二十一世紀地球數據科學的學與用

Geo-Data Science

Photo Credit: NASA

Photo Credit: NASA

Motivational Questions

- What is science (physics, chemistry, biology, mathematics, geosciences, etc.)?
  - scientific behaviors
  - scientific method; the process of science
- What is “Earth system science”?
- Who studies geosciences and why? What does a geoscientist do?
- What is “Geodata Science”?

What is Science

Definition. Our *knowledge* of the natural world and the *process* through which that knowledge is built.

The *process of science* relies on the testing of ideas with evidence gathered from the natural world.

Science as a whole cannot be precisely defined but can be broadly described by a set of *key characteristics:*

Please see the Understanding Science Website:
http://undsci.berkeley.edu

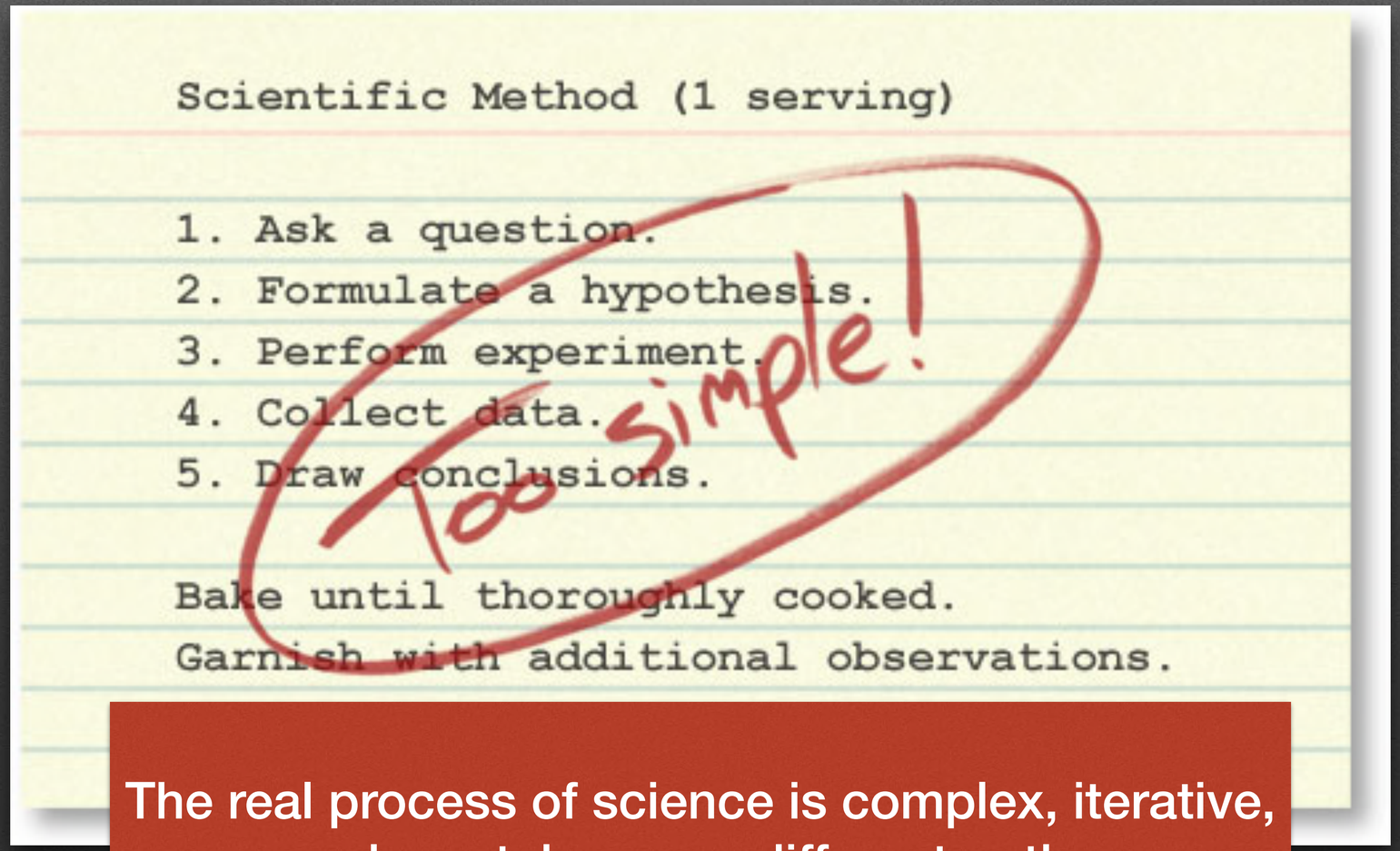
Characteristics of Science

- Focuses on the natural world
- Aims to explain the natural world
- Uses testable ideas
- Relies on evidence
- Involves the scientific community
- Leads to ongoing research
- Benefits from scientific behaviors:

