Video-based pair programming increases students' ability to visualize and understand geoscience datasets

Matthew J. Oliver[1] Jonathan H. Cohen[1]

Joe Levy[2]

[1]University of Delaware

[2]Colgate University

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When we think about evaluating the truthfulness of a scientific story, there are both technical and narrative challenges

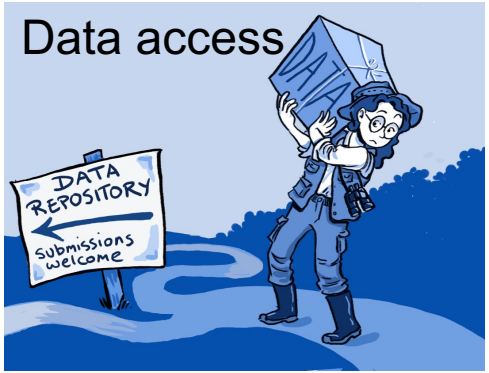
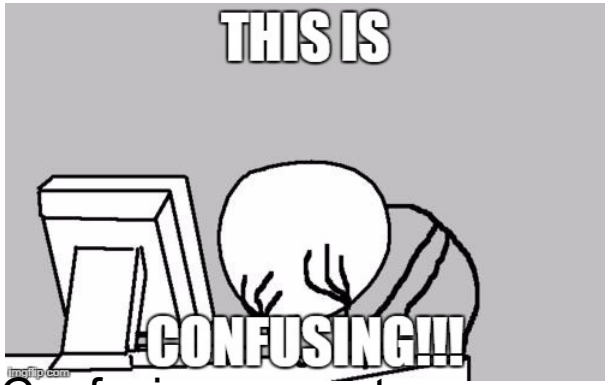
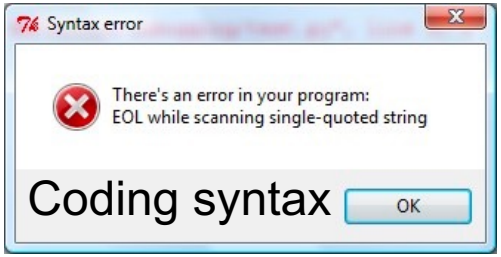


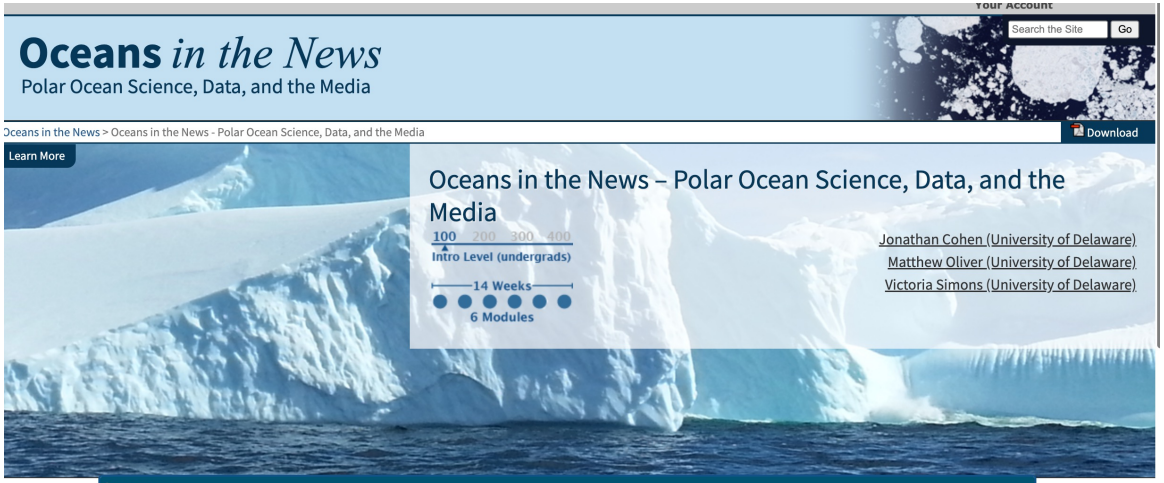
Illustration credit: Ainsley Seago.
doi:10.1371/journal.pbio.1001779.g001



