DATA COLLECTION USING THE LEGO® MINDSTORMS PLATFORM

Presented by:

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Friday, 10/30/2015 2:15-3:15

- Description:
  - LEGO has sold millions of their MindStorms robotics kits, but almost no one is using its most powerful tool... data collection.
  - The system allows for data logging from any of attached sensors, and there are over 70 to pick from. The data is available for real time analysis, manipulation or downloading and storage as your own spreadsheet.
  - Now your students can collect and do the math on their own data! Learn how to use this simple but powerful tool.

DATA LOGGING:

- The data logging feature in MindStorms is basically LabView from National Instruments
- The data logging feature comes on the Educational version of MindStorms but NOT on the commercial version of MindStorms
- Commercial LabView:
  - $999
- Student version LabView:
  - $19.99
- Included in the MindStorms Educational software

DATA LOGGING:

- With data logging you can use the EV3 (and the NXT) to collect data.
- For each sensor attached to the EV3, you can specify how often you want to sample
  - Take samples every:
    - 1/1000 of a second
    - 0.5 seconds
    - 180 seconds (3 minutes)
    - 3600 seconds (1 hour)
    - 86400 seconds (1 day)
    - And everything in between
  - You can take multiple inputs for each sample time
    - Check Light values and Temperature values at the same time
  - You can set the length of sample time (from a second to a year)

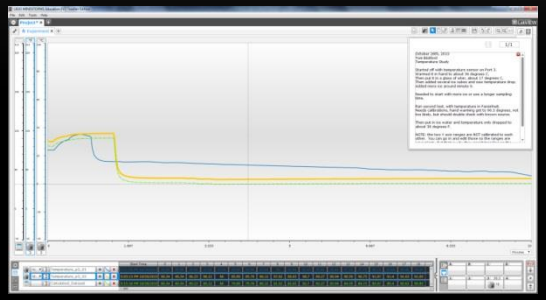
HOW MANY INPUTS?

- Both the NXT and the EV3 allow for 4 sensor inputs, therefore you can sample all four sensor ports for data.
- If needed, you can also sample motor angle measurements to allow for additional data input (if you can configure your experiment to need that kind of input)
  - This allows for 3 additional rotational sensor (motor) inputs on the NXT and
  - 4 additional rotational sensor inputs on the EV3

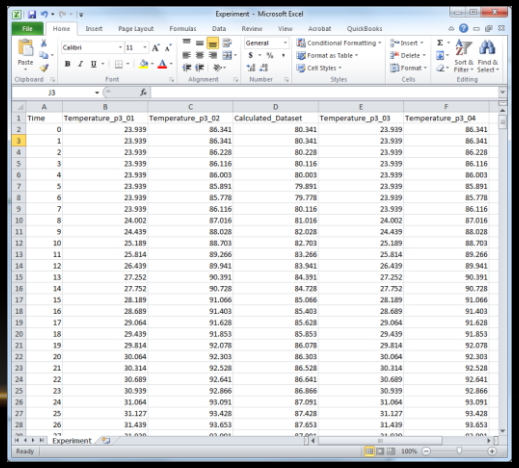
- The NXT has no internal clock, therefore it will simply list the samples in an array
- The EV3 has an internal clock, therefore it will have a time stamp for the dataset, but only on the EV3 or the saved dataset on the computer, this does NOT exort with the dataset, so experiment notes are important.
  - 600 samples over 6 seconds? Or over an hour? The graph looks the same, but the evaluation might be totally different.

EXPERIMENT:

Data Acquisition



Raw Data



Equipment & Design

WHAT ARE THE LIMITS?

- SENSORS:
  - There are at least 4 vendors that supply different sensors for the NXT and EV3
  - NXT sensors can be used with the EV3, and probably the other way as well
- DATASETS
  - The NXT has more limited memory for long term data storage but you can get between 1,000 and 2,000 stored data points.
  - The EV3 has a lot more memory and could easily collect data (unconnected) for a long, long time.
- Both the NXT and the EV3 can be operated as tethered data collectors (connected to the computer, with real time display)
- Or as stand alone portable data collection systems.