Scientific Behaviors

- Finding out what have been done; understanding the current state of knowledge.
- Exposing ideas to testing!
- Assimilating the evidence, not ignoring it.
- Communicating ideas and tests to others.
- Maintaining high standards of honesty, integrity, and objectivity.
  - Scientific research is therefore reproducible

Scientific Method:
The process of Science

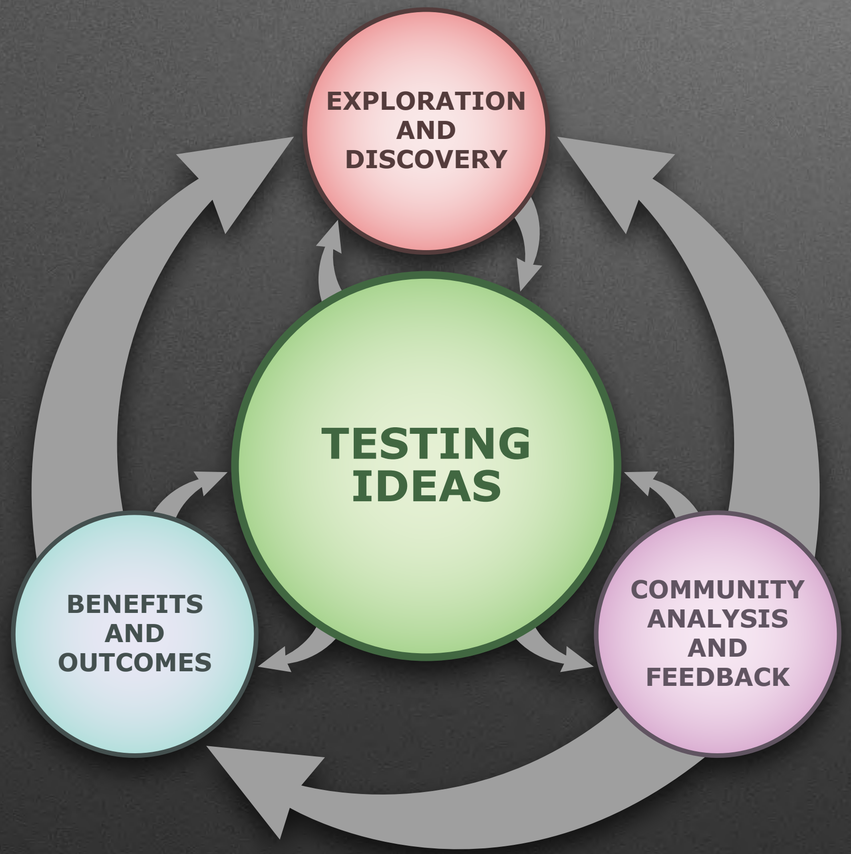


The real process of science is complex, iterative, and can take many different paths.

