Assimilating Computational and Mathematical thinking into Earth and Environmental Science (ACMES)

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What is ACMES?

An Exploratory Integration project which aims to nurture the next generation of innovators by advancing student learning in STEM+C through a seamless integration of earth and environmental science, mathematics and computer science in Grades 5-7.

Background

Issues	ACMES can help in
Human activity is the primary cause of environmental imbalance (NRC, 2000)	Educating generations in conserving our natural environment in a sustainable way (Bostrom et. al., 1994)
Although 71% of jobs in STEM are related to computing, only 8% of STEM graduates are computer science majors (US Bureau of Labor Statistics, 2012)	Preparing our next generation computing workforce by stimulating students' interest in computing (CSP AP, 2016)
Students' performance and their interest in mathematics decreases after 4th grade (Wells, Sanchez & Attridge, 2007)	Providing the students opportunities to see the purpose and utility of mathematics (Ainley & Pratt, 2006)

Research Questions

Curriculum Design and Implementation

1. What are the most effective activities and tools that assimilate computational and mathematical thinking into Earth and Environmental Science?
2. What forms of students' reasoning can be seen to develop as a result of students' systemic engagement in the ACMES modules?
3. How can teachers use the ACMES instructional modules for instruction and formative assessment practices?
4. How can ACMES instructional materials be integrated and implemented into existing curricula?

Methodology

- Design-based research methodology (Brown, 1992; Cobb et al., 2003) focusing on continuous cycles of design, enactment and redesign.
- Whole class design experiments
- Ongoing analysis (Cobb & Gravemeijer, 2008) as each experiment proceeds to plan for the next session.
- Retrospective analysis (Cobb et al., 2003) at the end of each experiment aiming to monitor how students' reasoning progresses through the module and refine the module accordingly.

Module Design

Each module:

- consists of 3-4 lessons;
- focuses on an Earth and Environmental Science (EES) topic (e.g. Water Cycle);
- integrates EES with mathematical and computational thinking in Grades 5-7;
- utilizes interactive computer simulations (Netlogo, Scratch, Phet and JavaScript) to explore the various EES topics;
- is based on a learning progression from simple to more complex thinking of EES phenomena, mathematics and computer science.

Modules

Earth, Water & Weather	Earth & Solar System
Greenhouse Effect	Lunar Phases
Climate	Shadows & Time
Weather	Day/Night & Seasons
Water Cycle	Orbit
Rock Cycle	Gravity

The Water Cycle Module

Mathematical Thinking	Earth & Environmental Science	Computational Thinking
• Variable as a quantity that varies • Covariational Relationships • Coordinate plane • Translations • Patterns	• Water Cycle concepts • What is a cycle/system? • What are the variables? • What are the relationships?	• Sequence, loop, events, conditionals, operators and data analysis • Reusing and Remixing • Debugging & Testing

Selected References

Ainley, J., Pratt, D., & Hansen, A. (2006). Connecting engagement and focus in pedagogic task design. *British Educational Research Journal*, *32*(1), 23-38.

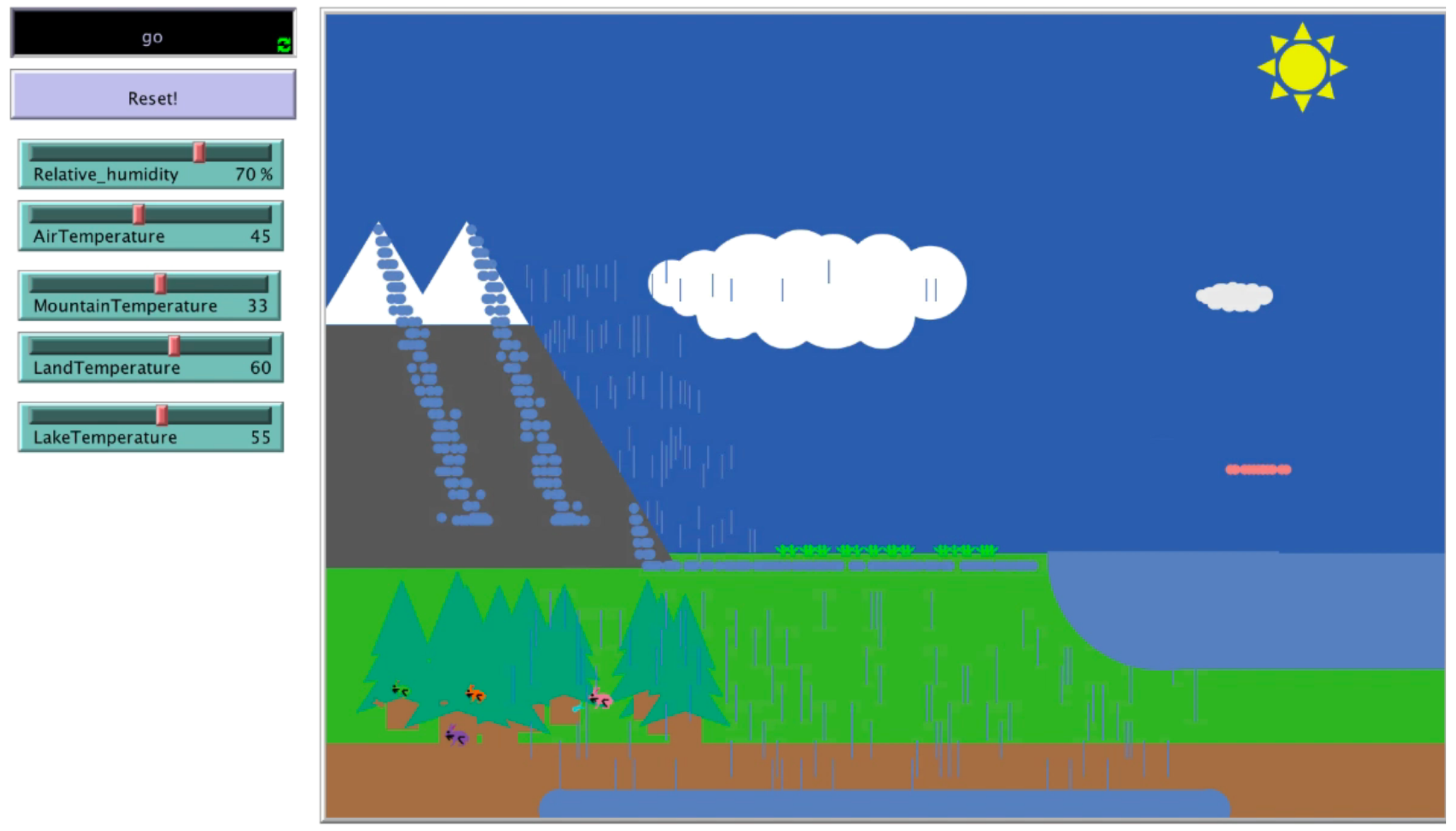
Brown, A. L. (1992). Design experiments: Theoretical and methodological challenges in creating complex interventions in classroom settings. *The Journal of the Learning Sciences, 2*(2), 141-178.

