij/winter13/real_world_conn.html

Hill, L. 2000. The Chicago River: A Natural and Unnatural History. Chicago: Claremont Press.

Illinois Department of Public Health. 2015. Bathing Beaches. http://www.dph.illinois.gov/topics-services/environmental-health-protection/recreation/bathing-beaches (accessed January 24, 2015).

Martyn, M., and F. Movahedzadeh. 2014. "Undergraduate Research: The Final Frontier." Paper presented at the conference of the American Association of University Administrators (AAUA). Washington, DC: April 25–26. http://www.aaua.org/seminar-program-details.htm (accessed January 24, 2015).

Martyn, M., F. Movahedzadeh, and S. Burke. 2013. Chicago Waterways: STEM to STEAM. Paper presented at Transforming STEM Education: Innovation, Inquiry, and Evidence, conference of the American Association of Colleges and Universities: San Diego, October 31–November 2. http://www.aacu.org/events/chicago-waterways-stem-steam (accessed January 24, 2015).

Movahedzadeh, F., R. Patwell, J.E. Rieker, and T. Gonzalez. 2012. "Project-Based Learning to Promote Effective Learning in Biotechnology Courses." Education Research International. Article ID 536024.

MWRD, Metropolitan Water Reclamation District of Greater Chicago. Disinfection Task Force. 2011. Evaluation of Disinfection Technologies for the Calumet and North Side Water Reclamation Plants: Technical Memorandum 2, 4–17.

North Carolina Department of Health and Human Services. 2011. Avoiding Recreational Water Illnesses. http://epi.publichealth.nc.gov/cd/water/prevent.html (accessed January 24, 2015).

Oh, G. 2012. "Coming Clean: Swimmable Chicago River To Become Reality." Medill Reports, Northwestern University.

The State of College & Career Readiness: Part 1. Infographic. 2013. http://www.pearsonlearningsolutions.com/blog/wp-content/uploads/2013/05/college-readiness-infographic3.pdf (accessed January 24, 2015).

Webb, Jeffrey A. 2013. "Integrating SENCER into a Large Lecture General Education Chemistry Course." Science Education and Civic Engagement 5 (2).

PROJECT REPORT

The Northern Forest Canoe Trail Course

Robert Sanford
University of Southern Maine

Joseph Staples
University of Southern Maine

It is commonly assumed that "distance learning," or education that is asynchronous and non-residential, involves a substitution of the on-line version of traditional pedagogies—lectures, assignments, discussions, etc.—for live, in-class experiences, often at the cost of student engagement in the social and experiential aspects of learning. However, new technology can also allow faculty to design independent, unscripted, and embodied learning experiences that deepen students' engagement with their own learning. The innovative course described below used simple and widely available technological tools to empower students to become self-directed learners while contributing to the body of public knowledge about an important environmental resource.

The Northern Forest Canoe course is a freshman general education ("core") course developed by an interdisciplinary team of three faculty (Joseph Staples, chemical ecology; Robert Sanford, environmental planning; and Elizabeth Vella, psychology) at the University of Southern Maine (USM) to provide an experiential, non-residency learning experience. This course was designated an "entry year experience" (EYE) that reflects the principles of Science Education for New Civic Engagements and Responsibilities (SENCER). We wanted to create a course that would provide learners with basic competency in environmental science field skills (GPS, compass, dichotomous keys, transects, shoreline field assessment, tree and aquatic plant identification, use of canoes and field equipment for water quality sampling) through an immersion experience that connected students to a natural community and would foster a sense of stewardship.

We developed this as a "distance learning" course rather than as a true online course, because the learning occurs at a distance, through field work, and is the result of the student's own activities and reflections—there are no online lectures or formal sessions. Instead, the course is an asynchronous learning experience that takes place at the convenience of the student during a designated portion of the summer. However, the possibility remains of offering future versions as a synchronous "expeditionary" course led by an instructor.

The location of the course (fig. 1) is the Northern Forest Canoe Trail, 740 miles (1,190 km) of marked canoeing trail extending from Old Forge, New York to Fort Kent, Maine. The specific sections of the trail to be investigated are selected by the individual student. There is no fixed distance a participant must travel, but the student must spend at least 10 days in which five or more hours per day are spent on the waters of the trail.