Image Credit: http://undsci.berkeley.edu

The Real Process of Science

simpler view



complex view

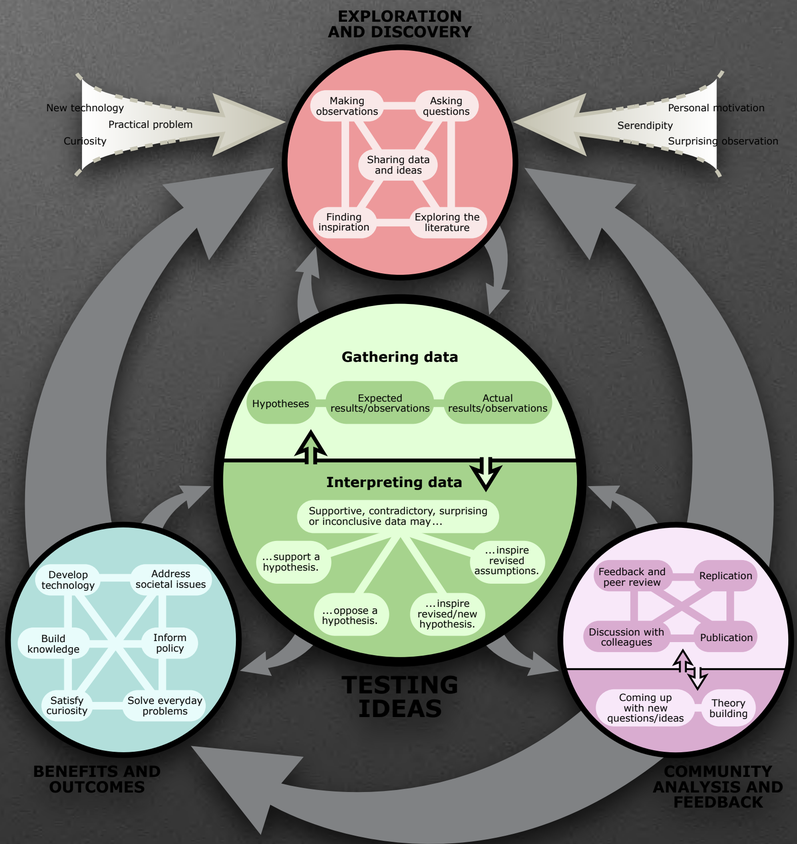
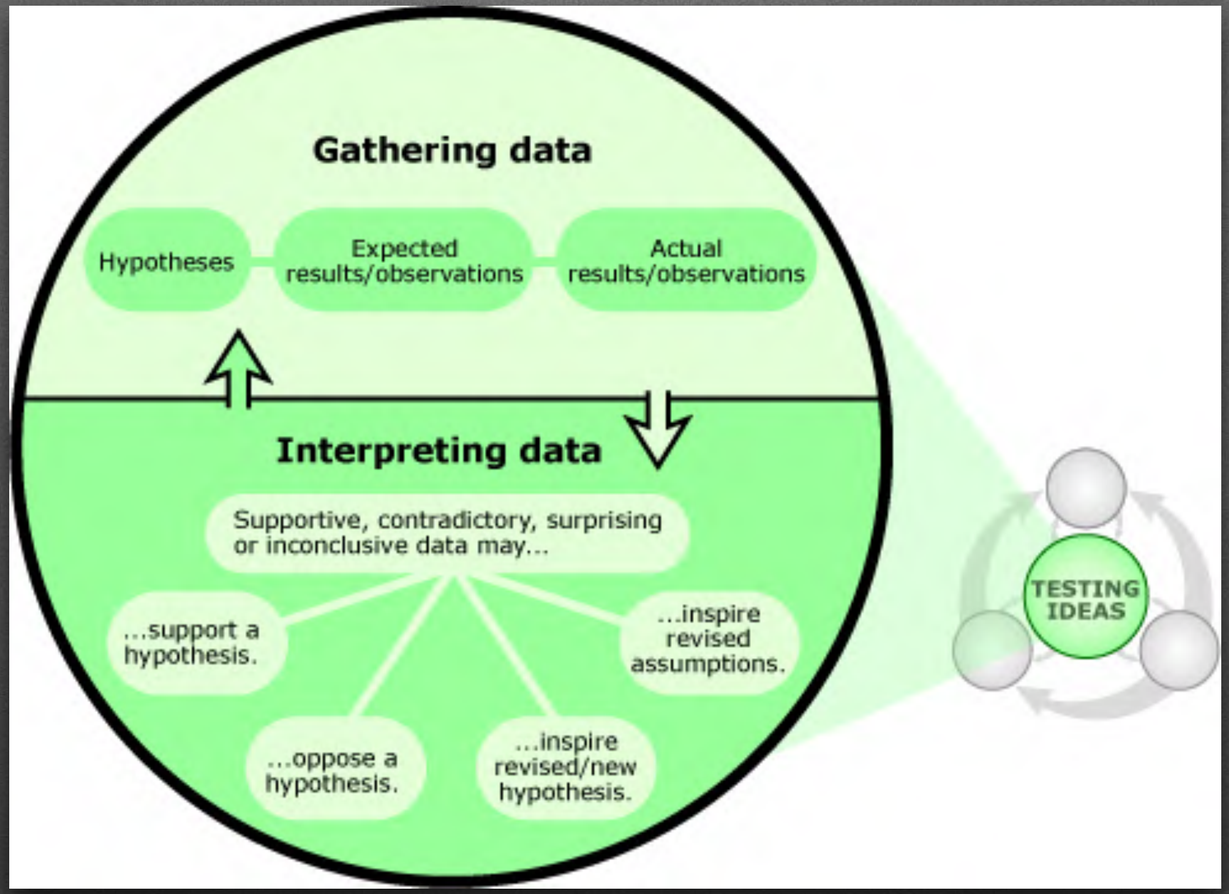


Image Credit: http://undsci.berkeley.edu/



Scientific Testing

Image Credit: http://undsci.berkeley.edu/

"If it disagrees with experiment, it's wrong."

Richard P. Feynman
(1918—1988)

On Testing a Guess (Hypothesis) in the Scientfic Method

https://youtu.be/OL6-x0modwY

Photo Credit: Nobel Foundation

What is Earth System Science

Earth System Science Approach of Geosciences:

Interactions among the atmosphere (air), the hydrosphere (water), the solid Earth (aka. lithosphere, land), and the biota (biosphere, life).

Image Credit: http://serc.carleton.edu

Earth System Science Approach to Geosciences

- Geo-. (Greek) Earth; Geosciences study the Earth using scientific method.
- Earth system science embraces physics, chemistry, biology, mathematics and applied sciences in transcending disciplinary boundaries to treat the Earth as an integrated system and seeks a deeper understanding of the physical, chemical, biological and human interactions that determine the past, current and future states of the Earth.
- Earth system science provides a physical basis for understanding the world in which we live and upon which humankind seeks to achieve sustainability.