LEGO SENSORS:

- no adapter needed
- NXT Light Sensor
- NXT Sound Sensor
- Color Sensor
- Touch Sensor
- Ultrasonic Sensor
- Temperature Sensor
- Infrared Sensor

HITECHNIC SENSORS (NO ADAPTER NEEDED):

- no adapter needed
- Angle Sensor
- Acceleration / Tilt Sensor
- Barometric Sensor
- Color Sensor V2
- EOPD (Electro Optical Proximity Detector)
- Force Sensor
- Gyro Sensor
- IRLink Sensor
- IRReceiver Sensor
- PIR Sensor (passive infra-red)
- Compass Sensor
- Magnetic Sensor
- IR Seeker Sensor

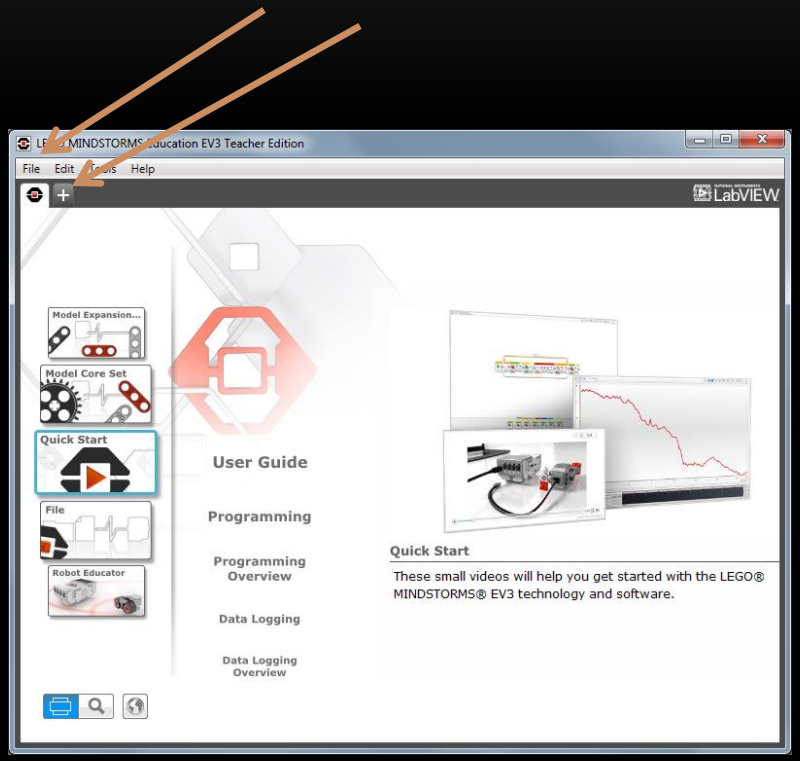
LOGIT SENSORS:

- LogIT to NXT adapter
- 100mV signal adapter
- Adjustable pH amplifier
- Adjustable pH amplifier & probe set
- Air pressure sensor
- Ammonium electrode
- Barometric air pressure sensor
- Bromide electrode
- Calcium electrode
- Carbon Dioxide
- Chloride electrode
- Colorimeter
- Conductivity sensor
- Current Measurement set
- DO2 spare membranes
- ElectroSmog sensor
- Flouride electrode
- Force sensor
- General Light level sensor
- HiTemp
- Humidity sensor
- HumiPro sensor
- Infrared sensor
- Infrared source
- ION/ORP Redox adapter
- K-Type Thermocouple adaptor
- Light gate set
- Light level sensor with lens
- Light switch sensor
- Linear accelerometer sensor
- LUX sensor
- Magnetic Field sensor
- Magnetic switch
- Movement & Position sensor
- Nitrate electrode
- pH amplifier
- pH Coax to BNC adapter
- pH electrode
- pH electrode & amplifier set
- Pressure mat set
- ProTemp & molded extension
- ProTemp temperature sensor
- Pulse monitor
- Push switch
- Radioactivity sensor
- Reflective light switch
- Serial balance adaptor
- Single light gate
- Sound level sensor
- Sound wave sensor
- Spare membrane set
- SPX LUX sensor
- Start/Mark switch
- Stream flow sensor
- Submersible Dissolved Oxygen Probe
- Sulphide electrode
- Ultrasonic Ranger VS sensor
- Ultraviolet light sensor
- Voltage Measurement set
- Weather station adapter
- Wireless Heart receiver

VERNIER SENSORS:

