A curriculum for advancing do-it-yourself (DIY) environmental sensing networks to monitor water quality and quantity in streams and rivers

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Introduction

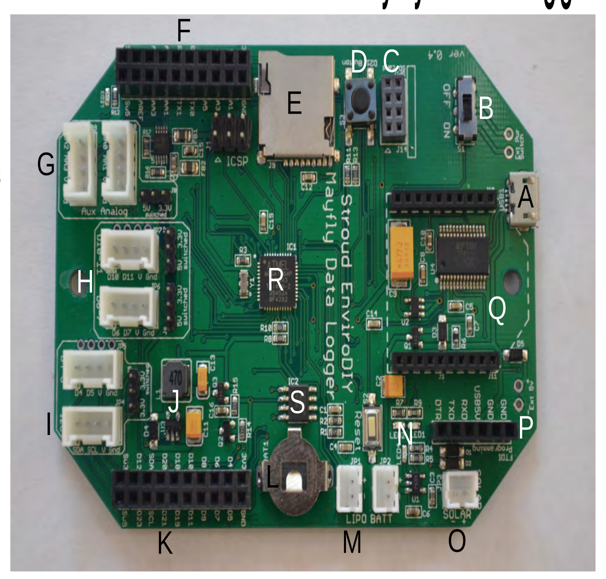
Here we present a Science, Technology, Engineering, and Math (STEM) curriculum targeted for secondary education that introduces an approach to building, customizing, and deploying real-time data logging environmental sensor kits. The curriculum uses the topic of water quality monitoring to introduce students to a diverse set of STEM topics and enables students to collect advanced water quality data on healthy and impaired waterways throughout the U.S. Students will develop skills in critical thinking, data interpretation, watershed science, and use of technology for scientific research. The technology that serves as the basis for the curriculum is the "EnviroDIY Mayfly Data Logger™", developed by Stroud Water Research Center™. The Mayfly board can be connected to a vast amount of sensors, which perform many monitoring components such as: water depth, air and water temperature, specific conductivity, turbidity, dissolved oxygen, precipitation, solar/light levels, and/or soil moisture. Students will learn about water quality and quantity and how naturally occurring conditions differ from human impacted conditions.

Science

Students will learn about water quality and quantity of local streams/rivers using the Mayfly board. Numerous labs have been developed as part of the curriculum to teach students to use the Mayfly boards in short-term experiments, as well as long-term deployments, to assess the physical, hydrological, and chemical dynamics of their study systems (e.g., stream, river, lake, or pond). The curriculum will lead students through the details of many of the natural and anthropogenic factors that affect both the quality and quantity of their aquatic ecosystem. Students will gain insight into how these variables respond to environmental conditions, how certain variables influence one another (e.g., water temperature effects on dissolved oxygen concentrations), as well as methods and procedures that can help to improve the quality of their aquatic ecosystem.

Features of the EnviroDIY Mayfly Data Logger

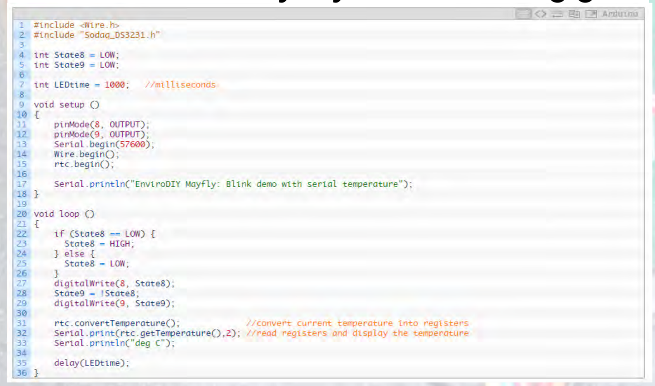
- A: MicroUSB port
- B: Power switch
- C: MicroSD connector
- D: Push button
- E: MicroSD card Socket
- F: 20-pin header for analog pins
- G: Auxiliary 16-bit Analog-to-Digtal Connectors
- H: Grove Digital ports
- I: I²C port
- J: 5V boost converter
- K: 20-pin header for digital pins
- L: Battery backup for real time clock
- M: LiPo battery connectors
- N: Red & Green LEDs
- O: Solar panel connector
- P: FTDI programming port
- Q: Bee Module Socket
- R: Processor
- S: Real time clock



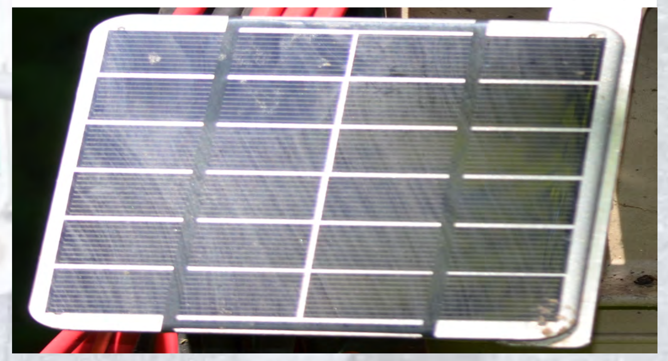
Technology

Students will begin exploration of their EnviroDIY Mayfly boards and the associated Arduino programming language before setting up long-term deployments. Students will gain insight into the basic programming that enables the board to communicate with sensors/probes and to transmit data to off-site databases. Simple code instructions will be included in the curriculum for students to get hands on experience into programming as well as learning basic programming syntax. Students will learn about loops, counters, input/output commands, using built in libraries, manipulating timers and many other basic programming skills and approaches. Students will also gain an understanding of digital versus analog inputs/outputs, as well as learn to use a solar panel/rechargeable battery system to power their Mayfly boards and the associated sensors.

Code for Mayfly Data Logger



Solar Panel Powering a Mayfly



Engineering

Students will need to fabricate waterproof housing for their Mayfly boards to ensure long-term sustainability of their deployment in the environment. Students will design cases for the Mayfly boards as well as adaptors and mounting hardware for various peripheral devices that are connected to the board. Students will have to find suitable locations for keeping their Mayfly boards dry and safe, setting up solar panels that ensure maximum efficiency and mounting sensors to ensure accurate readings while minimizing the risk for interrupted signals or environmental hazards (e.g., flooding, wild animal and human curiosity). Brackets and various other devices will be constructed and manipulated by the students to help with both short and long-term deployment and upkeep of the Mayfly boards.

Mathematics

Math skills are developed during units that introduce techniques for the management and analysis of time-series data recorded from environmental sensors. Using statistics, students will calculate regressions and residuals for their data and try to model predictions over longer periods of time. Students will use multi-degree polynomials as well as sine functions to model their data. Students will be asked to present their data in different formats using various algorithms and graphical analysis. While observing trends over time, students will gain a deeper understanding of the mathematics involved in long-term monitoring. Using these models, students will begin to predict trends and identify possible solutions to stream/river management issues, while avoiding major pitfalls such as over-extrapolation and using short-term models to predict long-term effects.