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Hands on Math Modeling through Building and Programing Intelligent, Adaptable Display Systems with LEDs and Arduinos

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Todd France is the director of Ohio Northern University's Engineering Education program, which strives to prepare engineering educators for grades 7-12. Dr. France also helps coordinate the first-year engineering experience at ONU. He earned his PhD from the University of Colorado Boulder in Architectural Engineering, and conducted research in K-12 engineering education and project-based learning.

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Dr. Hylton is an Assistant Professor of Mechanical Engineering and Coordinator of the First-Year Engineering experience for the T.J. Smull College of Engineering at Ohio Northern University. He previously completed his graduate studies in Mechanical Engineering at Purdue University, where he conducted research in both the School of Mechanical Engineering and the School of Engineering Education. Prior to Purdue, he completed his undergraduate work at the University of Tulsa, also in Mechanical Engineering. He currently teaches first-year engineering courses as well as various courses in Mechanical Engineering, primarily in the mechanics area. His pedagogical research areas include standards-based assessment and curriculum design, including the incorporation of entrepreneurial thinking into the engineering curriculum and especially as pertains to First-Year Engineering.

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As math modeling is a critical component of engineering, it is important for first-year students to become comfortable and proficient with basic math modeling skills and concepts. To help support student understandings, a multi-day activity was facilitated in a first-year multidisciplinary engineering course.

1. *Construction of circuit*
   Students learn to solder LEDs, resistors, and a pin header to a premade programmable circuit board (PCB; see Figure 1). This circuit has six LED lights connected to a common ground. An Arduino microcontroller can be connected to turn each LED on, allowing them to be used as a simple one-row display. For this activity, the LED row is used to display a linear scale.

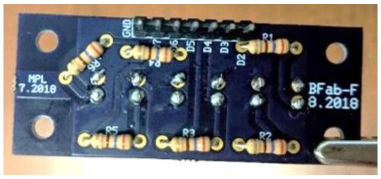

Figure 1: Back of PCB with resistors and pin header shown

2. *Basic programming*
   Students follow "complete the code" activities via a self-paced basic programming guide. The guide walks them through the setup of a potentiometer to control the number of lit LEDs.

3. *Data collection*
   Using a light dependent resistor (LDR), photometer, flashlight, computer, Arduino, and their PCB, students collect data. They first write a program that outputs the voltage drop that the Arduino reads across the LDR. Students then collect varying illuminance values (measured in foot-candles or lux) and pair this information with the voltage drop at each corresponding light level.

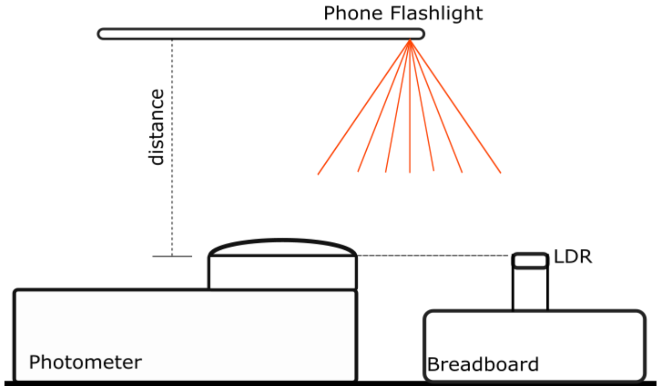

Figure 2: Basic experimental setup

4. *Modeling*
   Students use Excel to generate a regression line with the collected data. Students are given a prompt which tasks them to light of the LED bar as a percentage of maximum light (e.g., increments of 20 foot-candles light up each successive LED). Students write the program to turn on the appropriate number of LEDs compared to what the LDR sees.

Outcomes

Students gain experience with soldering, basic Arduino programming, and experimentation. In addition, students use math modeling to create a device that models information instantaneously. Prior to this activity, students apply math modeling concepts to solve static problems, such as optimizing a solution; creating a dynamically-changing device that functions with variable data adds a layer of complexity and engagement.