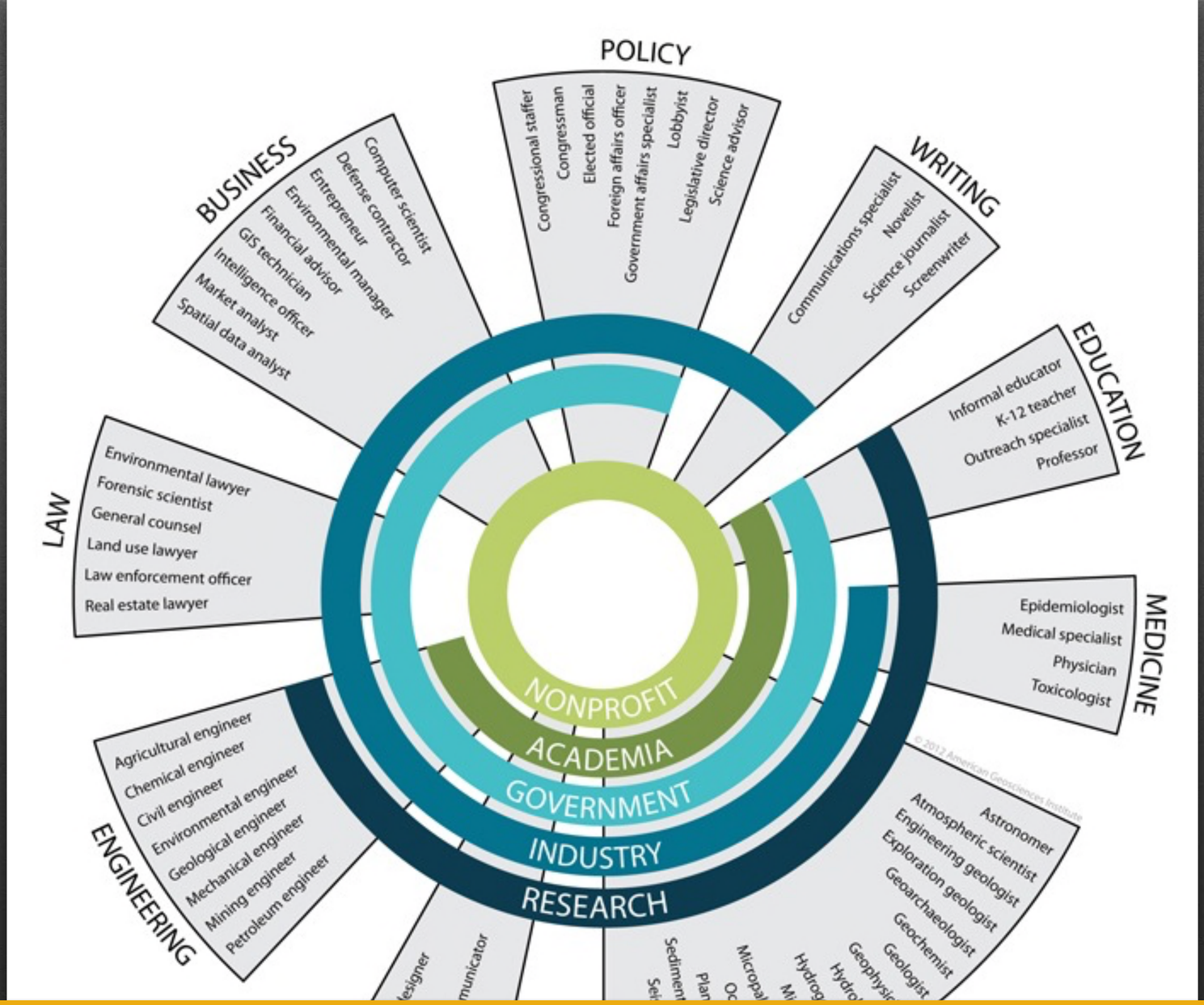
Who studies geosciences and why?

“Anyone who has been in a thunderstorm has enjoyed it, or has been frightened by it, or at least has had some emotion. And in those places in nature where we get an emotion, we find there is generally a corresponding complexity and mystery about it.”

Richard P. Feynman (1918—1988)

What are you going to do with geoscience knowledge?

Learning the Earth system science approach broadens your career options…



Source: American Geosciences Institute
http://www.americangeosciences.org/workforce/workforce-infographic

The “Geo-Data Scientists”

US Private Sector is Rising

US Weather Landscape

- Government deficit pressures continue
- Private sector: innovation and consolidation continues
- Recognition of the value of weather and climate information
- Federal investment in weather and climate research continue to decline
- Congressional interest in weather legislation

Global Landscape

- Government met services generally underfunded
- Varying legislative regimes
- Recognition of increasing value of weather data
- Universal recognition of government responsibility to warn people of hazardous weather
- Distrust of the private sector

Data & Information

Source: Mary Glackin TWC/IBM

IBM finally reveals why it bought The Weather Company

By Jennifer Booton

Published: June 15, 2016 12:54 p.m. ET

IBM launches 'hyperlocal' weather forecasts for companies

—J. Davis, InformationWeek

The Weather Company Brings Together Forecasting And IoT

The Weather Company estimates that weather is perhaps the single largest external factor affecting business performance, to the tune of nearly $1 trillion lost annually in the US alone. Combining weather data with business data can improve decision-making for a wide range of companies. The company's work earned it the No. 2 spot on the 2016 InformationWeek Elite 100. *—J. Davis, InformationWeek*

SKILLS AND TALENTS NEEDED BY THE WEATHER COMPANY/IBM

It’s not just about meteorology any more!

