Using School of Ice Laboratory Tools for Undergraduate Climate Change Education

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* (MSI-ReACH Diversity Project - AMS Workshop 2013, Washington D.C., School of Ice Workshop and U.S. IDPO - 2015, Denver, Colorado and IODP Ocean Sediment Workshop 2016, College Park, TX)

* Delaware State University Climatology (NTRS 303-01)

* Fall 2014 # of Students = 12
* Fall 2015 # of Students = 11
* Fall 2016 # of Student = 9

* Taught by Rose Ozbay, Laurieann Phalen (TA)
Lab-centered teaching is an integral part of the Climatology course taught at Delaware State University (DSU), which uses course materials developed by the American Meteorological Society (AMS) Education Program.

* Laboratory activities become the centerpiece of the students’ learning - allowing them to make real-world connections to material acquired during lecture, and implementing the concepts and skills learned through hands-on discovery.

* Investigating the thermal expansion of water.
Goals - Two lab hands-on activities focusing on ice cores, and one activity focusing on ice and sea level rise adapted from the AMS Diversity Project and School of Ice Workshop were taught to 12, 8, and 9 students in the Climatology course in the fall of 2014, 2015, and 2016, respectively.

The sea level rise activity will be used with the 16 students in the Introduction to Environmental Science course during the Spring 2017 semester.

Target audience includes students from both environmental sciences, natural resources and agricultural majors and other non-majors.
Student Learning Outcomes

- Making scientific observation
- Improving critical thinking skills
- Formulating research questions
- Having hypothesis
- Analyzing data
- Interpreting graphs
- Using claim evidence reasoning technique to discuss data
- Draw conclusion
- Provide Big Picture (Broader Impact)
* This was the first lab activity in the Climatology class and was done after an introductory overview of Climate Change - cause & effects. This lab contained elements of the lab “Flooded! An Investigation of Sea-Level Rise in a Changing Climate”, and was adapted from Part 2 - Sea Level: On the Rise - EPA.

* Students explored the relationship between climate change and sea-level rise, and performed an experiment to learn that melting land-based ice contributes to greater sea-level rise than melting sea ice.
As an independent research extension activity students completed page 2 of the Climate Change Inquiry Lab; Melting Sea Ice and Sea Level Rise.

(http://pmm.nasa.gov/education/sites/default/files/lesson_plan_files/climate%20change%20inquiry/climate%20change%20inquiry%20sea%20level%20lab.pdf)
A hands-on activity was done with the students during the face-to-face session on density, temperature, salinity, and convection currents in order to facilitate a better understanding of The Great Ocean Conveyor, World Climate, and Climate Change.

* Students performing density experiments (left), Egg sank in freshwater and floated in saltwater (middle), Freshwater layered on saltwater (right).
*The two ice-core labs focused on student learning about climate change from ice core data which was particularly relevant to the Climatology course, and taught in conjunction with one another.

*The first lab activity, entitled Ice Core Research, was adapted from the laboratory “Exploring the History of Climate Change” - Wisconsin Department of Natural Resources-Climate Change: A Wisconsin Activity Guide.

*In this activity, students discovered first-hand what historical information scientists can obtain about climate from ice cores by analyzing the pH and relative amount of particulates in each layer of a homemade ice core.
In the second lab, students built upon the knowledge gained from the first lab, and discovered how the deuterium/hydrogen isotope ratio, a paleoproxy for temperature in ice cores, can be used by scientists to gain temperature information about the past.

This activity was adapted from a hands-on Ice Core Lab and allowed students to participate in scientific practices such as collecting, processing, and interpreting temperature and CO$_2$ data.

Students dissected and analyzed layers of homemade ice cores containing various amounts of colored beads. These beads acted as a proxy for hydrogen isotope ratios present at the time when the layer was formed.
To monitor students’ knowledge and understanding of the materials covered in the class, assessments followed the lectures and laboratory activities, via google forms.

**Assessments**

*Isotopic Fractionation and Paleoproxies*

**What affect does a rise in ocean temperature have on sea level?**
- There is no correlation between temperature and sea level
- Increasing ocean temperatures cause decreasing sea levels
- Increasing ocean temperatures cause increasing sea levels

**Explain your answer to the previous question about temperature & sea level.**

**Melting sea ice has the potential to raise sea level by several meters**
- True
- False

**Explain your answer to the previous question about melting sea ice and sea level rise.**
Assessments showed that these lab-centered teaching activities engaged students and enhanced their understanding of how historical ice core data are used to understand changes in the magnitude and rate of temperature changes, as well as the relationship between sea ice, land ice, and sea level rise.
Rather than making the entire ice core in a polyethylene graduated cylinder, recycled water bottles were used to make each layer of the ice core.

This allowed students to access the layers in a more timely manner, and prevented the loss of some of the sediment from one layer to an adjacent layer. The bottles were later recycled.
Small pringles cans were used to form each of the layers for each ice core - this allowed the “layers” to be melted right in the can in order to collect the CO$_2$ and deuterium isotope data.
Homework & Activity Assessment Grades **Without Hands-on Labs**

- **Non-major**
  - Natural science Non-Majors: 80%

- **Major**
  - Natural science Majors: 95%

**Legend:**
- Blue bar: Homework
- Green bar: Activities
Climatology Class 2014

Homework & Activity Assessment Grades **With Hands-on Labs**

Natural Science Non-Majors vs. Majors

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Homework & Activity Assessment Grades With Hands-on Labs

Natural Science Non-Majors vs. Majors
Homework & Activity Assessment Grades With Hands-on Labs

Average Grades (100%)

Lab activity
Homework

Natural Science Non-Majors vs. Majors
* Student grades were primarily A’s
* Non-natural resource majors performed just as well, if not better than natural resource majors when hands-on labs were done.
* Teaching Climatology is a complex subject - hybrid format for teaching the class was stressful to the students

* Although all the students passed the course and received A’s and B’s, student learning were significantly different between natural resources majors and non-majors

* By providing both lectures and hands-on practices to all students in the class, we were able to minimize these discrepancies in learning between the majors and non-majors

* We were able to provide a better setting for discussion on local and regional emerging issues in the environment and climate change issues.
* We would like to focus students on decision making about campus-wide practices (i.e. recycling)
* Have students to be advocates on various topics of their interest and partner with journalism students to publish opinion articles/produce a video
* Campus-wide student symposium/workshop on sustainability and ethics
* Encourage students to become the educators to the youth (informal - upper elementary aged students)
* Find a funding source to allow students to attend an earth science or environmental symposium in the region
Challenges (Field trip - class time)

Previous Years
* Baltimore Aquarium
* University of Maryland College Park Sustainability Program
* Climatology Class Group Picture
* AMS
* SOI Team
* IODP Team
* NCAR Team
* FAMU and UF Teams
* MADE-CLEAR Program Team
* Northeast Climate HUB Team
* Graduate Students, Melanie Fuoco and Nivette Perez-Perez
* USDA-NIFA Capacity Building Grant Programs long term partners - Dr. Shobha Sriharan (VSU), Dr. Chunlei Fan (MSU) and Drs. Linda Hayden and Francisco San-Juan (ECSU)