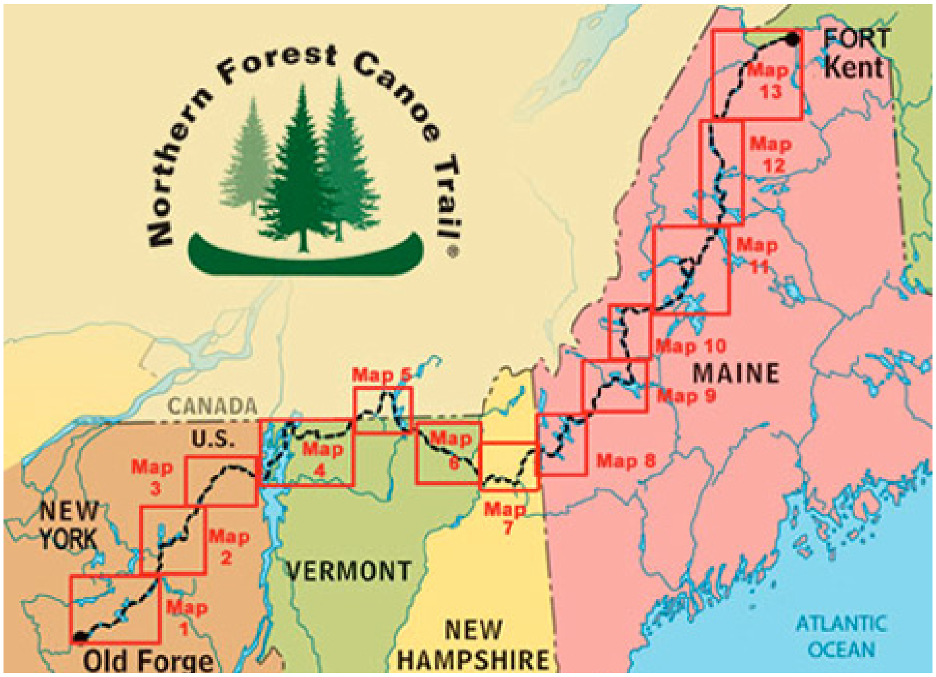


FIGURE 1. The 740-mile (1,190-km) Northern Forest Canoe Trail runs from Old Forge, New York to Fort Kent, Maine. Students are free to select any use any portion of it or its related tributaries and watersheds. (Map by Northern Forest Canoe Trail, http://www.northernforestcanoetrail.org/).

Target populations for the course include military veterans returning to school and desiring a gradual entry through a contemplative nature experience, other non-traditional learners, and freshmen who want to get a head start on their college educational experience before the academic year commences. The authors of this paper, as veterans themselves, particularly sought the opportunity to reach out to veterans. Psychology Professor Elizabeth Vella's research focuses on the benefits of outdoor experiences for combat veterans, and a number of the reading assignments address the therapeutic aspects of outdoor recreation.

This course is designed to credentialize a self-guided outdoor learning experience mentored by university professors with interdisciplinary and multidisciplinary expertise. Participants undergo the equivalent of ten or more days (which need not be consecutive) of canoe or kayak trips along portions of the Northern Forest Canoe Trail. Since the goal is experiential, it is not important how much of the trail is covered, nor that the travel be completed all at once. Instead, participants set their own schedule, provide periodic online check-ins, and submit assignments designed to foster an experience that is contemplative and that builds independent learning skills. The course provides an introduction to environmental data gathering and assessment, to aspects of environmental management, and to critical thinking about personal, social, and ecological implications of the Northern Forest Canoe Trail. Students are assumed to have a knowledge of basic water safety, canoeing/kayaking ability, orienteering and map reading skills, and camping/cooking or other logistical support skills. The course is a self-guided experience; students are expected to rely upon their own abilities and to undertake only those trips that are safe and attainable within their skill set and equipment capabilities. Students are free to take along partners, friends, and family members.

This course is suitable for anyone seeking to explore the environment or learn about environmental science. It is also suitable for anyone who wants a self-paced entry to a college-level experience. The course fulfils the Entry Year Experience core education requirement for USM. Accordingly the course meshes with the core EYE goals, as specified on the syllabus.

This non-traditional approach constituted an act of faith between the developers and the summer program staff. The supervising program director stated: "I am pleased to have supported the innovative Northern Canoe Trail course as a pilot this summer, even with a small enrollment. If summer is not the time to incubate cool, experimental ideas that have the potential to reach students differently then I don't know when is! I hope this course will continue to gain momentum while inspiring students and faculty alike."[1] In furtherance of this goal, USM Online's Center for Technology Enhanced Learning (CTEL) provided a $2,000 development grant for the course. USM Reference Librarian Zip Kellog, author of several canoeing publications, provided input into the course development, as did the Veteran Certifying Officer, Laurie Spaulding; Susan McWilliams, Associate Provost for Undergraduate Education; and other staff at the university.