- Software Engineering
- Data Analytics
- Social Media
- Computer Science
- Communications in General
- Business Administration
- Engineering

- Team Player
- Business Sense

Source: Mary Glackin TWC/IBM

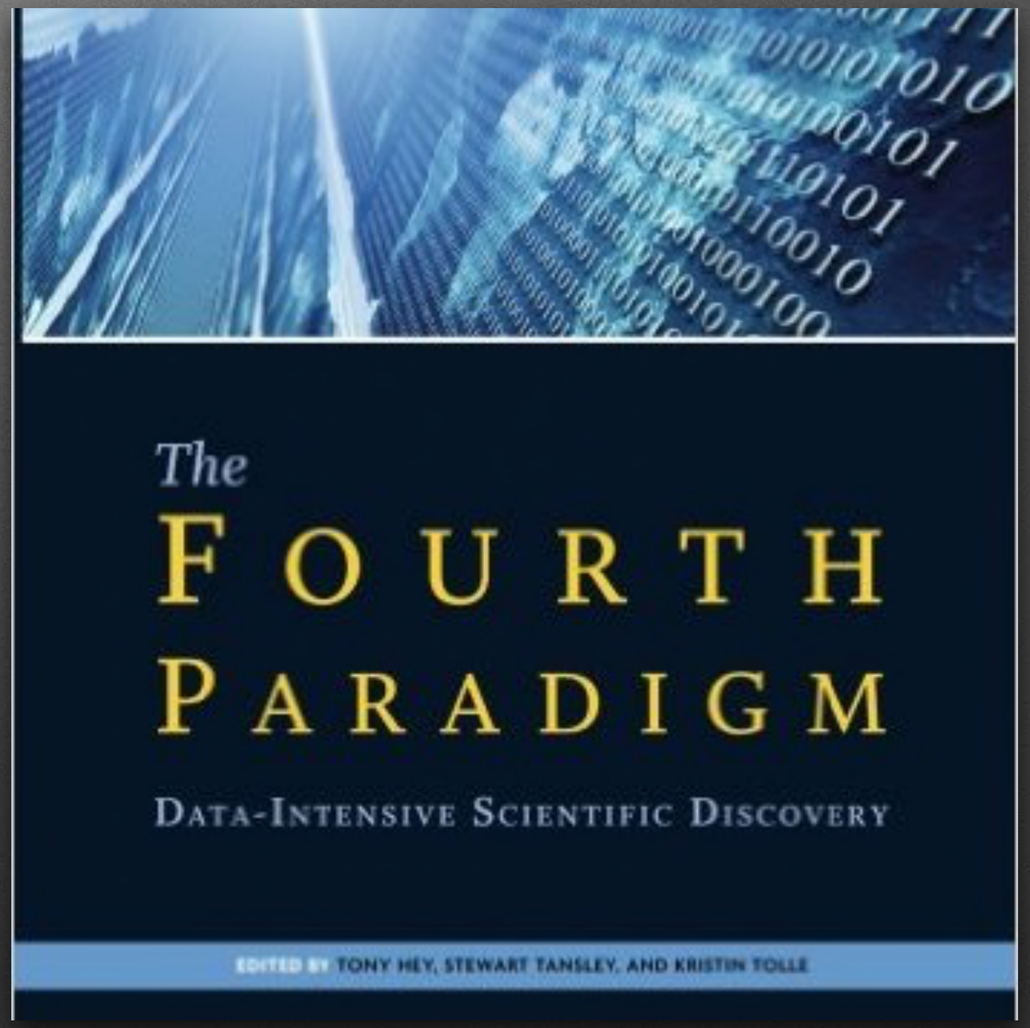
Data Literacy

The data-literate individual understands, explains, and documents the utility and limitations of data by becoming a critical consumer of data, controlling his/her personal data trail, finding meaning in data, and taking action based on data. The data-literate individual can identify, collect, evaluate, analyze, interpret, present, and protect data.

