

BRIDGING BIOLOGY AND COMPUTER SCIENCE TO ENGAGE HIGH SCHOOL STUDENTS IN SOLVING REAL-WORLD PROBLEMS

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ABSTRACT

In our increasingly data-driven society, high school students must learn to integrate computational thinking with science practices in order to solve complex real-world problems. However, it is difficult for educators to design and implement integrated STEM / computer science curricula, because each side has little understanding of the terminology, key concepts, tools, and approaches that the other side has to offer. We have tackled this STEM / computer science integration problem for a particular STEM field, biology. We have created a transdisciplinary team of biologists, computer scientists, and educators, comprising high school and university faculty and students, to design and implement the integrated Bio-CS Bridge Curriculum. In this Innovative Showcase, participants will learn how our team uses a Citizen Science research project to motivate the curriculum, which engages students in using and developing computational tools and approaches to address a real-world environmental problem, pollinator decline and loss of biodiversity. Participants may join in if they wish on their own devices, as we demonstrate our mobile bumblebee - flower identification web app, visualize and analyze data in our publicly available database to generate and test biological hypotheses, and build and run simple ecological computer simulations. We hope to inspire others to use and adapt our curriculum, which will be freely available online, as well as to build transdisciplinary collaborations of their own.

Keywords: *biology, computer science, ecosystem, pollinator, biodiversity, transdisciplinary, webapp, simulation, visualization, curriculum.*

INTRODUCTION, RELEVANCE, AND SIGNIFICANCE

The need for integrating computational thinking and approaches with STEM practices in educating our youth has been emphasized by several major scientific organizations, particularly in the life sciences (American Association for the Advancement of Science, 2011; National Research Council, 2009, 2012). Our goal in developing the Bio-CS Bridge Curriculum has been to bridge and integrate scientific practices such as experimental design and hypothesis testing with computational approaches to data collection, analysis, and visualization, as well as modelling, simulation, and software design (Fig. 1), while engaging students by addressing a complex real-world problem, pollinator decline and loss of biodiversity. The curriculum is standards-based, and modular; it can be used in both introductory and advanced biology and computer science classrooms. Students can use our computational tools ‘out-of-the-box’, learn to modify them, or build their own tools, depending on the goals of a particular class and student background. The curriculum has been developed by a transdisciplinary team of computer science and biology high school teachers and university faculty with funding from the US National Science Foundation, and it is currently being implemented in seven high schools in Massachusetts, US.

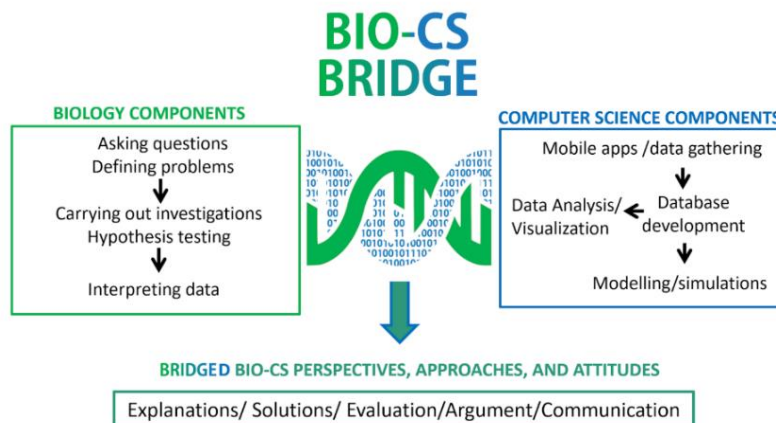


Fig. 1. Scientific practices and computational approaches are integrated in the Bio-CS Bridge curriculum.

GOALS, OBJECTIVES, AND IMPACT OF THE SHOWCASE

The Innovative Showcase will first provide a brief history of how our transdisciplinary team came together, and how we are using a university-driven Citizen Science research project to motivate an integrated biology / computer science high school curriculum. We will then provide an overview of the curriculum components, including both biology and computer science aspects. Participants will be introduced to the freely available curriculum, which is modular. Teachers and students can use ‘out-of-the-box’ components such as our web app, data visualization, analysis, and simulation tools to collect and analyze pollinator and flower data, and test hypotheses about ecosystems; and/or they can learn the programming skills to build their own simple agent-based simulations, learn web design, and develop web apps (Fig. 2). Participants are welcome to use our computational components as we go along during the session, and they will leave with curriculum that is ready to use in the classroom. Our overall goal is to inspire participants to use and adapt our curriculum, as well as to consider developing their own transdisciplinary teams and integrated curriculum.