Confusing computers



Narrative Challenge



Summary

Interpreting scientific data is one of the most challenging skills students face today. Students are overloaded with information from various media sources, and often lack both the technical skills to analyze data and the ability to recognize the overarching story the data support. This course uses polar science examples to address these technical and narrative challenges. Students will develop proficiency in data visualization and its application to the analysis of news stories about polar regions.

Strengths of the Module

- Students access and process up-to-date polar data sets to evaluate claims made in news media articles
- Students break down news articles into story components and identify what are the heroes, villains, problems, and solutions as posed by the article's author
- Students learn basic coding skills in the R programming environment, starting by using R as a calculator and progressing to making and

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We designed this course to address both **technical** and **narrative** challenges in teaching geoscience

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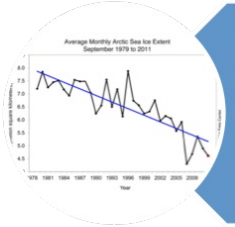
https://serc.carleton.edu/oceans_news/index.html

Introduction to Problem (1 Period)

Content: Introduction to a polar science news claim. Students will be asked to construct a knowledge base to evaluate the veracity of the claim.

Purpose: Providing background on key science concepts in the news claim.



Problem Analysis (2 Periods)

Content: Break-out groups with R instruction to discover and evaluate the data and the news claim.

Purpose: Give students open-access data tools to evaluate polar data.

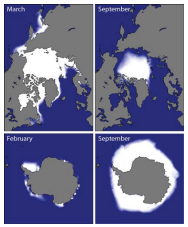
Synthesis and Evaluation (2 Periods)

Content: Class evaluation and discussion of news claim in light of discovered evidence.

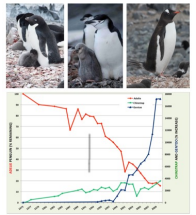
Purpose: Challenge students to think critically about the veracity of the claims being made in light of polar data.

theguardian

Why is Antarctic sea ice at record levels despite global warming?



'Grave indicator': Penguins' survival at stake as Antarctic ice disappears



High mercury levels prompt health advisory in Nunavut

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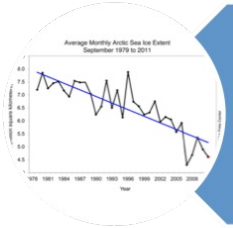

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NSIDC
National Snow and Ice Data Center

Palmer Station Antarctica LTER

NASA GLOBAL CLIMATE CHANGE
Vital Signs of the Planet

RStudio®

Pair Programming

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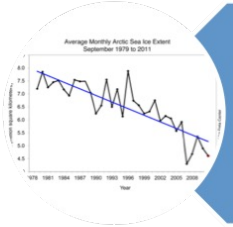