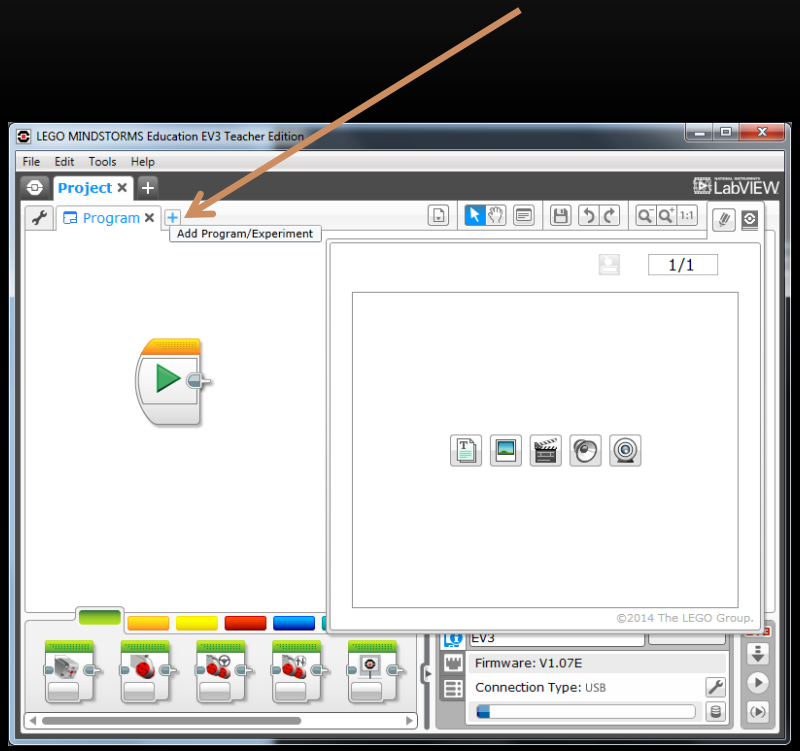
- Vernier to NXT adapter
- Accelerometers
- Anemometer
- Barometer
- Blood Pressure Sensor
- Charge Sensor
- CO2 Gas Sensor
- Colorimeter
- Conductivity Probe
- Current Sensors
- Davis Weather Stations
- Diffraction Apparatus
- Digital Control Unit
- Dissolved Oxygen Probes
- Drop Counter
- EKG Sensor
- Electrode Amplifier
- Ethanol Sensor
- Flow Rate Sensor
- Force Sensors
- Goniometer
- Gas Pressure Sensor
- GPS Sensors
- Hand Dynamometer
- Hand-Grip Heart Rate Monitor
- Instrumentation Amplifier
- Ion-Selective Electrodes
- Light Sensor
- Magnetic Field Sensor
- Melt Station
- Microphone
- Mini GC Plus Gas Chromatograph
- Motion Detectors
- O2 Gas Sensor
- Ohaus Balances
- ORP Sensor
- pH Sensors
- Photogate
- Polarimeter (Chemical)
- Power Amplifier
- Projectile Launcher
- ProScope USB Microscopes
- Pyranometer
- Radiation Monitors
- Relative Humidity Sensor
- Respiration Monitor Belt
- Rotary Motion Sensor
- Salinity Sensor
- Sound Level Meter
- Soil Moisture Sensor
- Spectrometers
- Spirometer
- Temperature Sensors
- Time of Flight Pad
- Turbidity Sensor
- UV Sensors
- Voltage Probes
- Watts Up Pro
- Wireless Dynamics Sensor System

TO START AN EXPERIMENT:



- Select:
  - FILE
    - New Project
      - Experiment
  - Or click the “+” tab at the top

SWITCH TO EXPERIMENT:



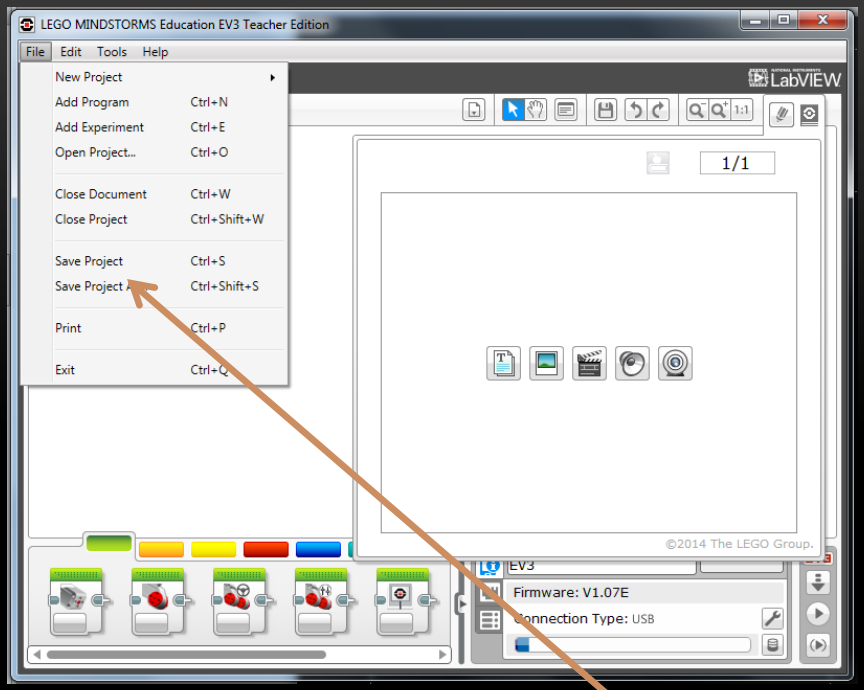
- If you already have a Project going, you can select the “+” tab in the second tier of tabs and you’ll see you have the option for:
  - Program (running the controller) or
  - Experiment (data logging)
- You can run a controller program and do data collection at the same time.