1 Karin D. Pires, Associate Director, Academic Programs, Professional & Continuing Education (PCE), University of Southern Maine, personal communication.

This course and USM's Entry Year Experience (EYE) goals:

1. Employ a variety of perspectives to explore the interrelationship between human culture and the natural world of the Northern Forest Canoe Trail.
2. Pose and explore questions in areas that are new and challenging: as a part of the river experience students will develop questions about the stewardship of this resource. Students may draw from conservation biology and ecology, geology, environmental history, environmental literature, economics, other social and physical sciences, and the fine arts.
3. The online posting requirements of this course give students opportunity to immediately respond to their experiences and to receive feedback from a mentor (one or more instructors).
4. Reflect upon and link learning in the course with other learning experiences (for example co-curricular experience). This course is co-curricular by its very nature. Students will provide formative assessments via their online postings/uplinks. The self-assessment piece at the end is a final summative.
5. Recognize that an individual's viewpoint is shaped by his or her experiences and by historical and cultural context. The student will evaluate his/her views and perspectives on the NFCT.

Course objectives

6. Complete a total of 10 or more days of canoe/kayak experience on the waters of the NFCT. These days need not be consecutive and can be selected at the convenience of the student within the timeframe of the course
7. Employ environmental science field skills (notably, GPS, compass, dichotomous keys, transects, shoreline assessment, tree and aquatic plant identification, use of canoes and field equipment for water quality and other environmental sampling) to gather data and document river travel.
8. Participate in a Google+ virtual community of paddlers.
9. Record reactions to an immersive, contemplative experience in rural or even wilderness riparian settings with the intention of deepening one's connection to a natural community and fostering a sense of stewardship.
10. Be able to describe the interdisciplinary nature of independent learning and self-assessment as part of a college-readiness experience.

The course uses a variety of assignments in a low stakes writing approach. Low stakes writing—"writing to learn"—is central to the achievement and assessment of learning outcomes. It is low stakes because there are no right or wrong answers and there are frequent assignments. Low stakes writing for this course includes a journal and separate responses to experience posted in the discussion section of Blackboard. The questions and writing prompts are drawn from Bloom's taxonomy of educational objectives and are keyed to the assigned texts, conditions of the environment, and the experiential nature of the course as a self-guided river corridor transit.

The course establishes an online community in which students share their work and their reflections and in which stakeholders can participate. The civic engagement aspects of this course include a "client" partner, the Northern Forest Canoe Trail (NFCT) non-profit organization. NFCT provided input into the development of the course, including requests for specific projects to be accomplished by the participants. One member of the NFCT Board of Directors responded: "We are delighted that Professor Sanford and his colleagues at USM have developed this innovative

FIGURE 2. Environmental Science major Amy Webb and her dog camping out along the Northern Forest Canoe Trail. Photo courtesy of Amy Webb.

course for experiential learning along the Northern Forest Canoe Trail. Students learn and earn credits toward a degree while enjoying a potentially life-changing experience, and their notes and observations provide NFCT additional information about trail conditions and usage."[2]

Although the numbers were small (six) for the trial run of this course, the participants seemed to benefit. One student (fig. 2) stated, "I really enjoyed the fully immersed, completely independent environmental experience that the Northern Forest Canoe Trail Course offered. While taking this class I was able to complete a full time internship, receive course credits, take my family along and teach them a thing or two about the environment!"

Basic technological literacy and equipment were required for students enrolling in this course, including a digital camera, GPS, and computer, iPad, or iPhone for online connection to the campus Blackboard[3] system for announcements, assignments, grades, discussions and other support activities. A Google account was required for participation in the Google+ virtual community. Links are provided to the various course documents.

About the Authors

Robert M. Sanford chairs the Department of Environmental Science & Policy at the University of Southern Maine, in Gorham, Maine. He is a SENCER Fellow and a co-director of the SENCER New England SCI.

Joseph K. Staples (PhD.) conducts research in the areas of forest ecology, environmental entomology & physiology, and integrated pest management in the Department of Environmental Science & Policy at the University of Southern Maine. He is a graduate of the Scholar Educator Program at Illinois State University and has taught more than thirty different courses in biology, ecology, and environmental science.

2 Will Plumley, NFCT Board of Directors, personal communication.

3 This description of the course assumes the use of Blackboard Learning System for course delivery. And Blackboard will be used to maintain an on-line confidential grade book. However, the final version of the course may use Google Community or other format as per the final syllabus.

EYE 199 Northern Forest Canoe Trail

Summer 2014 3 credits DRAFT proposed syllabus 3/25/2014

Instructors:
Dr. Robert Sanford, Department of Environmental Science;
Dr. Elizabeth Vella, Department of Psychology; Dr. Joseph Staples, Department of Environmental Science.

