Day 1

Introduction to Water as a Shared Resource

PACING GUIDE

Getting Started
Introduce the Water as a Shared Resource module and sharing resources / cooperation as a complex system phenomenon. **5 mins**

Activity 1
Watch & discuss Diary of Jay-Z in Africa: Water for Life. **15 mins**

Activity 2
Shared Water hands-on activity; experience the sharing of water resources from the perspective of various stakeholders. **25 mins**

Wrap-Up
How can computer modeling help us understand resource limitations and sharing? **5 mins**

LEARNING OBJECTIVES: Students will. . .

Complex Adaptive Systems
Be able to describe how a community of water users can be studied as a complex system phenomenon: there are many agents interacting following simple rules, there is no leader, there are emergent patterns and the system may be unpredictable [LO2].

Disciplinary Core Ideas
Learn of limitations of and threats to fresh water supplies [LO1].
Consider the importance of water for our survival [LO3].

Modeling and Simulation
Learn that models can be used to investigate water sharing scenarios and or policies. [LO4].

ASSESSMENTS OF UNDERSTANDING:

Complex Adaptive Systems
List two characteristics of water resources that show it is a complex system [LO2].

Disciplinary Core Ideas
List two threats to fresh water supplies [LO1].
List three ways humans are dependent on water for survival [LO3].

Modeling and Simulation
Why are modeling and simulation useful in understanding water resource management? [LO4]

Day 2

Math Basics for Modeling and the Water Pumping Base Model

PACING GUIDE

Getting Started
Review of the previous day's lesson and concepts. Connection to today's lesson. **5 mins**

Activity 1
Review math basics for modeling: coordinate space, relative vs. absolute position, agent heading, and angles of rotation. **20 mins**

Activity 2
Under the Hood: Inspecting the Water Pumping model. Find commands that are familiar and ones that are new. Decode model by procedures. Run the model multiple times. **20 mins**

Activity 3
Add a Slider for evaporation rate then run an experiment using the evaporation rate slider. Discuss the results and relate them to the hydrologic cycle. **15 mins**

Wrap-Up
Is anything unexpected happening in the model? **5 mins**

LEARNING OBJECTIVES: Students will. . .

Complex Adaptive Systems
Make observations of water being pumped out of the ground in the model.Identify an emergent pattern in the water pump model [LO5].

Disciplinary Core Ideas
Learn that water continually cycles among land, ocean, and atmosphere [LO6].

Modeling and Simulation
Identify abstractions made and limitations of the model [LO7]. Use the Water Pumping base model to conduct a repeated experiment and make observations (drawing simple correlations) [LO8].

Computer Science
Decode a model. [LO9] Trace a program's execution [LO10].

ASSESSMENTS OF UNDERSTANDING:

Complex Adaptive Systems
What is an emergent pattern being formed when we run the model? [LO5]

Disciplinary Core Ideas
Identify which part(s) of the water cycle is represented in the Water Pumping model? [LO6]

Modeling and Simulation
What are some of the abstractions or simplifications made in the model? [LO7] What were some of the observations you made as you ran the model? [LO8]

Computer Science
Name three blocks of code you recognized and what each one does [LO9]. List the steps the program executes in order in the forever loop [LO10].

Day 3

Adding More Water Pumps and Running Experiments

PACING GUIDE

Getting Started
Review of the previous day's lesson and concepts and connection to today's lesson. **5 mins**

Activity 1
Add another pump to the Water Pumping base model and add monitors and graphs that collect data on the amount of water pumped by each pump. **20 mins**

Activity 2
Design and run an experiment to see the effect of the modification. What is the impact of multiple users? What factors determine which user gets more water? **20 mins**

Wrap-Up
What does the computer model enable us to do that wouldbe difficult to do in the real world? How could a model like this one be used to manage water resources? **5 mins**

LEARNING OBJECTIVES: Students will. . .

Disciplinary Core Ideas
Learn that typically as human populations and consumption of natural resources increase, so do the negative impacts on Earth [LO11].

