

An Exploration into Student Conceptions of Systems through a Writing Activity

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Background

- Physics 140 is the Introduction to Mechanics course at the University of Michigan. It serves over 600 students each semester.
- Writing-to-Learn (WTL) has shown to improve student's conceptual knowledge in the sciences.
- M-Write is a campus wide, socio-technical system that works with courses to implement WTL activities.
- Each activity consist of a First Draft, Peer Review, and Revised Draft.
- In our course, Students had approximately 2 weeks to complete each activity.
- Submissions were required to be within 300 to 500 words and Peer Reviews were expected to be thoughtful and substantive.
- The grading and feedback given to students was done by M-Write Fellows. We currently have about 15 M-Write Fellows for Physics 140.



How Students Defined the System

How students defined the system in their writing was broken into the following categories. These were constructed by reading student work.

Earth and Water

"The system we are working with is in reference to the mass of the water and the Earth as a whole unit."
— Student 227, First Draft

Earth, Water and Plant

"We can define the system that the energy is flowing into and out of as the Earth, the water, the reservoir, and the turbines."
— Student 375, First Draft

Water

"The system that the energy flows in and out of is the lake water itself."
— Student 155, Revised Draft

Plant

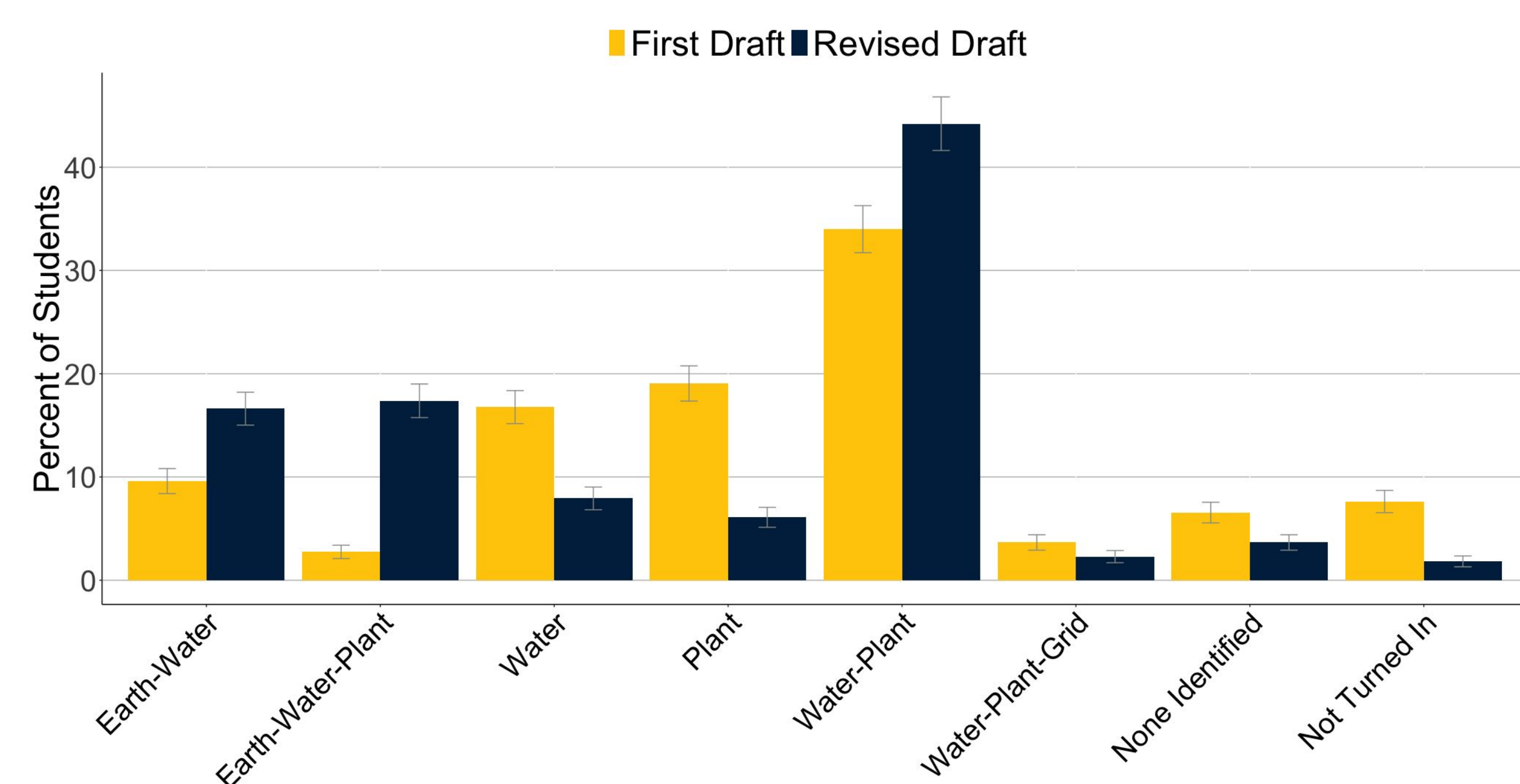
"When they referred to an energy system, they were talking about how their system converts energy to help their needs, in this case electricity."
— Student 391, First Draft