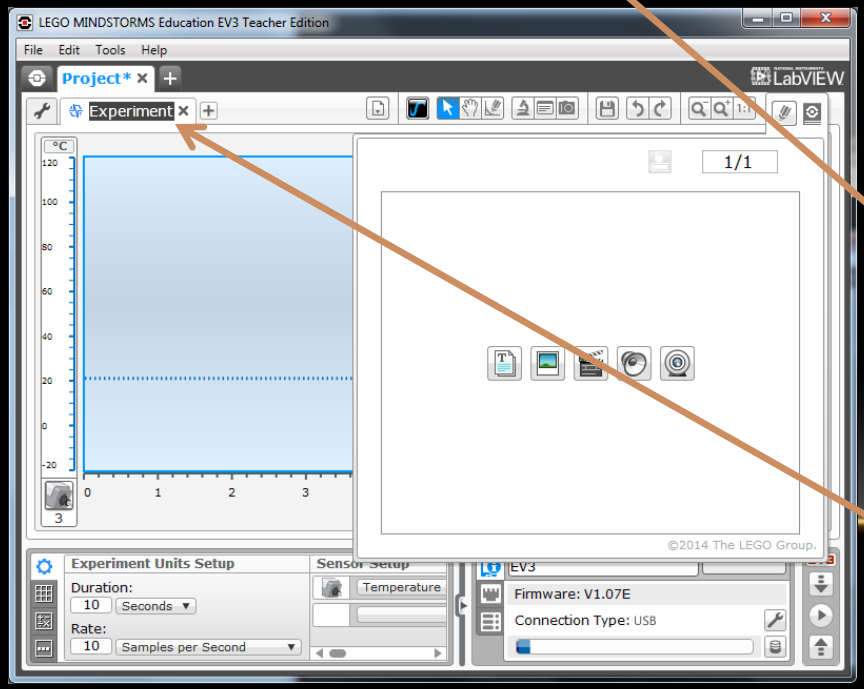
EXAMPLE OF HAVING A CONTROL SYSTEM AND DATA COLLECTION: GREENHOUSE CONTROL SYSTEM

- Data collection:
  - Zone air temperature
  - Zone soil temperature
  - Soil moisture
  - Humidity
  - Wind direction

Feedback

- Controlled components
  - Ventilation fans
  - Passive vents
  - Watering system
  - Heating system
  - CO_2 content