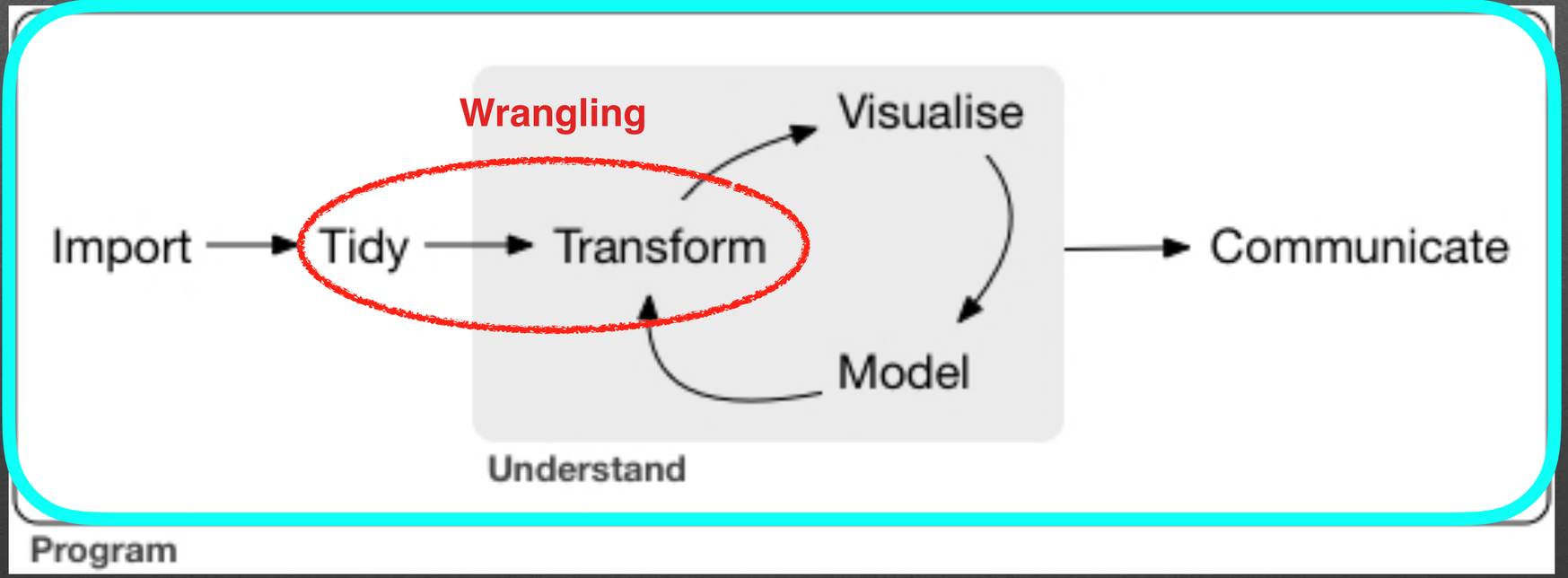
Source: IBM and Oceans of Data Institute, Education Development Center, Inc.

Four paradigms in scientific research

- Experiments
- Theories
- Computation
- Data
  (e.g., National Science Board, 2005; Gray, 2007).



Schematics of a typical data-science project



Grolemund and Wickham (2016) “R for Data Science”

Data Science Initiatives at Purdue University

Education

- CS+STAT Undergraduate Data Science Program (Fall 2018)
- Earth, Atmospheric, and Planetary Science GeoData Professional MS Concentration (Spring 2018)
- Data Science and GeoData Science MOOCs (2018—2019)
- Online Digital Agricultural MS Program with GIS, Remote Sensing, and Data Science (in planning)

Research Support Groups

- Weather, Climate, Environmental, Resource, Energy, and Societal (WCERES) Consortium (at Purdue, a proposal has been submitted to NSF EarthCube for nation-wide participation)
- International Data Science Consortium

Purdue Computing

- Existing Hathi and WSC Hadoop Cluster
- New WCERES (Weather, Climate, Environmental, Resource, Energy, and Societal) Nexus Cluster
  - 10 nodes
    - 20 cores each (200 cores in total)
    - 128 GB RAM each node
    - 8x4 TB each node
  - Name node
  - Frontend Server

From Earth System to Global Engagement

- The mission statements and strategic plans of most colleges and universities claim to prepare graduates for a global society and global citizenship.
- Yet the assessment of such competencies is elusive, especially in regards to Global Learning.
- Even less is known about the pathways by which these skills can be fostered and developed in an online, off-campus learning environment.
- At Purdue, preliminary data have been collected from 2 completely-online courses: The Dynamic Earth (EAPS 109) and Introduction to Geography (EAPS 120).

