Enhancing Data Literacy by Bringing Data into Introductory Oceanography Courses

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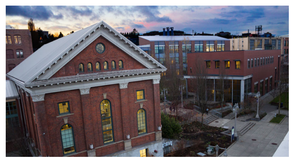
Motivation

We live in a 'big data' world where there are 'oceans of data' available for anyone to download and explore. Easily accessible data provide an opportunity to teach students standard approaches to working with data that can be applied broadly across many fields and prepare them for their future careers. However, many students lack the skills required to navigate these large data sets on their own. Data activities were incorporated into two different introductory oceanography courses at the University of Washington (UW) with the intent of increasing student engagement and enhancing students' ability to use and interpret oceanographic data. *Data Explorations* developed by the Ocean Observatories Initiative (OOI) Data Lab Project were integrated into both lecture and lab sessions. Students were given a pre- and post-survey to evaluate their attitudes about the use of data in the classroom and their data literacy.

Study Setting & Population

UNIVERSITY of WASHINGTON



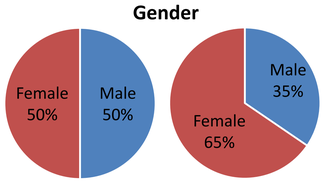
UW Tacoma (PUI)
Small urban campus with ~5000 undergraduate students. Over 50% transfer students and 64% first in family to attend college.

UW Seattle (R1)
Large campus with more than 500 buildings. Enrolls ~46,000 with a 32% graduate student population.

T GEOS 241 (UW Tacoma)	OCEAN 101 (UW Seattle)
16 students; 1 lab section	84 students; 4 lab sections
88% of students report having used data before in other courses.	98% of students report having used data before in other courses.
76% have used data before outside of school.	72% have used data before outside of school.
88% have used graphs in other classes.	96% have used graphs in other classes.
71% have used graphs before outside of school.	63% have used graphs before outside of school.

T GEOS 241 OCEAN 101 T GEOS 241 OCEAN 101

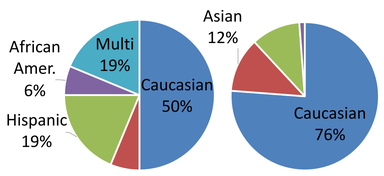
Gender



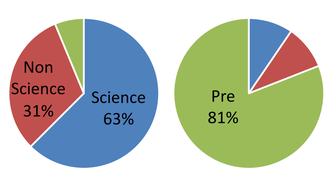
Class

T GEOS 241 OCEAN 101 T GEOS 241 OCEAN 101

Ethnicity



Major



Data Activities

Below is an example of one of the *Data Explorations* that was incorporated into the curriculum of both courses. The Learning Cycle[1] with data orientation questions was used to guide students through the activity and help them interpret patterns in data. Additionally, students were asked application questions requiring them to use data and apply their knowledge and data skills to new problems.

OOI Education Portal http://explorations.visualocean.net/

Exploring Properties of Seawater with OOI Data collection *asks students to explore seawater characteristics and processes that are correlated with changes in salinity over time, with water depth and between different locations.*

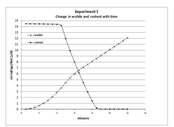
Surveys

Three types of survey questions were developed to evaluate student attitudes. Students were asked questions about their 1) attitudes and confidence using data in classes, 2) ability to read and interpret data from graphs, and 3) ability to graph 2-D data by hand (pre-survey) and using Excel (pre- and post-surveys). The surveys were assigned to all students during the first and last week of weeks of the quarter.

Part 1: Pre- and Post-Survey Attitude Questions:
Q5/1: I like to use data.
Q6/2: I find data useful.
Q7/3: I am good at using data.
Q8/4: I feel comfortable reading and interpreting data from tables.
Q9/5: I feel comfortable reading and interpreting data from graphs.
Q10/6: I feel comfortable plotting data on a 2D graphs by hand.
Q11/7: I feel comfortable plotting data on a 2D graphs in Excel.
Q12/8: Using data helps me better understand a subject or system.
Q13/9: I am good at using data to answer quantitative questions about a subject or system.
Q14/10: I am good at using data to answer qualitative questions about a subject or system.
Q15/11: I think it is important to use data to learn about a subject or system.

Coding of Survey Data was as follows:
- *Part 1: Scaled as Agree, Neutral or Disagree*
- *Part 2 & 3: Graded as Correct, Mostly Correct, Incorrect, or Blank*
- *Data for Parts 2 & 3 from a "make believe" experiment that does not require any previous knowledge to read and interpret the graph.*
- *Pre- and Post-Surveys were similar*

Part 2: Post-Survey Reading a Graph Questions:
Answer the following questions about the graph below to the best of your ability.