Class Times: This is an experiential learning course undertaken at the convenience of the student during Summer Session II (June 30–August 15). Each student is required to spend 10 or more days on or along the waters of the Northern Forest Canoe Trail. These days do not have to be completed all at once; choose the days you want—whatever fits your schedule—as long as ten of them occur within the prescribed Summer Session time period.

Location: Off-campus at various sections of the Northern Forest Canoe Trail selected by the participant. 740 miles (1,190 km) of marked canoeing trail extend from Old Forge, New York to Fort Kent, Maine. There is no fixed distance a participant must travel, but the student must spend at least 10 days in which five or more hours per day are spent on the waters of the trail.

Texts and Resources recommended/required:

1. A personal NFCT narrative, such as Brakeley, Sam. 2012. *The Northern Forest Canoe Trail: A Journey Through New England History*. You can get a copy from the Northern Forest Canoe Trail web site http://www.northernforestcanoetrail.org/ (only $10-$11). You can also use a different book or narrative.

2. The official NFCT trail guide, Thompson, John et al. 2010. *The Northern Forest Canoe Trail: Paddle and Enjoy the 740-Mile Water Trail Across New York, Vermont, Québec, New Hampshire, and Maine*. The NFCT Official Guidebook. The Mountaineers Books. http://www.northernforestcanoetrail.org/ The Mountaineers Books publishes trail maps for various sections of the NFCT—select the ones for where you plan to travel.

3. Invasive aquatic plant species guide, such as Hill, Roberta and Scott Williams. 2007. *Maine Field Guide to Invasive Aquatic Plants and Their Common Native Look Alikes*. Maine Center for Invasive Aquatic Plants, Maine Volunteer Lake Monitoring Program. This is a nice spiral-bound, affordable book with good pictures. Feel free to use online sources or select an aquatic plants guide more suited to the region you will be paddling in.

4. A tree book that has a key for identifying trees in the northeast. Choose your own. *Forest Trees of Maine,* 2008 centennial edition, Maine Forest Service, has a simple winter key and summer key. This terrific spiral-bound book has color photographs and diagnostic features.

5. Environmental education: Orion. 2013. *Leave No Child Inside: A Selection of Essays from Orion Magazine*. The Orion Society, Great Barrington, MA.

6. Thoreau on rivers: Thoreau, Henry David. 1848. *A Week on the Concord and Merrimack Rivers.* You can purchase this from various sources but you do not have to buy it—you can read it online or download it for free (http://www.gutenberg.org/ebooks/4232)

7. Outdoor experiences and psychological/personal benefits. Read at least one of the following articles posted on Blackboard and use for Assignment 5 (Restorative Powers)

- Berman, M.G. et al. 2008. The cognitive benefits of interacting with nature.
- Dustin, D. et al. 2011. The promise of river running as a therapeutic medium for veterans coping with post-traumatic stress disorder.
- Garg, R. et al. 2010. Perceived psychosocial benefits associated with perceived restorative potential of wilderness river-rafting trips.
- Kleiber, D.A. et al. 2002. Leisure as a resource in transcending negative life events: Self-protection, self-restoration and personal transformation.

8. Journal: It is good to have a physical notebook even if you also use a digital one or laptop. Rite in the Rain all-weather environmental field books work well (there are various versions of this—get the one you like), and there are other manufacturers. Bring rain-proof writing utensils.

9. Other resources and field guides: rocks, trees, birds, insects, etc. *National Audubon Society Regional Guide to New England* (National Audubon Society Regional Field Guides). Turtleback.

10. Northern Forest Canoe Trail (non-profit organization): In addition to maps, gear and other resources, the online bookstore contains a number of guides to the trail, including Sam Brakeley's book. http://www.northernforestcanoetrail.org/

11. Suggested reference and writing guide:
Hacker, Diana (various years and editions), *A Writer's Reference*, Boston: Bedford/St. Martin's; or Hacker, Diana and Nancy Sommers, A Pocket Style Manual, Boston: Bedford/St. Martin's.

Required technology: Digital camera, GPS, and computer, IPad, or IPhone for online connection to the Blackboard[1] system established for this course. This course uses Blackboard for announcements, assignments, grades, discussions, and other support activities. All students enrolled in courses at USM receive an email address that enables access to Blackboard. Please contact the Computer Center for information on access and use of Blackboard. The following link presents a quick guide for students new to Blackboard: http://www.learn.maine.edu/crs/bb5_guide.html

1 This proposed syllabus assumes the use of Blackboard Learning System for course delivery. And Blackboard will be used to maintain an online confidential grade book. However, the final version of the course may use Google Community or other format as per the final syllabus.