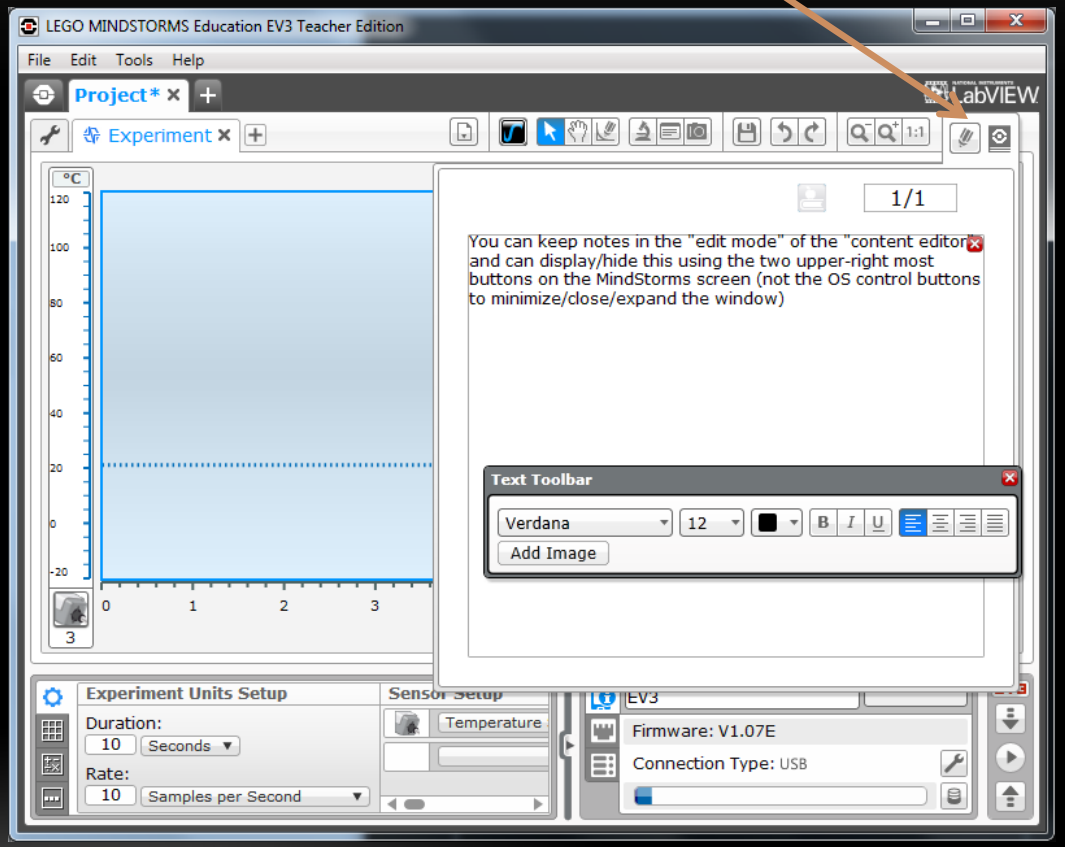


NAMING PROJECT AND EXPERIMENT:

- The Project is the overall name and can have a number of experiments and programs within it.
- The Experiment or Program are more specific.
  - An Experiment will likely be a date and time specific evaluation and collection of data, so name accordingly.
- For example:
- Project: Tom's Weather
- Experiment: 10-30-15weather
- Use FILE – SAVE PROJECT AS to rename a project from the default "Project"
- Experiments and Programs can be renamed by clicking in their name and typing in the new name.

USING THE CONTENT EDITOR:

- Built into the system is the ability to append information to your projects, including:
  - Text
  - Sound
  - Video
  - Images
- You can select/hide these features using the two buttons on the upper right corner of the MineStorms interface (not the control buttons to minimize/close/expand the windows)