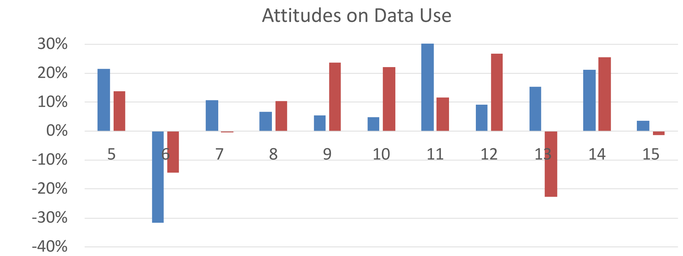


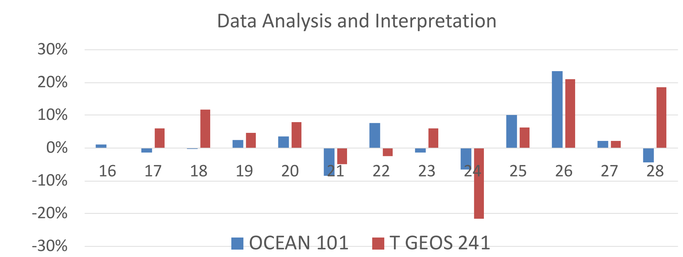
Q16: What is plotted on the x-axis?
Q17: What plotted on the y-axis?
Q18: What is the name of the parameter that is plotted on the curve with "x's"?
Q19: What is the name of the parameter that is plotted on the curve with solid dots?
Q20: Describe how ratats change over time.
Q21: Describe how soshas change over time.
Q22: How many c/d ratats had the system reached after 5 minutes?
Q23: At what time do ratats and soshas have equal c/d's?
Q24: At the point when soshas reached maximum c/d's, how much ratats were present?
Q25: What is the average rate of increase in soshas over the course of the experiment in c/d per minute?

Part 3: Post-Survey Making a Graph Questions
Q26: In a program like Excel, create and upload an XY scatter plot to this assignment for your course on Canvas based on the data in the table below. Be sure to label the axes on the plot. Then answer the following questions.
Q27: Is there a trend or correlation between bergas and tribas?
Q28: If there is a trend or correlation between bergas and tribas – please describe it.

Student Attitudes & Data Literacy

The bar graphs below show the percent difference between pre- and post- survey responses. A negative percent change indicates a decrease in either the agreement with an attitude question (Part 1) or correct response to a data literacy question (Parts 2 & 3).





Student attitudes about and their ability to use data changed during the quarter of instruction. The trends in both attitude and ability were similar for all students despite the differences in student demographics between the two campuses. In general, the data literacy of all students improved.

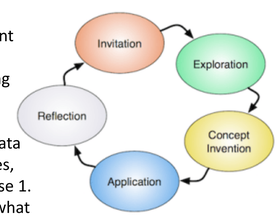
- Overall, student attitudes and confidence using data in the classroom *increased*.
- Overall, students' ability to read and describe patterns in data *improved*.
- An increase in agreement for all attitude questions, except questions 6 (for both UW Seattle and Tacoma) and 13 (only for UW Tacoma) was recorded.

There is a discrepancy between students' attitude about the use of data (Question 6) and their perceived ability to use data to answer quantitative questions about a subject or system (Question 13). This discrepancy is likely the result of the challenge that comes with working with environmental data as students must develop complex lines of reasoning to interpret and make meaning from the real data[2]. Instructors can support students by inviting them to explore real-life phenomenon and guiding them through the large data sets with orientation questions that are appropriate for the goals and the level of the course.

Teaching with Data – Broader Implementation

The Learning Cycle[1] is a powerful model to integrate data activities into any course or discipline. Each phase of The Learning Cycle offers an important step in assisting students in their learning and understanding of the concepts being covered and how to use data to compliment their learning.

The five phases of The Leaning Cycle:
1. **Invitation** - Invite students to explore data by introducing a relevant problem or natural phenomenon.
2. **Exploration** - Guide students through the exploration of data using orientation questions and clear instructions for manipulating the visualization tool.
3. **Concept Invention** – Ask students to find and remove irrelevant data or outliers, scale or find quantitative relations between data variables, and formulate next steps in data analysis to solve problem from phase 1.
4. **Application** – Ask students to find new data evidence to support what they framed in phase 3.
5. **Reflection** – Ask students to recount and evaluate their experiences and learning using data.



The five phases of the learning cycle.

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School of Oceanography
College of the Environment

You can find the full collection of Data Explorations and other resources at:
datalab.marine.rutgers.edu

For more information, please contact mrasmuss@uw.edu

Citations:
1. Kastens, K.A. and M. Turrin (editors) (2010) Earth Science Puzzles: Making Meaning from Data, National Science Teachers Association Press.
2. The Learning Cycle is an approach to designing learning experiences that capture best the knowledge and theory of how people learn, which was developed by the University of California, Lawrence Hall of Science.