STEM+C: What is the need?

- **Need for fundamental change** in the teaching of biology in order to emphasize learning of core concepts rather than memorizing large numbers of facts.
- To learn to solve today’s complex problems, students should engage with scientific practices, including the process and interdisciplinary nature of scientific discovery, communication and collaboration, quantitative data interpretation, and experience with modeling, simulation, and systems approaches to biology — in short, computational thinking and approaches.
- To address this need, new standards for high school instruction require integrating scientific practices with computational thinking: STEM + C curriculum.
- But... it is difficult for educators to design and implement STEM+C curricula because they often have little understanding of the terminology, key concepts, tools and approaches that each side has to offer.

The Bio-CS Bridge Project

- We propose that fostering transdisciplinary teams among STEM and computer science educators and students at multiple levels (high school, post-secondary) is critical for developing highly effective STEM+C integrated curricula.
- Faculty teacher
- Curriculum must be highly modular to allow for integration with biology and CS classes, at levels from freshman intro to senior AP.
- Students are most engaged when they are involved in solving real-world problems they perceive to be important.

Research Questions

- **The need**: Integrating biological practices and computing approaches to teach students how to address real-world problems.
- **Our vision**: Transdisciplinary teams to build a modular curriculum.
- **Research Question 1**: Is developing a transdisciplinary, vertically integrated team comprised of biologists, computer scientists and education specialists a transformative precursor for the generation of effective computational tools and STEM+C curricula?
- **Research Question 2**: Will modular curriculum incorporating computing and computational thinking into scientific practices allow teachers to effectively deliver classroom content to students at multiple levels in biology and computer science?

The Bio-CS Bridge approach

- **Students engage in scientific practices using biological data that they collect themselves**.
- **Students design and implement computational tools to gather and analyze data**.
- **Students address a complex biological problem**: our example is pollinator decline and loss of biodiversity.
- **The strategy is generalizable**, and can be modified to address other biological questions, and even other STEM fields.

The motivating biological problem: Pollinator decline

- **Pollinator diversity is critical to ecological resilience**: plant-pollinator interactions provide food and habitat for many species.
- **Pollinators are declining in biodiversity and distribution**: partly due to many causes: pesticides, habitat loss, disease, invasive plant species.
- **Data is needed** on current distribution of pollinators, in particular native bumblebee species, and interactions with plant species.
- **Analysis of these data needed** to determine and mitigate factors important in decline.
- **Understanding the use of computational thinking and approaches to this important problem** will motivate students and prepare them to address other important societal problems.

Creating a Transdisciplinary Team

- **The Transdisciplinary (TD) Team**:
  - WPI faculty: 1 Bioinformatics, 1 Biology, 1 Computer Science, 1 Education
  - High School Teachers: 2 Biology, 2 Computer Science; 10 teacher integrators to be recruited for years 2 and 3
  - Graduate Students: 2 Bioinformatics, 1 Computer Science
  - Undergraduate Students: 1 Bioinformatics, 5 Computer Science
  - High School Students: 1 Computer Science
- **The entire TD Team** met four times during the academic year (3 hours/meeting) and will meet for 2 weeks in the summer.
- **The software development team**, led by Ruiz, Gegear, and Ryder and including all of the students, met weekly throughout the academic year and developed a suite of software tools (please see our Digital Arcade poster!)

Strategy and timeline

**Academic Year**

- **Year 1**: Development Curriculum System (all 3 years)
- **Year 2**: Curriculum development (1st & 2nd year) / feedback / development & team
- **Year 3**: Curriculum development (3rd year) / feedback / development & team

- **Teacher leaders** are an essential component of the TD team throughout the project — both during academic year and summers.
- **Summer Workshops**
  - Train teachers in the Bio-CS Approach, and the use and design of software tools
  - Taught by faculty first time; teacher leaders later train teacher integrators
  - Teacher leaders develop curriculum later in the summer with support of the TD team.
- **All teachers implement curriculum** during academic years 2 & 3.

TD Team meeting topics

- **Brainstorms**: getting on the same page
  - What is needed for a transdisciplinary team to succeed?
  - Communication / Mutual respect / Open-mindedness
  - What is computational thinking?
  - Abstraction / logic / strategies / tools / pattern finding / data analysis / prediction
- **Learning teachers’ needs**
  - Curriculum standards
  - Content of classes – replacing, NOT adding more material
  - Teachers learning to use and design simulations
  - Group discussion / refinement over several sessions: What should a curriculum module look like?
- **From our evaluator**: The team members draw from the knowledge of each discipline and representative to solve problems as they move forward in the development process.

Creating Modular Curriculum

- **What should a curriculum module look like? An illustration using our Simulation Component**
  - Module: Simulation of bees in a floral environment
  - **Plug and Play**: Using the simulation to test hypotheses in a biology classroom
    - Example Hypothesis: Invasive floral species will disrupt the ecosystem balance and lead to the loss of native bumblebee species
    - Use the simulation to create this scenario (by adjusting sliders)
    - Generate data for analysis
  - **Design**: Assembling a simulation to either a biology or a computer science classroom
    - Agent-based modeling:
      - Each type of ‘agent’ (e.g., bees, flowers) follows ‘rules’ based on biology
    - **Netlogo** - a simple block-based language for beginners
- **Modular structure**: can start from scratch, or add modules to a ‘starter sim’
  - Designing the simulation based on the biology
- **Resources**
  - Starter simulation, additional modules, complete simulation, all developed by WPI students
  - Biology background info on pollinator decline
  - Computer science background info; tutorials for both programming languages
  - Lesson plan developed by teachers

Accomplishments in our first 9 months

- **TD Team creation & development**
  - Suite of software tools designed and implemented (please see our Digital Arcade poster!)
  - Teacher training & feedback on simulation tools
  - Agreement on initial module ideas for the curriculum

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