Water and Plant

"Let me start with defining the system that your example refers to. The system relates the bodies water and the turbines."
— Student 27, Revised Draft

Water, Plant and Electrical Grid

"The Plant system is comprised of the power grid, turbines, water, and reservoir."
— Student 539, Revised Draft



A Writing Activity

Title: A Watershed Moment in Energy Storage

Scenario: The student is placed in the role of a consultant working at a renewable energy firm. Their boss is interested in the Ludington Pumped Storage Plant which uses pumped water that is held above a bluff on the coast of Lake Michigan to store energy. Their boss tasks the student with writing a memo describing the physics of the storage facility.

The Task: The students must define the system that the energy is flowing into and out of and describe the energy transfers that occur while the water is moving through the facility. They also were asked to explain how energy can be "lost" while being consistent with the Conservation of Energy.

Our Definition of the System: We hoped that students would define the system as the water and the Earth. We still gave full points if the students also included any parts of the plant itself (e.g. turbines and/or pumps), as long as they still included the water and the Earth. The reason that we wanted students to defined the system this way is because you need the water and the Earth in your system to talk about both the Kinetic Energy and Potential Energy.



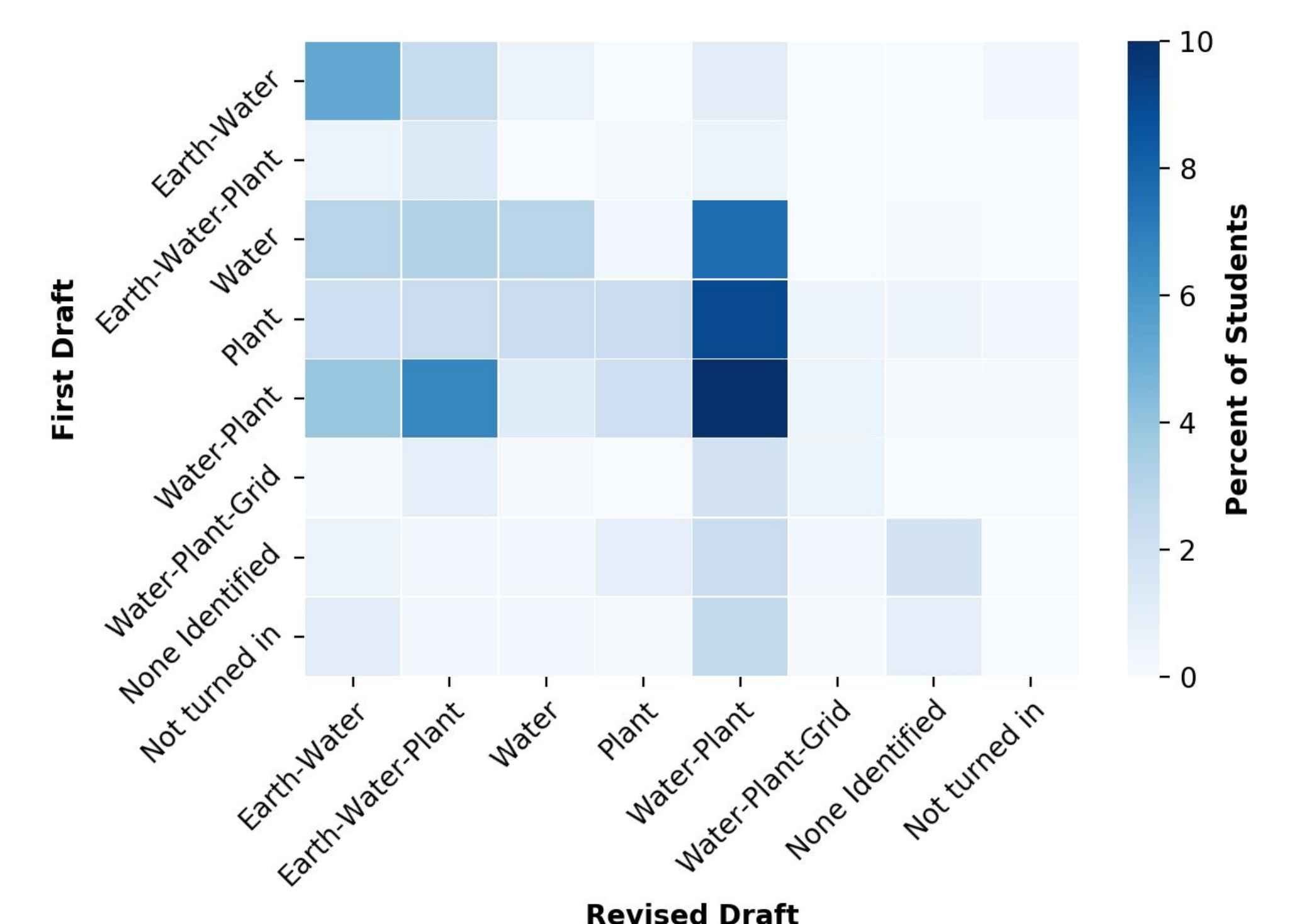
Aerial picture of the Ludington Pumped Storage Facility [3].

How Students Changed Their Definition

