Research-Practice Partnership-Designed Modules Integrating Computer Science into Middle School Earth, Life, and Physical Science: Outcomes from the Initial Design Process

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Research-Practice Partnership

Figure 1. Teachers, researchers, scientists, computer scientists, and staff came together for two full-day school year sessions and two summer weeks to design the initial modules. Photo taken by Laura Millay.

Background

This project develops and investigates an innovative model for preparing and supporting both pre-service and in-service science teachers in grades 6-8 to teach computing integrated with and applied to the practice of science. The model includes professional learning experiences for teachers, co-design of three modules (one each for grades 6-8) to integrate computing as a problem-solving tool into the existing life, Earth, and physical sciences curricula, and implementation, evaluation, and refinement of the modules. Classrooms participating in the project currently use the Science Education for Public Understanding Program (SEPUP) classroom materials for middle school science and are supported by the Maine STEM Partnership, a statewide STEM education research and professional learning community.

Module Design Process and Learning Outcomes

Design Process

Three teams of teachers, researchers, scientists, and computer scientists collaborated to develop integrated learning modules for life, Earth, and physical science during two full-day school year sessions and two summer weeks. The design process included sessions focused on computer science and science content, and design sessions with groups working to modify existing SEPUP science lessons to include computer science in ways that have potential for enhancing student learning of the science content.

Professional Learning

In computer science, 13 of 17 design process participants (76%) reported increasing comfort by a full Likert level or more as a result of the STEM+C project to date. This was a statistically significant shift ($p<0.001$, 2-tailed t-test); 16 of 17 (94%) reported that their definition of computer science had changed as a result of the STEM+C work.

In science content, 6 of 16 participants (38%) reported increasing their comfort with the science by a Likert level or more; also a statistically significant shift ($p=.02$, 2-tailed t-test).

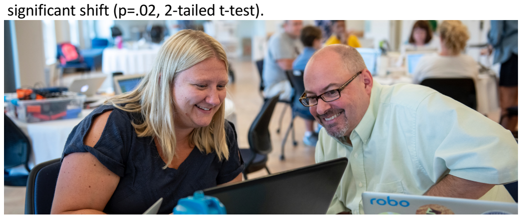

Figure 2. Collaborations during the module design weeks. Photo taken by Adam Kuykendall.

Project Goals

1. **Design, iterate, and evaluate integrated modules for teaching science and computer science as part of middle school life, Earth, and physical science.**
2. **Support teachers in learning and applying computer science and computational thinking and teaching integrated modules.**
3. **Rigorously study outcomes for students and teachers.**
4. **Distribute the refined integrated modules along with an effective model for supporting teachers throughout Maine and beyond.**

Key Features of the Integrated Modules

Earth Science and Computer Science: Continental Drift and Modifying/Debugging Code

Students use a simulation to place continents in former and current positions and to evaluate fossil evidence supporting the claim that the continents have moved over time. Then students modify and debug Scratch code to change the positions of the continents.

Figure 3. The Earth science module design team working on Scratch coding. Photo taken by Adam Kuykendall.

Which of the following statements provides evidence to support the claim that the continents were once joined, and have moved?

- ○ The same kinds of fossils are found in South America and Africa.
- ○ The same kind of rock layers are found in North America, Europe, and Africa.
- ○ GPS measurements show that Earth's plates are moving at a rate of centimeters per year.
- ○ The right edge of South America almost appears to fit the left edge of Africa as if it were a puzzle.
- ○ All of the above.

Figure 4. One of several questions used as a pre- and post-instruction assessment of student learning of science content within the Earth science module.

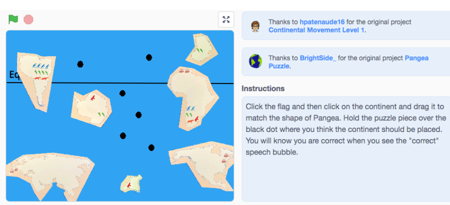

Figure 5. For the Earth science module, students use fossil evidence to manipulate puzzle pieces of the continents and match them into a single supercontinent. Students debug Scratch programs to fix the puzzle.

Life Science and Computer Science: Ecology and Estimating Populations Using Transects

Students program Edison Robots, then are introduced to transects and quadrats using a Scratch simulation. Students modify the simulation to create their own quadrats and see relationships between actual and average population counts. Then, students make a plan and gather data to see relationships between biotic and abiotic factors in ecosystems, use CODAP to analyze the data., and use a simulation to explore a model of predator-prey relationships.

Figure 6. The life science module design team demonstrating population estimates using quadrats and transects. Photo taken by Adam Kuykendall.

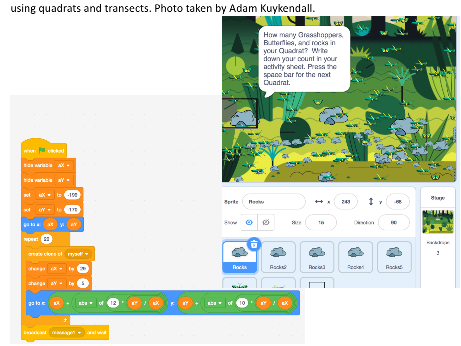

Figure 7. For the life science module, students use and modify a simulation to explore using quadrats and transects to make population estimates.

Physical Science and Computer Science: Studying Motion Using Edison Robots

Students practice programming Edison Robots, then gather data from Edison Robots moving at constant speed and graph the data using CODAP. Students continue to practice graphing data and interpreting graphs by programming their robots to run different courses, predicting what graphs of different programs will look like, graphing the data, and comparing their graphs and predictions.

Figure 8. The physical science module design team practicing with Edison Robots. Photo taken by Adam Kuykendall.

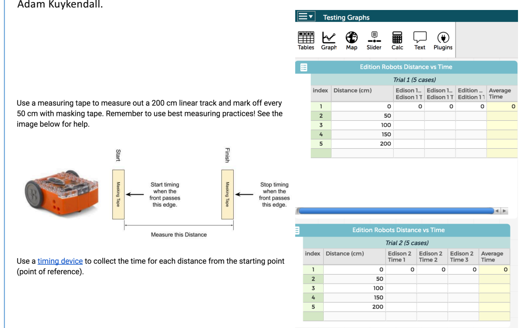

Figure 9. For the physical science module, students program Edison Robots, gather data, and create graphs using CODAP.

Next Steps

Integrated modules are being piloted during the 2019-2020 school year and data gathered to measure student learning of science and computer science, and students' attitudes toward STEM using both published and project-generated surveys[1-4]. School-year supports for teachers include supports for materials provided by project staff, teaching partners, and cohort meetings to be held during the school year. The modules will be modified during Summer 2020 based on feedback and other data and taught in additional classrooms during the 2020-2021 school year.

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Sources for Data Collection Instruments:
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[2] Computational Thinking Abilities Assessment for Students: Wiebe, Mott, Boyer, & Lester. (2019). Development of a Lean Computational Thinking Abilities Assessment for Middle Grades Students. In *SIGCSE* (pp. 456–461).
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