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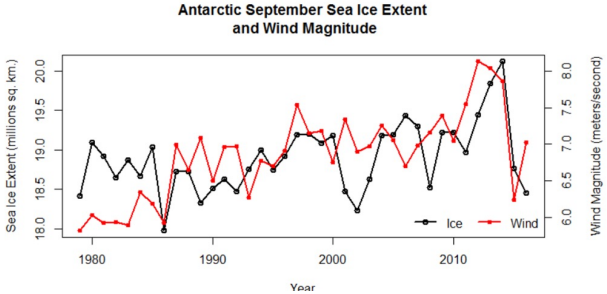
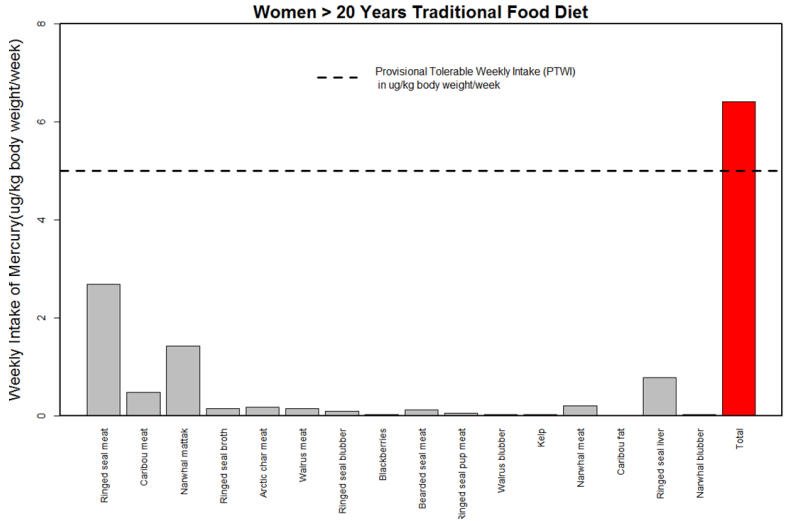
Example Student Output





What do students think about Pair Programming?

"What I liked best about this class is that I think it really prepares us for real world applications. I feel like the whole coding aspect is important, especially nowadays I feel like almost every job requires you to have basic knowledge of computers and coding. So, I think that I like that it has real world application like that."

"I really liked the real-world application and building the skill set that I know I'm actually going to be able to apply in my future studies."

RStudio

Pair Programming

What do students think about Pair Programming?

"So with the videos, he kind of tells us... He walks us step by step, everything we need to know is right there and he explains it. What we're doing, why we're doing it, where we're getting our data from how we're getting the data into our.... Explains everything. That way, all of his bases are covered. Like we understand what we are doing."

"I like the fact that he gave videos to reference while we coded, but also like the fact that we then have to create our own data, which means like we have to find own data and then we have to write our own code, but we have the videos to reference and they're also weird."

RStudio

Pair Programming

Does Pair Programming improve data visualization skills?

Quiz Instructions

In the two questions below you will be asked to look at this data table and (1) make a graph, and (2) interpret the graph in 5 sentences or less.

Table of Average Monthly Surface Air Temperature in Degrees Celsius in the Northern (Equator to North Pole) and Southern (Equator to South Pole) Hemisphere

Months, starting Jan. 2001	Average Northern Hemisphere Air Temperature C.	Average Southern Hemisphere Air Temperature C.
1	-0.8	8.3
2	-0.3	6.8
3	1.5	3.5
4	5.6	1.5
5	10.6	0.5

Treatment Design (all entry level non-STEM majors)
Fall 2021- Spring 2022

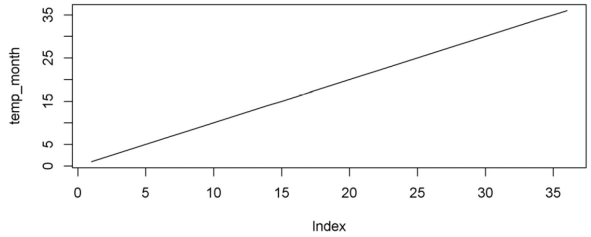
1. **UD Undergrad class w Pair Programming**
2. **UD undergrad class w/out Pair Programming**
3. **Colgate Undergrad class w Pair Programming**
4. **Colgate undergrad class w/out Pair Programming**