Introduction:

This course is designed to credentialize a self-guided outdoor learning experience mentored by university professors with interdisciplinary and multidisciplinary expertise. Participants undergo the equivalent of ten or more days (which need not be consecutive) of canoe or kayak trips along portions of the Northern Forest Canoe Trail. Since the goal is experiential, it is not important how much of the trail is covered, nor that the travel be completed all at once. Instead, participants set their own schedule, provide periodic online check-ins, and submit assignments designed to foster an experience that is contemplative and that builds independent learning skills. The course provides an introduction to environmental data gathering and assessment, aspects of environmental management, and critical thinking about personal, social, and ecological implications of the Northern Forest Canoe Trail. Students are assumed to have basic water safety, canoeing/kayaking ability, orienteering and map reading skills, and camping/cooking or other logistical support skills. Since this is a self-guided experience, students are expected to rely upon their own abilities and to undertake only those trips that are safe and attainable within their skill set and equipment capabilities. Students are free to take along partners, friends, and family members.

This course is suitable for anyone seeking to explore the environment or learn about environmental science. It is also suitable for anyone who wants a self-paced entry to a college-level experience. The course fulfils the Entry Year Experience core education requirement for USM.

This course and USM's Entry Year Experience (EYE) goals:

- Employ a variety of perspectives to explore the interrelationship between human culture and the natural world of the Northern Forest Canoe Trail.
- Pose and explore questions in areas that are new and challenging. As a part of the river experience, students will develop questions about the stewardship of this resource. They may draw from conservation biology and ecology, geology, environmental history, environmental literature, economics, other social and physical sciences, and the fine arts.
- The online posting requirements of this course give the student opportunity to immediately respond to his/her experiences and to receive feedback from a mentor (one or more instructors).
- Reflect upon and link learning in the course with other learning experiences (for example co-curricular experience). This course is co-curricular by its very nature. Students will provide formative assessments via their online postings/uplinks. The self-assessment piece at the end is a final summative.
- Recognize that an individual's viewpoint is shaped by his or her experience and historical and cultural context. The student will evaluate his/her views and perspectives on the NFCT.

Course objectives

- Complete a total of 10 or more days of canoe/kayak experience on the waters of the NFCT. These days need not be consecutive and can be selected at the convenience of the student within the timeframe of the course
- Employ environmental science field skills (notably GPS, compass, dichotomous keys, transects, shoreline assessment, tree and aquatic plant identification, use of canoes and field equipment for water quality and other environmental sampling) to gather data and document river travel.
- Participate in a virtual community of paddlers.
- Record reactions to an immersive, contemplative experience in rural or even wilderness riparian settings with the intention of deepening one's connection to a natural community and fostering a sense of stewardship.
- Be able to describe the interdisciplinary nature of independent learning and self-assessment as part of a college-readiness experience.

Evaluation

Evaluation will be through student assignments. Through low-stakes writing—"writing to learn"—we assess achievement of learning outcomes. It is "low stakes" because there are no right or wrong answers and there are multiple assignments. No one assignment is critical; they all add up. Assignments consist of individual task write-ups you do at your own pace, and a journal you maintain. The journal is your own record, but we will read it, review it, and if it is in physical form, we will return it to you after the course concludes. The journal can also be kept online as an assignment section in which only you and the instructors can see it. Thus, it is separate from anything you might post in the discussion section of Blackboard, although you can use it to develop ideas and observations that you might want to go on to post in the discussion section or for other assignments. The questions and writing prompts drawn from Bloom's taxonomy of educational objectives and are keyed to the assigned texts, conditions of the environment, and the experiential nature of the course as a self-guided river corridor transit.

When to do it	Assignment #	Description
Week 1	Assignment 1	Introduce self
Continuous	Assignment 2	Maintain personal journal
Continuous	Assignment 3	Travel log postings
By halfway point of course or trip	Assignment 4	Environmental education reaction
By halfway point of course or trip	Assignment 5	Restorative powers article
Your choice	Assignment 6	Tree identification
Your choice	Assignment 7	Shoreline erosion
Your choice	Assignment 8	Invasive water plant
Second half of course	Assignment 9	NFCT data contribution
Second half of course	Assignment 10	Thoreau report
Upon completion of final leg of canoe trip	Assignment 11	Hand-drawn explorer's map
Final week	Assignment 12	Self-assessment memo

Assignment 1: Personal introduction. During your first week of the course, use the discussion section of Blackboard to introduce yourself. You can try Screencast-O-Matic (it is free), photos, documents, drawings, or other ways to accompany a short narrative introduction. Post information about yourself that you do not mind sharing. For example: Do you work? Where are you from? Kids/siblings? Pets? Academic major or interests? Career and life goals? Preferred learning styles/formats? Things you like about the outdoors? What canoe/kayak do you use? The objective is to improve learning by establishing an online community, and for us to know a little more about you so we can do a better job as instructors.

