Teaching Teamwork:
Learning Electronics in a Collaborative Environment

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Teaching Teamwork
What is this project about?

≠ Not so much teaching teamwork, as in assessing it.
≠ Really assessing teamwork, not so much the content.
≠ Tasks involving collaborative problem solving.
≠ Evaluating the contributions of individuals who are asked to solve a problem as a team.
≠ We want to identify the “team players,” the “leaders,” the “followers,” the “freeloaders,” the “saboteurs,” etc.
I’ll discuss:
- Background for project
- Description of project
- Timeline for project
- Different activities in this project
- Challenges/Findings of the project
- Future for project
- Demo activities

Project Background

**CAPA** (Computer-Assisted Performance Assessments). Developed simulated performance assessment tasks in introductory electronics to provide evidence of student understanding (better than paper/pencil test).

**SPARKS** (Simulated Performance Assessments for Related Knowledge and Skills). Encouraged learning by using assessments with improved simulated activities repeatedly.

**TT** (Teaching Teamwork). Develop simulated hands-on activity-based assessments to collect, analyze, and quantify evidence and effects of collaboration on students.
Our Team

* Concord Consortium
  Concord, MA

* CORD
  Waco, TX

* TCC
  Virginia Beach, VA

* ETS
  Princeton, NJ

Project Description

* NSF-funded project: July 2015 – June 2017

* Goals: Seek how to encourage, measure, and facilitate collaboration among students.

* Web-based software connects students in diverse locations to solve realistic electronics problems.

* Computer “looks over students’ shoulders,” logs every action and chat exchanges, saved on central server.

* Trying to develop a semi-automatic analysis of logged data.
Project Timeline

**Year 1:** Develop Activity 1, pilot test, revise, initial analysis and interpretation of logged data.

**Year 2:** Revise Activity 1 to perfect data logging and interpretation. Develop, pilot test, revise Activity 2, and perhaps Activity 3.

**Year 3:** Revise Activity 3. Field test activities with multiple schools, analyze data, submit final report.

So let’s look at the activities…

Project Activity 1

Series-resistance problem.

**Given:** A battery and four resistors in series; DMM.

Each student can manipulate DMM and their one R on a breadboard.

Battery and one R are “external,” with unknown values.

On-screen calculator

**Goal:** Collaborate to obtain specified voltages across R₁, R₂, R₃.

We log every action and chat of the students.
**Project Activity 2**

Connect microcontrollers.

- 10-digit keypad must light 7-segment LED digit via three microcontrollers.
- **Student 1**: Wires keypad to microcontroller that interprets key press row/column.
- **Student 2**: Wires the key-press row-column value to microcontroller that converts to binary value.
- **Student 3**: Wires binary value to microcontroller that lights proper segments for corresponding digit.
- We log *every action and chat*.

**Project Activity 3**

Elementary logic gates (AND, OR, NOT)

- Gates must be connected to perform specified functions, e.g. XOR or “adder”.
- **Student 1**: Connects NOT and AND gates to provide input for Student 2.
- **Student 2**: Using inputs from Student 1, connects OR gates.
- We log *every action and chat*. 
Project Challenges

- Realistic simulations and user interface
- Log everything possible, and manage the data
  - Student actions: mouse click, mouse drag
  - Value changes (e.g., resistance)
  - Chat text (by whom, when, to whom, info?)
  - Calculator actions
  - Confidentiality (no names, unique identities)
- Data
  - Granularity: millisecond → LOTS of data!
  - Store and identify each bit of data
  - Understand each bit of data

Activity 1:
Five Levels of Difficulty

1. Battery E given, Resistor R = 0, Goals V1 = V2 = V3.
2. Battery E given, Resistor R given, Goals V1 = V2 = V3 (all same).
3. Battery E given, Resistor R given, Goals V1 ≠ V2 ≠ V3 (not same).
4. Battery E not known, Resistor R given, Goals: State E, V1 ≠ V2 ≠ V3 (not same).
5. Battery E not known, Resistor R not known, Goals: State E and R, and V1 ≠ V2 ≠ V3 (not same).
When the group has achieved each of their goal voltages, one of them can click the ‘We got it!’ button!

Each member receives the congratulations.

They are ready to move on to the next level!

Students learn (hopefully!) that achieving the goals requires communication and cooperation.

How well did they communicate and cooperate?
What We Are Learning

- Even simple tasks (like resistors in series) can be challenging—even more so when collaborating.
- Orientation video reduces User Interface (UI) confusion that “muddies” good data.
- Confidence and more reliability comes with increasing levels of difficulty.
- Students need a big picture view without exposing too much info.
- Analyzing chat data is hard, but not impossible.
- Details of task ontologies will facilitate analysis.

Most surprising finding…

- Students are SMARTER than we think!
- In Activity 1, some groups solved the hardest level 5 in a few seconds, with NO chatting (i.e., no visible collaboration).
- Surprise! They were solving the problem like a video game! Students dragged their resistor sliders back and forth to stay close to the goal voltage. They behaved like a “voltage regulator!”
- Our Fix? Replace “slider” with “pick list.”
Examining the Logfile

- Raw log files contain LOTS of information!
  - User and group info, activity level, time of entry
  - Event type (changed circuit, attached probe, detached probe, DMM measurement, DMM knob change, sent message, etc.)
  - Event values (message text, each circuit’s voltage, resistance, DMM setting, DMM display value, probe location, etc.)

Closer analysis reveals some emerging patterns.
- Messages exchanged via chat window
- Measurements made with DMM
- Changes to the circuit (R-values, lifting of wires)
Pre-surveys
- **Personal information**: *username*, age, sex, race, native language, % spoken at home, school, mother's education, books at home, number of siblings, several personality traits rating, etc.

- **Reading the Mind in the Eyes**
  Estimating “social intelligence.”
  Hateful? Jealous? Arrogant? Panicked?

Post-survey
- *username, team name*
- State Ohm's law.
- Solve some problems: R1 and R2 in series, R1-R2-R3 in series, R1-R2-R3 in parallel, etc.
- Reactions to today’s simulation, collaboration, teammates, etc.
Next Steps…

- We are just starting to collect data from Activity 2.
- Activity 3 is not yet complete.
- Data analysis engine is undergoing revision.
- Seeking Pilot sites for Fall 2016 and Spring 2017:
  - “Intro Electronics” classes
  - “Intro Microprocessors” classes
  - “Intro Digital Logic” classes

The Project Continues

- Year 3: challenging work begins…
- Piloting modules with students.
- Collecting and analyzing the voluminous log data.
- …from three very different activities!
- If you wish to know more about this project, and/or wish to be a pilot site and contribute data from your students, please contact:
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