15 min to complete task

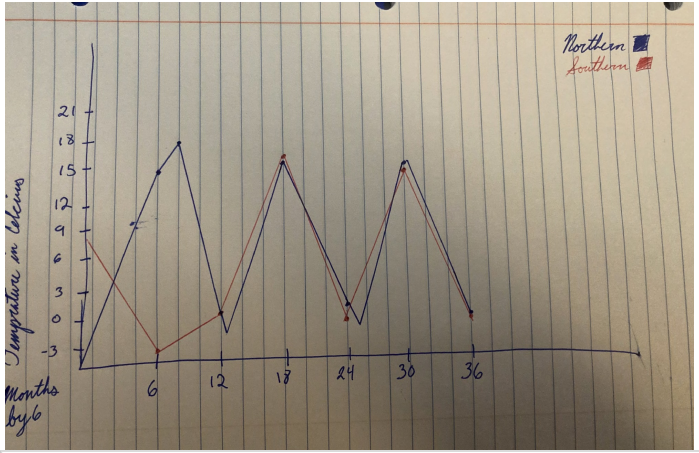
Make a graph. Use the data table to make a graph. You can prepare the graph any way you choose, for example by hand on paper, using a spreadsheet, or using graphing software.
Interpret the graph. In five sentences or less, please describe your graph, and any patterns in the data that you think are important.
Upload your answer. Then, upload an image of your graph along with the description of your graph. It can be a cell phone picture, a screen capture, or an exported image file, word document, a powerpoint document. The same data are also available in a .TXT file Download .TXT file, a .CSV file Download .CSV file, and a .XLSX Download .XLSXfile.

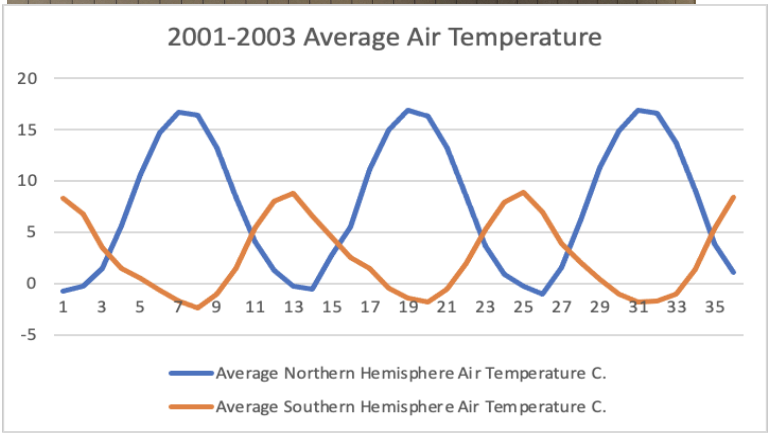
Does Pair Programming improve data visualization skills?

Example Pre-Test Submissions



This graph shows the average temperature for the North and South pole. The data is taken over 36 months and increases over the summer. The temperature also decreases over the winter.

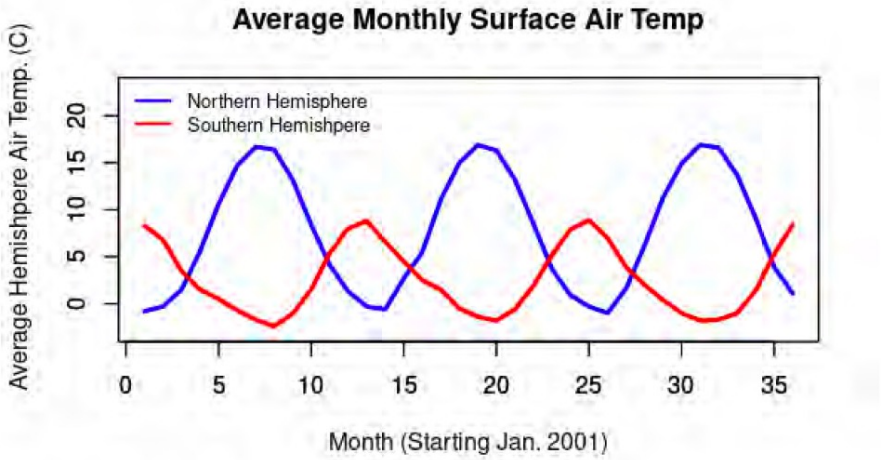




Does Pair Programming improve data visualization skills?