Assignment 2: Maintain a journal for each day you are on the water (ten days) and for any additional days you spend working on the course. We are interested in understanding your perceptual experience as a student in this class. Please consider this journal a medium for your expression. Although you are being asked to write in this journal following each day on the Northern Forest Canoe Trail, please feel free to write in this journal on other occasions throughout the duration of your enrollment in this course, should you feel inspired to do so by other experiences/reflections of time spent outdoors. Please be sure to mark the date and time of each entry.

General Instructions: Following each day on the Northern Forest Canoe Trail, please take a moment to reflect upon your experience by writing in this journal. In particular, please reflect upon any personal insights that you may have experienced during your time outdoors, as well as the thoughts, feelings, and emotions that surfaced throughout the day.

First Entry Instructions: Please describe why you selected this course amid the other Entry Year Experience options and document three goals/expectations that you have for your overall experience as a student in this course. What emotions did you find yourself experiencing today? Please feel free to write about any other thoughts/concerns that may be on your mind.

Final Entry Instructions:Please take a moment and reflect on your experience as a student in this course. What events come to mind for you as shaping your overall experience? Revisit the three goals/expectations that you documented in your first entry, commenting on the degree to which each of these was realized, or if new goals/expectations emerged for you throughout your enrollment in the course. Please describe any experiences that you feel may impact your life in a meaningful way. Please feel free to write about any other thoughts/concerns that may be on your mind.

Assignment 3. Travel log postings. For every day you are on the water or camping/traveling as part of the course, post an entry into the discussion section of Blackboard about your experience. You can use your journal as the basis for this if you wish. If you do not have internet access for several days during your travels you can make up for this by posting multiple entries as soon as you are able. Your entries can include (or be in the form of) reactions to other people's postings as you deem appropriate.

Assignment 4. Environmental education reaction. Read one of the essays in the Orion book and critique it or react to it from the context of your NFCT experience. Five pages.

Assignment 5. Restorative powers article. Read one of the posted articles posted on Blackboard (Berman et al., Dusting et al., Garg, et al., and Kleiber et al.). Having been on the NFCT waters yourself by now, write a personal reaction to the article in which you assess the potential role of your trip as a "restorative powers experience." (Write 4-5 pages double-spaced, full reference citations. Illustrations/figures optional.)

Assignment 6. Tree Identification. Select a site with trees, take one or more digital photos of them, provide one set of GPS coordinates for the site, identify five different trees on it using a dichotomous ("two equal parts") key, tell whether the trees are native to the area, state what type of habitat the tree is commonly found in, and describe the condition of the tree (e.g., mature, healthy, damaged by insects). A dichotomous key has us compare a characteristic that can have only one of two outcomes, something that we can fairly easily decide. We continue with a pattern of yes/no decisions based on our answers that narrows down the species. If you happen to already know what the tree is, that is OK, but you still have to give a pathway through the key to identify it, showing that you know how to use the key. For example, suppose we have a tree that we think is a pine. Instead of just looking up pines and seeing which is closest, start at the beginning of the key. For example, a first question might be whether or not the tree has needles (actually, a type of leaf) or "regular" leaves—something that usually is fairly easy to decide. If our answer is yes to needles, then the key leads us to a second question, whether the needles occur individually or in bundles. If in bundles, are they in groups or three or not? If not in groups of three, are they in groups of five; if not in groups of five, are they in groups of two? If in groups of two, are the needles short or long (7 or more cm)? If yes, you have a red pine (Pinus resinosa) as the result of a series of characteristics that have gradually narrowed down the range of species. There are over a hundred species of pine, so constructing such a key has to be done with care, and it is best tailored for specific regions. Tree report should be 4-5 pages, with references.

Assignment 7. Shoreline erosion. Select a site where water craft can access the river (use a current access point or a potential one) and where you believe there are some erosion control issues. Fill out an erosion control checklist (use one of the forms on Blackboard), with photos to illustrate key issues. Assess the overall stability and the overall condition of existing erosion control measures. Accompany your form with a one-page summary narrative.