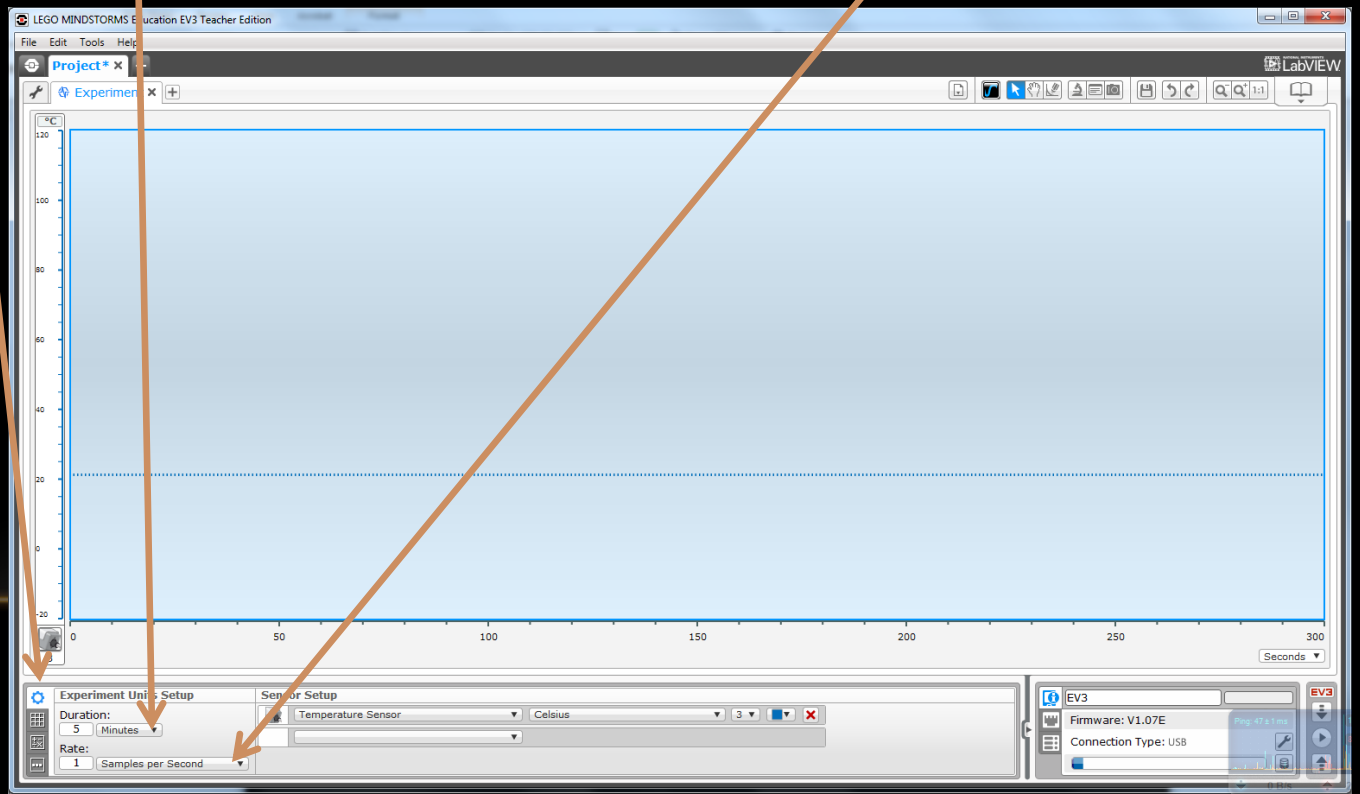


NEW EXPERIMENT:

- Define what you want to do:
  - “Measure the temperature at which water freezes, using an ice bath”
  - OR “Determine if adding salt to a ice water bath will change it’s freezing temperature
  - NOTE: while you aren’t freezing water, a water bath at equilibrium is at 0 degrees C or 32 degrees F
- Determine what you will need:
  - Styrofoam cup
  - Water
  - Ice
  - Salt
  - Teaspoon
  - EV3
  - Temperature sensor
  - Connecting wire for sensor
  - USB wire back to computer

SET BASIC VARIABLES:

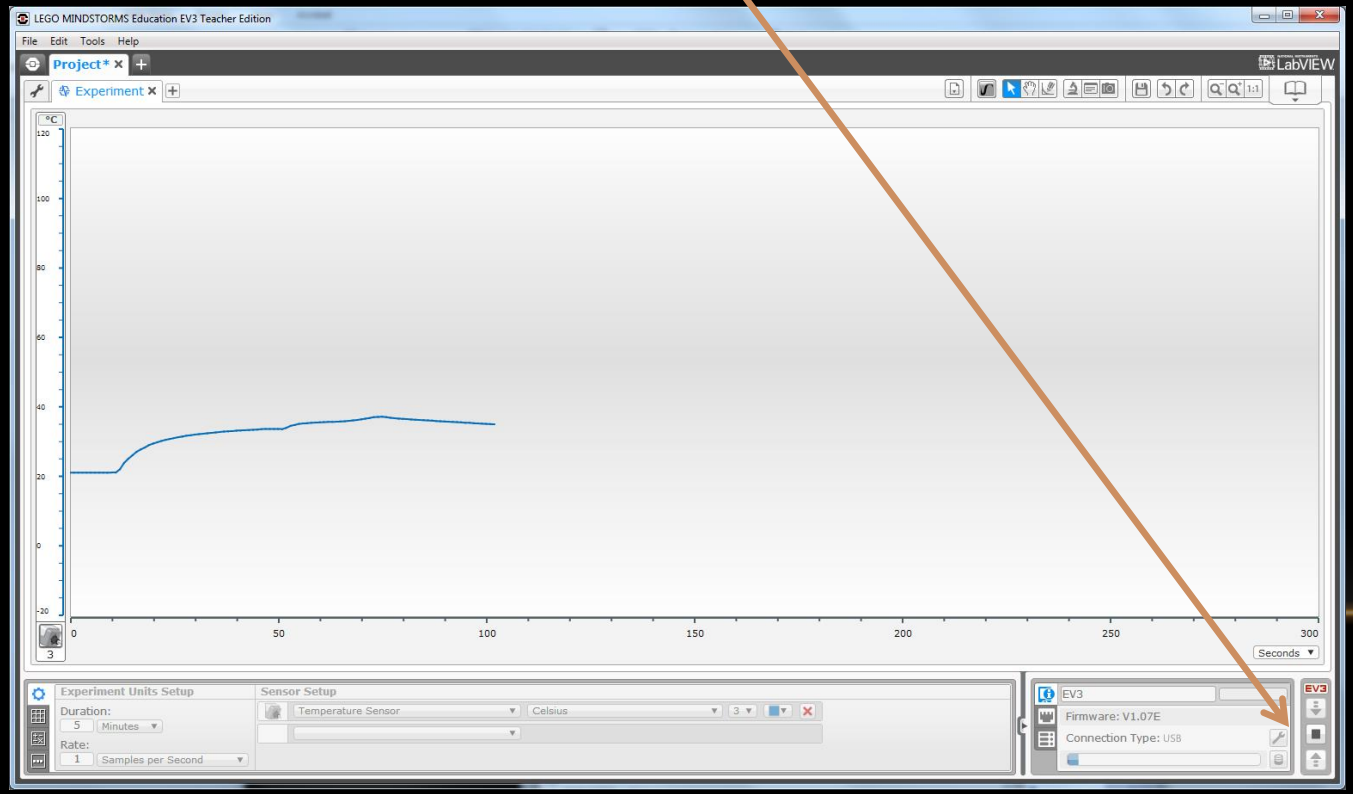
- The EV3 will automatically sense the temperature sensor when plugged in. The NXT has to be told where to look.
- Determine the DURATION of the experiment
  - I'm going to use 5 minutes
- This is done in the Experiment Configuration tab on the lower left
- Determine the RATE of the experiment (how many data samples per second or how many seconds between data samples.
  - 1/second = 60 samples per minute
  - 5 seconds between = 12 samples per minute
  - I'm using 1 sample per second