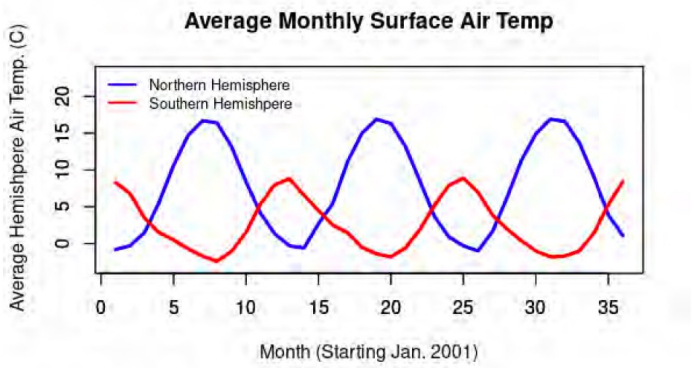
Example Post-Test Submission (Treatment)

66% of “Treatment” students submitted an R-based for the final evaluation



This graph represents the average monthly temperature of surface air in degrees celsius starting in January 2001. In blue is the average northern hemisphere air temperature and in red is the average southern hemisphere air temperature. The temperature in the southern and northern hemispheres fluctuate, when its warmer in the northern hemisphere, it is cooler in the southern hemisphere. From this graph we can conclude that the temperature change with the seasons, when we are in the warmer months in the northern hemisphere, people living in the southern hemisphere are going through the fall and winter months.

Evaluation Rubric



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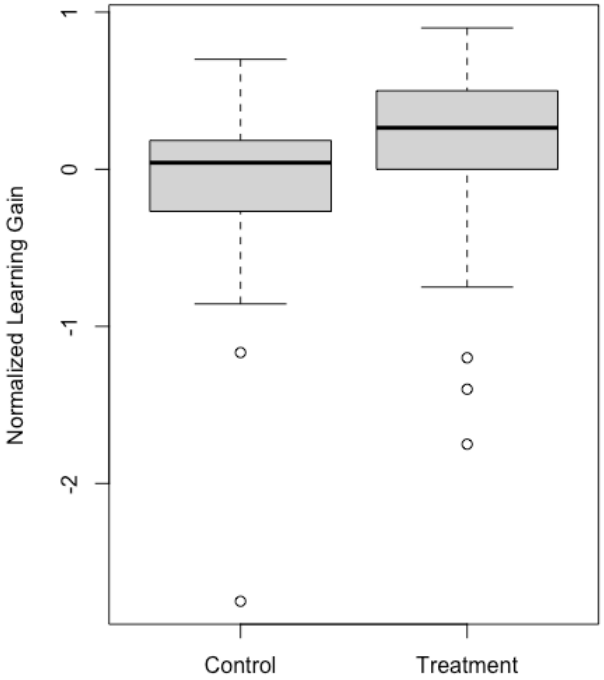
This rubric is a list of yes or no questions. “Yes” answers = 1, “No” answers = 0

1. Correct data has been accessed and plotted
2. Correct plot type is used (line, scatter, bar, etc.)
3. Axes are properly labeled and legible
4. Text in the graphic is legible
5. Graphic includes other contextual data that aids in interpretation of the primary data set
6. Line weights are appropriate
7. Graphical symbols are appropriate
8. Pleasing use of colors or greyscale
9. A well-developed legend that adds information to the graphic
10. Caption is concise and descriptive of the plot and is helpful in interpretation

Normalized Learning Gain

NLG = (Posttest score - Pretest score) / (10 - Pretest score)