Assignment 8. Invasive water plant. For this assignment you will write a brief field report on one invasive water plant. Identify an invasive water plant you have encountered on/in the water during this course. Draw the plant by hand and digitally photograph it. Provide ecological background on the plant—guiding questions: where did it come from, how does it propagate, how invasive is it, what does it do to the ecosystem, what role do humans, other plants, animals play in its lifecycle? What management issues does it present for the waterway? What do you recommend? Submit as a 4-6 page report with figures and references.

Assignment 9. NFCT data contribution. Each student will select and do a project from the needs identified by the NFCT organization/staff. This may be environmental data collection, inventories, aspects of a management plan, an environmental lesson/education activity, or some other project we agree upon.

Assignment 10. Thoreau report. Henry David Thoreau spent a great deal of time on various rivers and ponds. He wrote about this in several books, especially *A Week on the Concord and Merrimack Rivers.* By now you yourself have spent some time on rivers of the Northern Forest Canoe Trail. Select several points or aspects of Thoreau's writings and respond to them from the context of your own experience. What might Thoreau notice if he were on the river with you? 4-6 pages.

Assignment 11. Annotated map of route. Provide a map that shows where you traveled for each day on the water. Remember, you are not expected to travel a specific distance—this is more about the experience you had while traveling. Please indicate what days, start and finish points, and other salient features for this geographic record of your experience. Choose appropriate scale, whether your distance was a few hundred yards or many miles. Provide at least one page of interpretive narrative/key information to accompany your map.

Assignment 12. Concluding self-assessment memorandum. Submit an assessment of your learning from four perspectives and in the context of the Sam Blakeley book *Paddling the Northern Forest Canoe Trail.* A couple of pages is sufficient.

- **a. descriptive** What did you do? Provide a literal description of your project.
- **b. analytical** Think about all the course materials. How did they fit into the course objectives, your own objectives, and your chosen field of study?
- **c. affective** How did you feel about the experience?
- **d. reflective** What did you learn from the experience, including the readings?

What to bring:

The list of recommended equipment depends on a variety of factors, including whether you will be camping trailside, how many people accompany you, how long you will be gone, the weather conditions, and what type of experience you intend. A sample list might include canoe or kayak, spare paddle, tarp, lifejacket, first aid kit, tent/hammock, sleeping bag, towels/washcloths/soap, personal toiletries, backpack for day use (or functional equivalent), GPS unit, wide-brimmed hat, sunscreen (at least SPF 25), bug spray, sunglasses, clothing for a variety of weather conditions (including rain), canteen/water bottle, field notebook and pencils, personal entertainment, sketchpad, camera/IPhone/iPad. Always have a pack that can sustain you if you get stranded overnight in questionable weather.

Online support:

This course has a Blackboard site for announcements, discussions, grades, and other course support activities. All students are expected to access this site and use it. All students receive a university email address that allows them into Blackboard for their courses. The following link presents a quick guide for students new to Blackboard: http://www.learn.maine.edu/crs/bb5_guide.html

Letter Grade Criteria:

We will sum up your performance as a percentage of 100.

A: Excellent. The student has clearly learned and obtained an excellent level of proficiency in critical thinking and in meeting the course objectives through the assignments. Aggregate 90–100% performance on evaluative instruments. Strong quality online participation. Quality writing, research, and analytical skills and superior documentation are evident.

A-: This is essentially a high B with an average of 87–89%.

B+: Good work, with an average of 85–86%.

B: Good work, 80 to 84% on evaluative instruments. Good writing, research, analytical skills. Work shows good development of ideas and thorough support of analyses. Student has a significant understanding of concepts and abilities reflected in the course objectives.

B-: Acceptable work, average of 77–79%.

C+: Acceptable work, average of 75–76%.

C: Acceptable or average, 70–74% on evaluative criteria. Acceptable college-level writing and analytical skills. Demonstrates reasonable organization and clarity. The student has demonstrated a basic understanding of the concepts and abilities identified in the course objectives.

C-: Marginal work, 68–69% aggregate average performance on exams and other evaluations, based on a scale of 1–100.

D: Marginal work, average of 6567%. Meets minimal requirements to pass the course. Only a few objectives met. Majority of assignments are not satisfactorily completed.

F: Below 65%.

Grading Weights

Assignments: 90%

Participation (interaction with instructor, Blackboard, others): 10%

Support for Students with Disabilities:

This course involves activities in an outdoor setting, including watercraft events. It is for adults who are expected to know their own abilities and to comport themselves safely. We are committed to providing course adaptations or accommodations as needed. Since we all learn in different ways, please do not hesitate to let us know your needs. We will do our best to accommodate you. If you need course adaptations because of a disability, please contact the Disabilities Services Center www.usm.maine.edu/dsc located in Luther Bonney 242, Portland Campus. Phone number 780-4706; TTY 7804395.