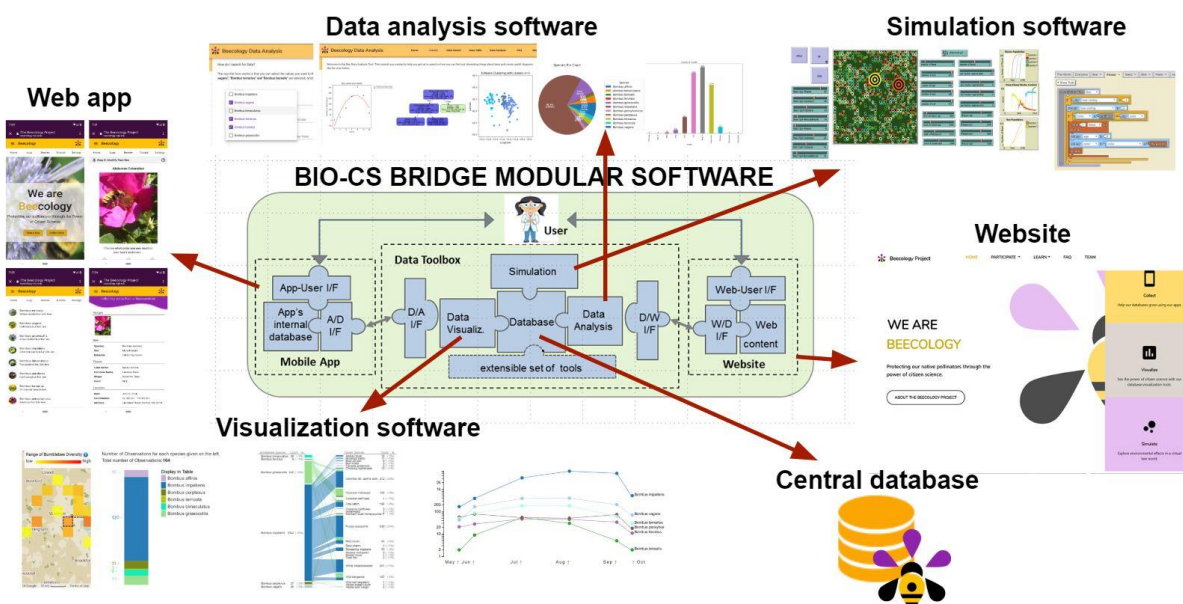


Fig. 2. The modular computational components of the Bio-CS Bridge Curriculum.

LOGISTICS

Relevant online resources:

Our project includes two web sites:

- The biocsbridge.wpi.edu site explains the Bio-CS Bridge Project, and highlights examples from our Bio-CS Bridge integrated curricular modules.
- The beecology.wpi.edu site describes the Beecology Citizen Science Project, on which our integrated curriculum is grounded. It is home to our bumblebee – flower identification web app, as well as visualization, simulation, and analysis tools.

Proposed time allocation: 90 minutes

1. Introduction to the Bio-CS Bridge Project (15 minutes)
2. Using the Beecology webapp to identify and log bumblebee-flower data from videos (20 minutes)
3. Hypothesis testing with Beecology data using visualization and analysis software tools (20 minutes)
4. Building and using computer simulations to make predictions about ecosystems (20 minutes)
5. Discussion: adapting the curriculum and building your own transdisciplinary team (15 minutes)

Modes of audience engagement:

- Participants can choose to simply follow along as we describe our transdisciplinary team and integrated curriculum approach and demonstrate our software tools and curriculum modules.
- Participants can choose to visit our websites during the session and use our web-based software tools as we demonstrate them, and they can download and run free simulation software.
- Participants can engage in a discussion on how they could adopt, adapt and/or extend (parts of) our university / high school collaboration and bridged curriculum frameworks to their own situations.

Maximum number of audience participants:

No limit

Special resources and requirements from the STEM 2020 organizers:

We just need wi-fi and a projector.

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