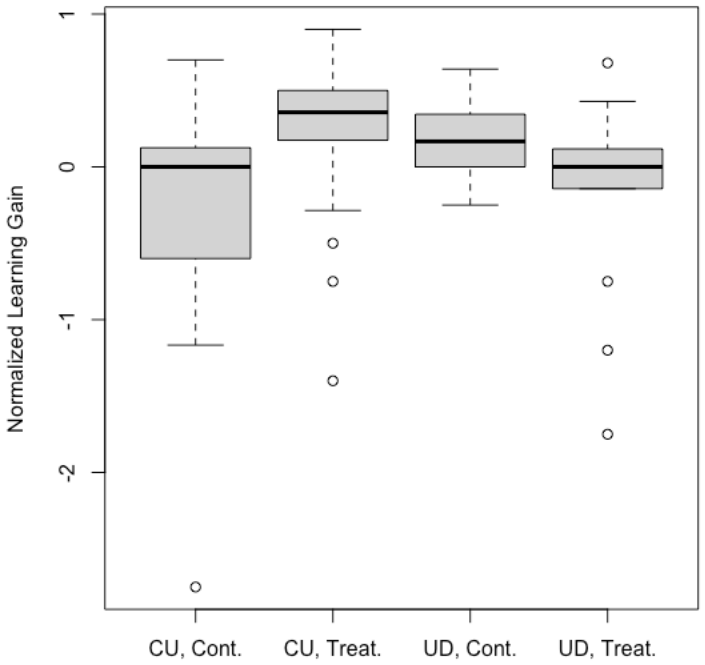
Results



Students that received pair-programming treatment showed a larger improvement than students that did not receive pair-programming treatment.

Whiskers represent the minimum and maximum.
Box represents the interquartile range.
Dark bar is the median.
Dots represent outliers.
($p = 0.043$, $n = 85$)

Results



Treatment classes, who had access to our guided graphical videos showed an increased ability to access and plot data after our courses only at Colgate University ($p = 0.0006$, $n = 61$). UD showed no significant effect ($n = 24$)

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Conclusions

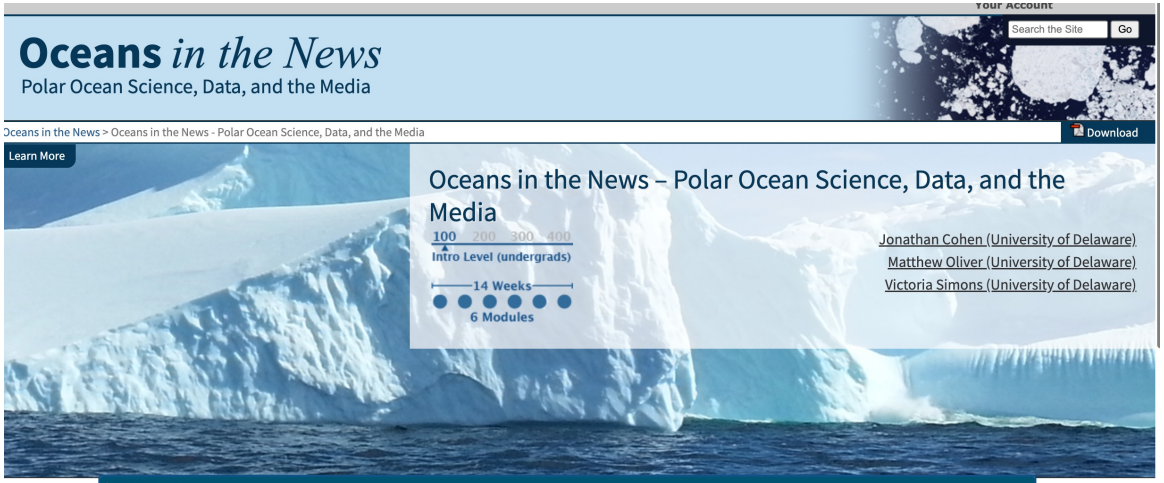
Pair Programming

Treatment classes showed higher ability to graph and understand geoscience data.

Major difference at Colgate, not at UD (Possibly due to sample size)

No differences between sex/gender

Looking for more partners



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