6 Constructs of Global Engagement

GLOBAL SELF-AWARENESS

PERSPECTIVE TAKING

CULTURAL DIVERSITY

PERSONAL AND SOCIAL RESPONSIBILITY

UNDERSTANDING GLOBAL SYSTEMS

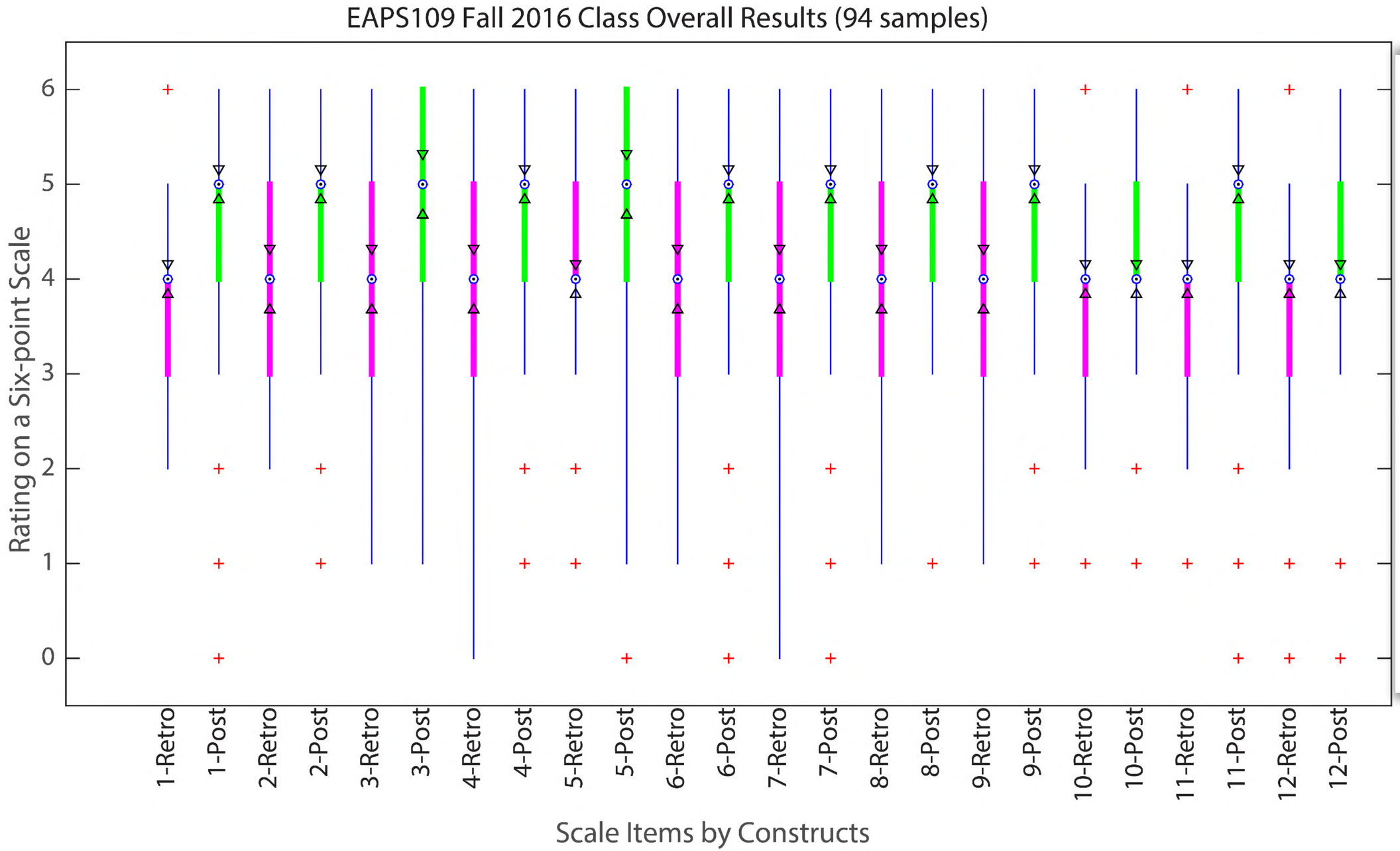
APPLYING KNOWLEDGE TO CONTEMPORARY GLOBAL CONTEXTS

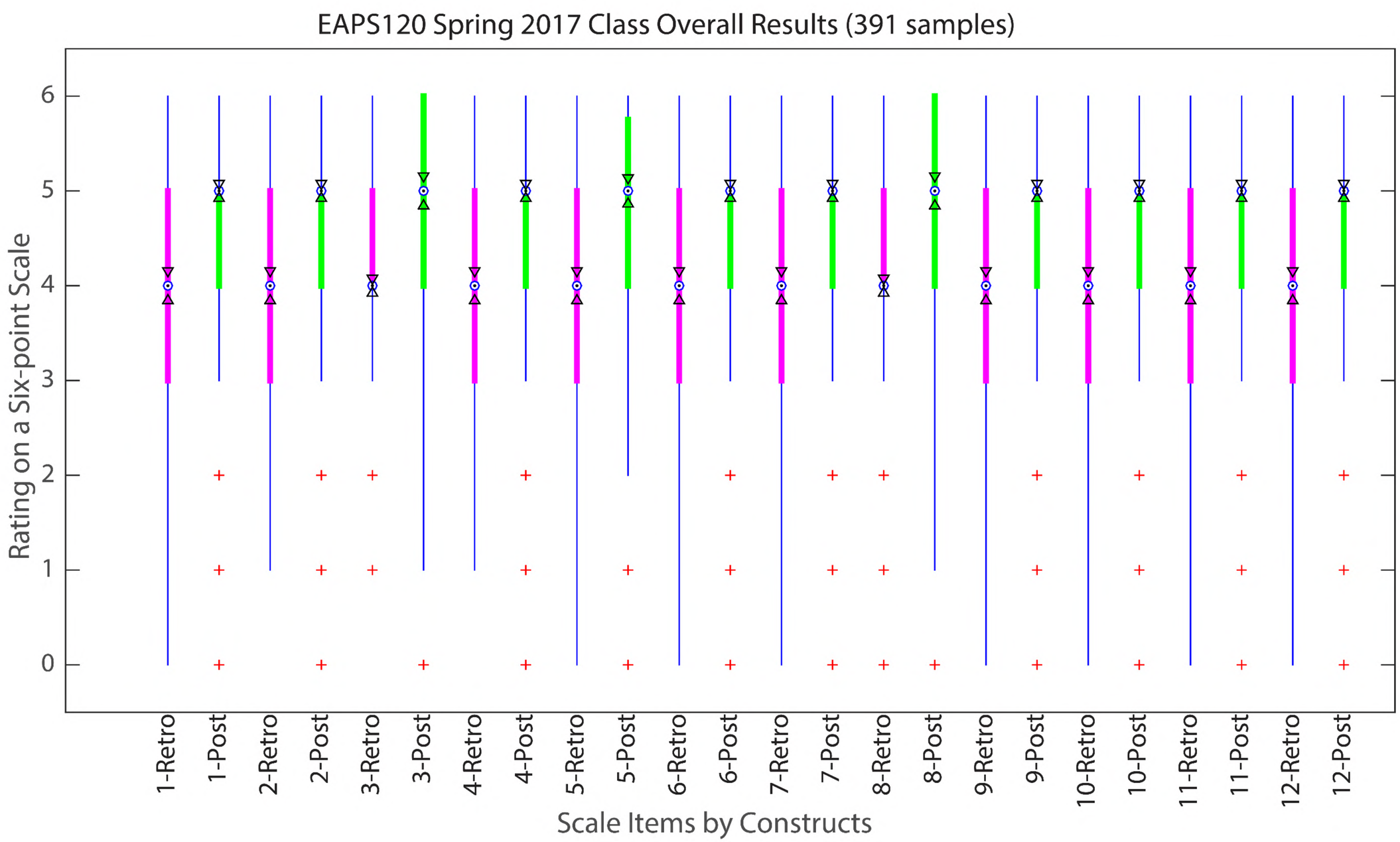
GLOBAL LEARNING SHORT SCALE (G.L.S²)

CONSTRUCTS KEY

Please respond to the following statements using the 6 point scale by rating the degree to which the statement represents your behaviors:

	1 not at all I am not aware of or do not recognize this behavior.	**2 low degree** I am only aware of and recognize this behavior.	**3 somewhat low degree** I cooperate or comply with this behavior if required by others.	**4 somewhat high degree** I recognize the value of and prefer this behavior.	**5 high degree** This behavior is an important priority to me.	**6 very high degree** This behavior is natural to me, is habitual to me, and embodies who I am.
1. I reflect on how **MY** local actions toward the natural and human world can have a global impact.	GLOBAL SELF-AWARENESS					
2. I reflect on how **OTHERS** specific local actions toward the human and natural world can have a global impact.	GLOBAL SELF-AWARENESS					
3. I consider ***different cultural, personal, and social perspectives*** to understand natural and human systems.	PERSPECTIVE TAKING					