STARTING THE DATA:

- Click the PLAY button in the lower right corner in the EV3 Brick Information

- The program gets downloaded to the EV3 and then data starts to flow. The program will run until you:
  - Stop it (either on the EV3 or by hitting the STOP button on the computer)
  - The experiment completes
  - Or the battery runs out

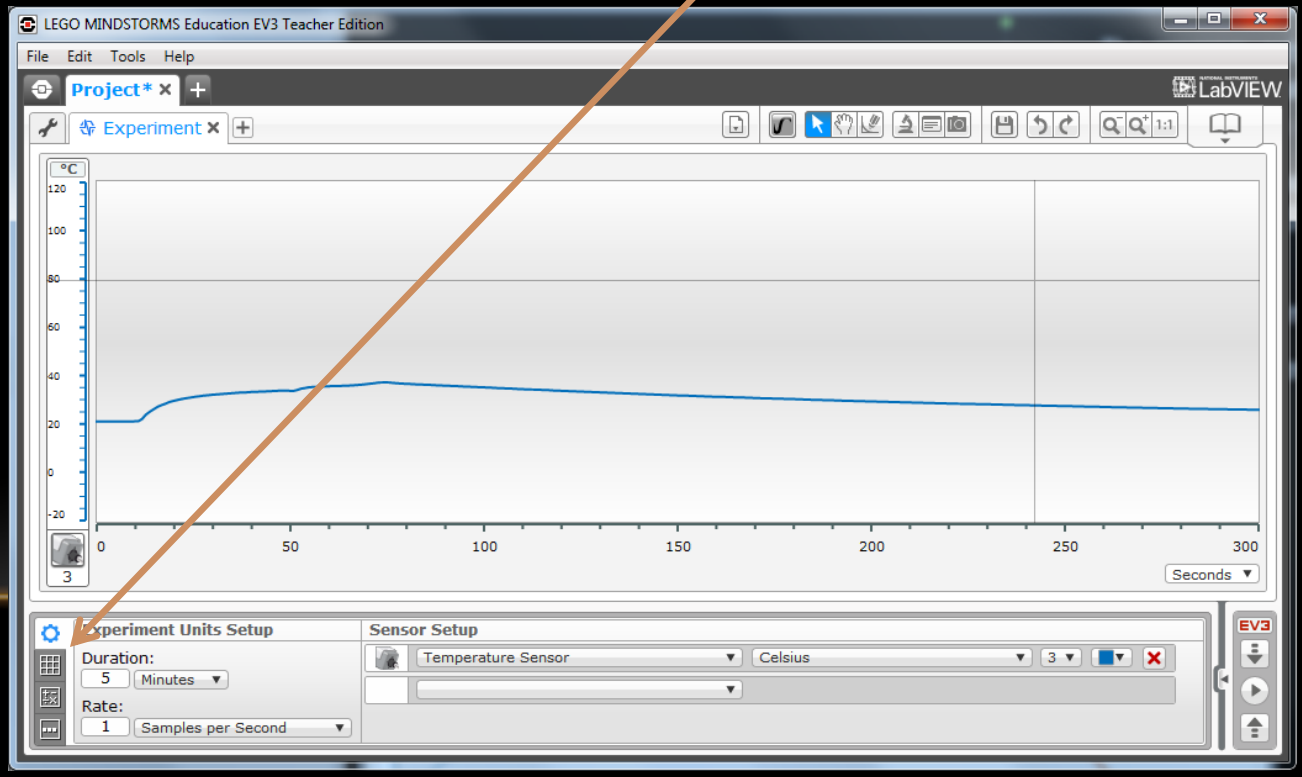


NOTE: Once downloaded, the program can be run independently on the EV3 for later upload. So you don't have to stay tied to the computer.