Cobb, P., Confrey, J., DiSessa, A., Lehrer, R., & Schauble, L. (2003). Design experiments in educational research. *Educational researcher, 32*(1), 9-13.

National Research Council (NRC). (2001). Grand Challenges in Environmental Sciences, National Academy Press, Washington DC.

Valerie Barr and Chris Stephenson (2011) "Bringing Computational Thinking to K-12: What is Involved and What is the Role of the Computer Science Education Community?" ACM Inroads, 2(*1*),pp. 48-54

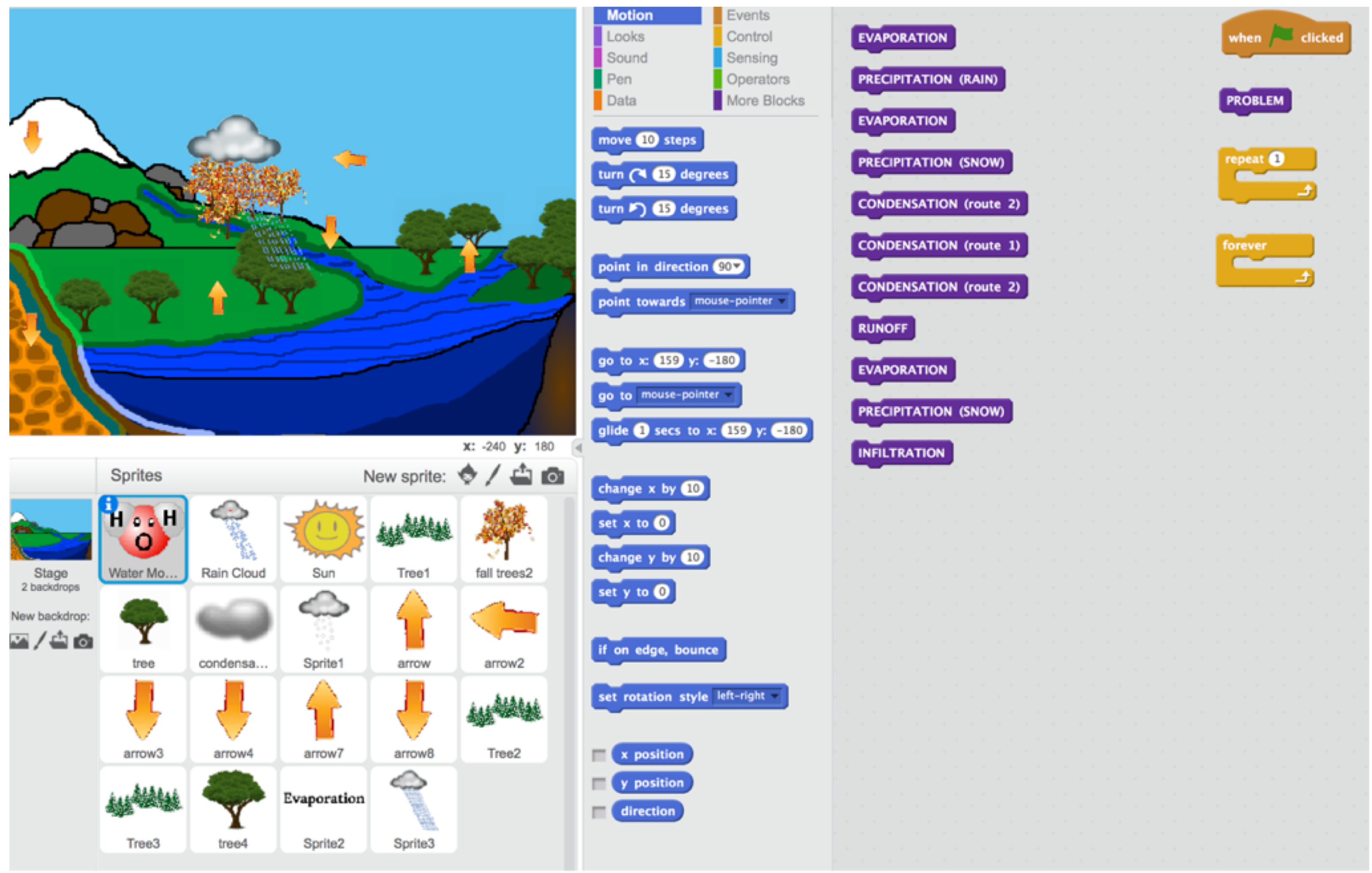
Examples of Simulations and Tasks in the Water Cycle Module