Modeling and Simulation
Ask a question that can be answered using the model as an experimental test bed [LO12]. Design and conduct an experiment [LO13]. Collect and analyze data to look for patterns [LO14]..

Computer Science
Modify a simple computer model and display output data using widgets [LO15]. Practice Pair Programming and Iterative design, implement, and test cycle [LO16].

ASSESSMENTS OF UNDERSTANDING:

Disciplinary Core Ideas
Describe potential negative impacts of adding additional water wells in a community with limited water resources [LO11].

Modeling and Simulation
See student Model Design Form and Experimental Design Form [LO12, LO13, and LO14].

Computer Science
Describe a procedure you added to the model [LO15]. In your own words, describe how you tested and, if necessary, refined your procedure [LO16].

Day 4

Customizing Your Water Pumping Model

PACING GUIDE

Getting Started
Review of the previous day's lesson and concepts and connection to today's lesson. **5 mins**

Activity 1
Introduce key elements of the computational science process. Discuss other factors that impact water availability. Discuss local or regional issues affecting water supply or quality. Then define your computational science project. **20 mins**

Activity 2
Design and develop your customized model in teams. Ideas for topics to investigate include variable rainfall, soil types, pollution, and/or regulations that impact water use. **20 mins**

Wrap-Up
What research is necessary to ground your model in reality? How will you check to see if your model is realistic? **5 mins**

LEARNING OBJECTIVES: Students will. . .

Disciplinary Core Ideas
Learn that resources are distributed unevenly around the planet as a result of past geologic processes [LO17]. Humans depend on water resources and many of these resources are not renewable or replaceable over human lifetimes [LO18].

Modeling and Simulation
Use the key stages of computational science and project design form to develop a question, create a model, and design an experiment [LO19].

Computer Science
Implement problem solutions using looping behavior, conditional statements, logic, expressions, variables and functions [LO20].and test cycle [LO16].

ASSESSMENTS OF UNDERSTANDING:

Disciplinary Core Ideas
Give three examples of how local conditions affect water supply or quality [LO17]. Describe why some water is not renewable or replaceable; where does the water go? [LO18]

Modeling and Simulation
See student Project Design Form. (Did student choose a question appropriate for answering with the model? Could student explain why it was chosen? Did student describe the aspects of the real world to be included in the model and why they were selected? etc.) [LO19].

Computer Science
Describe procedures in the model that you built. Choose one and describe how it works in detail [LO20].

Day 5

Experiment with Your New Water Pumping Model

PACING GUIDE

Getting Started
Review of previous day's lesson and concepts and connection to today's lesson. **5 mins**

Activity 1
Complete and debug code. **15 mins**

Activity 2
Run experiments, analyze results and discuss conclusions. Relate the results back to the bigger issue of shared resources and ground water. Prepare your model and results for presentation. **25 mins**

Wrap-Up
How would you know if your model reflects reality? What research is necessary to check if your model reflects the realworld? **10 mins**

LEARNING OBJECTIVES: Students will. . .

Complex Adaptive Systems
Revisit complex systems concepts and learn how they relate to understanding resource management [LO21].

Disciplinary Core Ideas
Gain a deeper understanding of impacts on ground water resources through experience creating and experimenting with a water pump model [LO22].

Modeling and Simulation
Use customized model as an experimental test bed to run experiments [LO23]. Learn that multiple runs of the experiment are needed at each variable setting due to inherent randomness in the model [LO24].

Computer Science
Use iterative refinement and apply debugging techniques to isolate and fix errors in code [LO25].

ASSESSMENTS OF UNDERSTANDING:

Complex Adaptive Systems
Describe four characteristics of a complex system and how they relate to a resource management situation [LO21].

Disciplinary Core Ideas
What local or regional issue impacting water resources was included in your model? What are some of the potential impacts of that factor or condition? [LO22].

Modeling and Simulation
See student Experimental Design Form [LO23, LO24].

Computer Science
Give an example of how you were able to find and fix an error you had in your code [LO25].