During revision, 66% of students changed how they defined the system. The pattern of how students revised is shown in the heatmap. Students' original definition of the system is along the y-axis, labeled by "First Draft". The students' revised definition is along the x-axis, labeled by "Revised Draft".

The increase in students who defined the system as the water and the plant itself is mainly due to the shift of students who originally defined the system as just the water or the plant.

The greatest contribution to the increase in students who included the Earth in their defined system comes from students who originally defined the system as both the water and the plant itself.



Conclusions

Through the submissions of the WTL activity, it is shown clearly that our students' understanding of systems varies dramatically. Most students made changes to their defined system during revision. However, even in the Revised Draft, most of our students did not include the Earth in the definition of their system. This result suggests that more effort should be placed on helping students understand what a system is, how to choose what is in your system and why defining a system is important for conservation laws.

Collaborators & References

[†]Heather Rypkema, Kairos Marquardt, Yuri Popov, Nita Kedharnath, Thomas Finzell, Juniar Lucien, Timothy McKay
[‡]Larissa Sano, Anne Gere, Ginger Shultz, and the MWrite Fellows

[1] Emig, J. (1977). Writing as a mode of learning. College composition and communication, 28(2):122-128.

[2] M-Write. See more at <https://lsa.umich.edu/sweetland/m-write.html>

[3] Consumers Energy, Ludington Pumped Storage Facility (2016).