4. I consider ***different disciplinary, environmental, local and global perspectives*** to understand natural and human systems.	PERSPECTIVE TAKING					
5. I discuss the importance of ethics and moral reasoning in a society.	CULTURAL DIVERSITY					
6. I examine different ways I can contribute to the local, national and global society.	CULTURAL DIVERSITY					
7. I examine the influence of power structures in society to understand inequalities among different groups.	PERSONAL AND SOCIAL RESPONSIBILITY					
8. I ask questions without making judgements about people from other cultures.	PERSONAL AND SOCIAL RESPONSIBILITY					
9. I differentiate the effects of the natural (physical, biological, chemical, etc.) and human (economic, political, historical, etc.) systems on the access of resources for people.	UNDERSTANDING GLOBAL SYSTEMS					
10. I identify the interrelationships among global systems to formulate solutions for change in society.	UNDERSTANDING GLOBAL SYSTEMS					
11. I collaborate with others from different backgrounds to formulate practical solutions to challenges in society.	APPLYING KNOWLEDGE TO CONTEMPORARY GLOBAL CONTEXTS					
12. I use my knowledge about historical and contemporary challenges in society to formulate practical solutions.	APPLYING KNOWLEDGE TO CONTEMPORARY GLOBAL CONTEXTS					





More Data to Analyze