Blackboard Discussion Rubric

EXPECTATION	RESPONDS TO DISCUSSION PROMPT	COMMUNITY	PROFESSIONALISM
10	The participant contributes well-explained, thoroughly addressed, thoughtful, and reflective ideas that have substance/depth. Includes pertinent questions, and additional or referenced resources. Discussion Prompt posts refer to the readings and are used to support the writer's position. The entry stimulates and opens discussion. Entries include references to one's own experiences that support the topic.	The participant is central to the discussion. Posts are made across the discussion period (beginning, middle, end). Posts indicate "listening" to others' positions, ideas, and questions by responding reflectively and with substance. Contributes multiple interactions and responses that foster a sense of community. Participant has more responses of substance than those of short comment or praise.	Entries are free of misspellings and grammatical errors. Entries use "People First" language and maintain respectful language, tone, and content. Maintains confidentiality. Electronic "Netiquette" (*below) is consistently practiced.
7	The participant contributes moderately well explained ideas that have some substance/depth. May include questions and additional or referenced resources. Discussion Prompt posts do not refer to the readings—instead they copy or restate content verbatim. The entry results in some continued discussion.	The presence of the participant is noticeable. Posts are made consecutively. Posts indicate "listening" to others' positions, ideas and questions. Responses include items both of substance and of brief comment or praise.	Entries are mostly free of misspellings and grammatical errors. Entries use "People First" language and maintain respectful language, tone, and content. Maintains confidentiality. Electronic "Netiquette" (*below) is practiced.
4	The participant contributes poorly explained, weakly addressed ideas, which la ck substance/depth and reflection. Discussion Prompt posts do not refer to the reading/other comments at all. The entry does not stimulate discussion; lacks references to one's own experiences.	The presence of the participant is barely noticeable. All posts are made in one day thus leaving no time for reciprocal conversation and commenting. Posts do not "listen" to others and respond. Responses are mostly brief comments or praise statements and contain almost no posts of substance.	Entries have misspellings and grammatical errors. Entries do not use "People First" language and may include disrespectful or offensive language, tone or content. Adherence to electronic Netiquette (*below) is not consistently practiced.
0	No participation or insignificant participation	No participation or insignificant participation	No participation or insignificant participation

*Netiquette, or network etiquette, is the contemporary term for the proper way we communicate and interact with each other using email over the Internet. http://www.library.yale.edu/training/netiquette/

Appendix 2:

Pack List for Expeditions

Day	Wkend	Week	GEAR
1	3	4-7	under-garments
1	3	4-7	pair socks (wool/wool blend or poly – not cotton)
1	1-2	2	shorts (nylon, not denim)
1	2	2-3	t-shirts
1	1	3	long sleeve shirts
1	1	1	wool or fleece shirt
1	1	1-2	pair pants (not denim)
1	1	1	fleece pants (not cotton)
1	1	1	rain jacket (lightweight, waterproof, breathable recommended)
1	1	1	rain pants (lightweight, waterproof, breathable recommended)
1	1	1	Sandals or water shoes
1	1	1	visor or hat with a rim
1	1	1	sunglasses

Day	Wkend	Week	OPTIONAL GEAR
1	1	2-3	long underwear
1	1	1	bathing suit
1	1	1-2	bandana
1	1	1	pile or wool mittens
1	1	1	wool or pile hat
1	1	1	parka
0	1	1	sneakers
1	1	1	hiking boots
1	1	1	boot gaiters
1	1	1	extra shoe laces
1	1	1	pajamas

Day	Wkend	Week	FIRST AID KIT
3	5	10+	antiseptic wipes
3	5	10+	pain reliever
0	1	2	safety pins
1	1	1	3" wide elastic bandage
1	1	1	box Band-Aids
2	3	5+	4" gauze pads
1	1	1	3" roll gauze
1	1	1	blister care kit (moleskin, mole foam)
1	1	1	1" wide waterproof first aid tape
1	1	3+	bottle tincture or benzoin
1	1	3+	rubber gloves
1	1	1	tweezers (may be attached to a knife) suited to remove ticks

Day	Wkend	Week	OPTIONAL FIRST AID.
1	1	1	allergy medicine / bee sting kit (Benadryl, epi-pen)
1	1	1	prescriptions (as needed)
1	1	1	CPR mask
1	1	1	Emergency blanket
1	1	1	electrolyte replacement powder (Gator-aid)
0	1	1	sewing kit (thread, needle, buttons, patch)
1	1	1	emergency snack food (protein bar)