1. Manipulate the sliders and identify the factors that influence evaporation. What factors affect evaporation? Check the ones that apply. Note that you need to click on Reset! and go before you start exploring each factor.
   - ❑ Lake temperature
   - ❑ Land temperature
   - ❑ Relative Humidity
   - ❑ Speed of evaporation

2. Change the relative humidity to 15 %. Then change it to 75 %. What do you observe?
The higher the relative humidity, the (higher / lower) the rate of evaporation and the (higher / lower) the amount of water vapor.

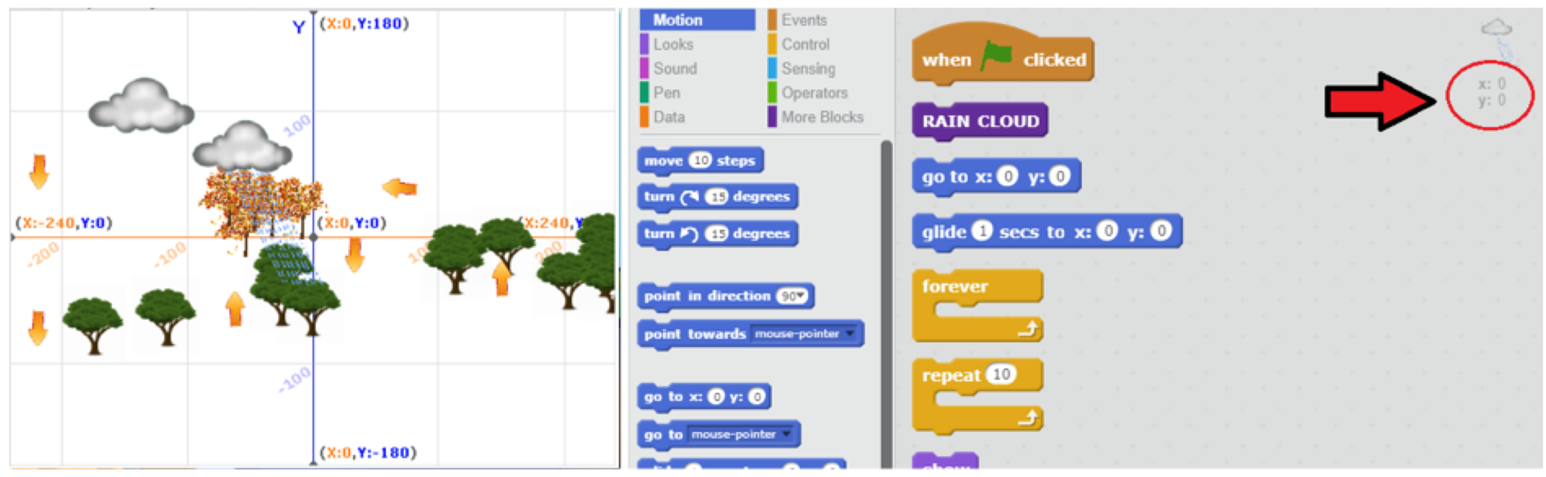
3. Change the lake temperature to 15 ^{o}F. Then change it to 75 ^{o}F. What do you observe?
The lower the lake temperature, the (higher / lower) the rate of evaporation and the (higher / lower) the amount of water vapor produced.



1. Let us help Water Molecule to move around the cycle. Combine the purple blocks to complete the Water cycle. Use all the purple blocks provided.

2. Use one of the yellow blocks to make the water molecule go around the entire water cycle 2 times without stopping.

3. Use one of the yellow blocks to make the water molecule go around the entire water cycle forever without stopping.



Use this block to move the rain cloud to the bottom right corner. What values did you use for *x* and *y*?

glide ◯ secs to x: ◯ y: ◯

go to x: ◯ y: ◯

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