Oops, shows already playing
Would look like the > play button

A COMPLETED EXPERIMENT/DATA COLLECTION:

- Notice that the EV3 buttons on the lower right are back to “download” “Play” and “upload”
- Notice the set of data on the screen
- Now let’s look at the data, click the dataset table tab on the lower left



ON THE DATASET TABLE:

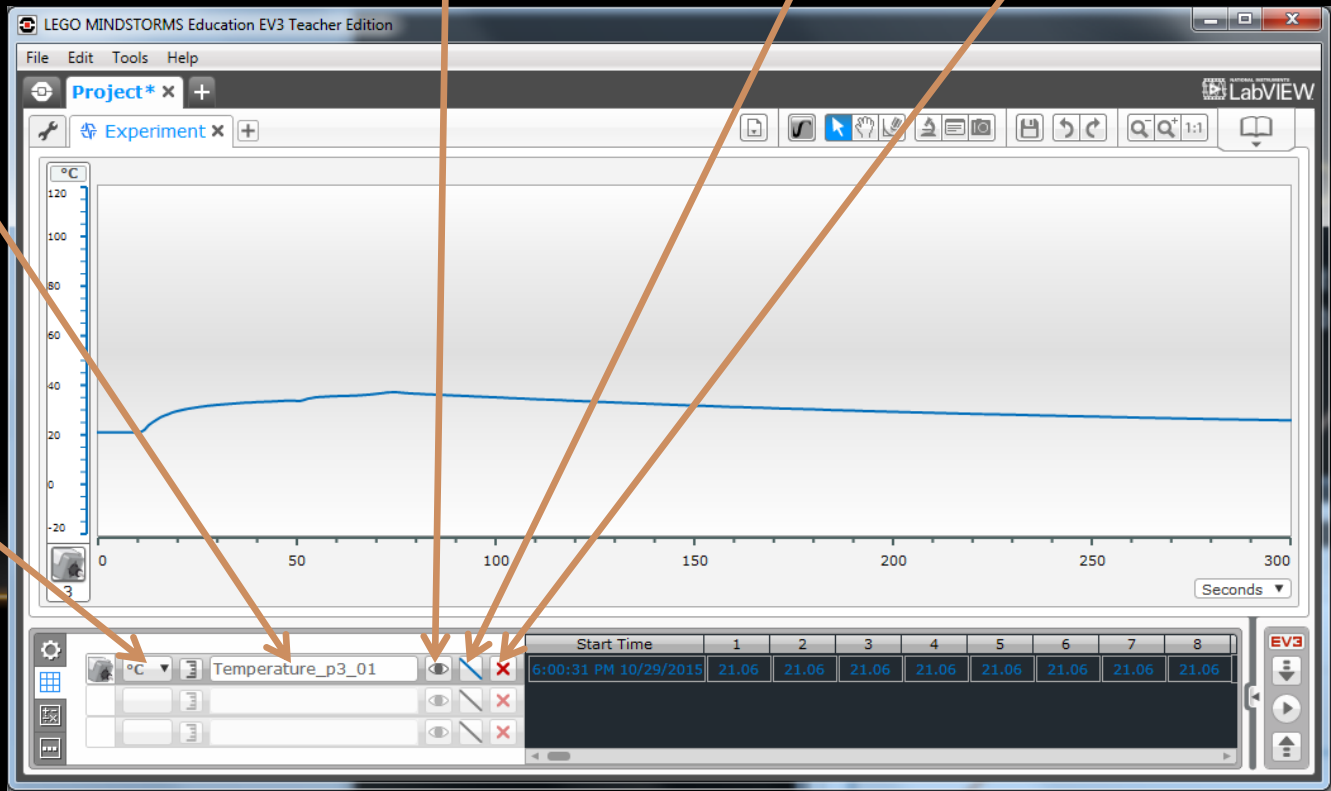
You can change the name of the dataset (hey _01, _02, _03 gets old quickly)

Make the dataset visible/invisible on the chart

Change the line color For the dataset

Delete the data set

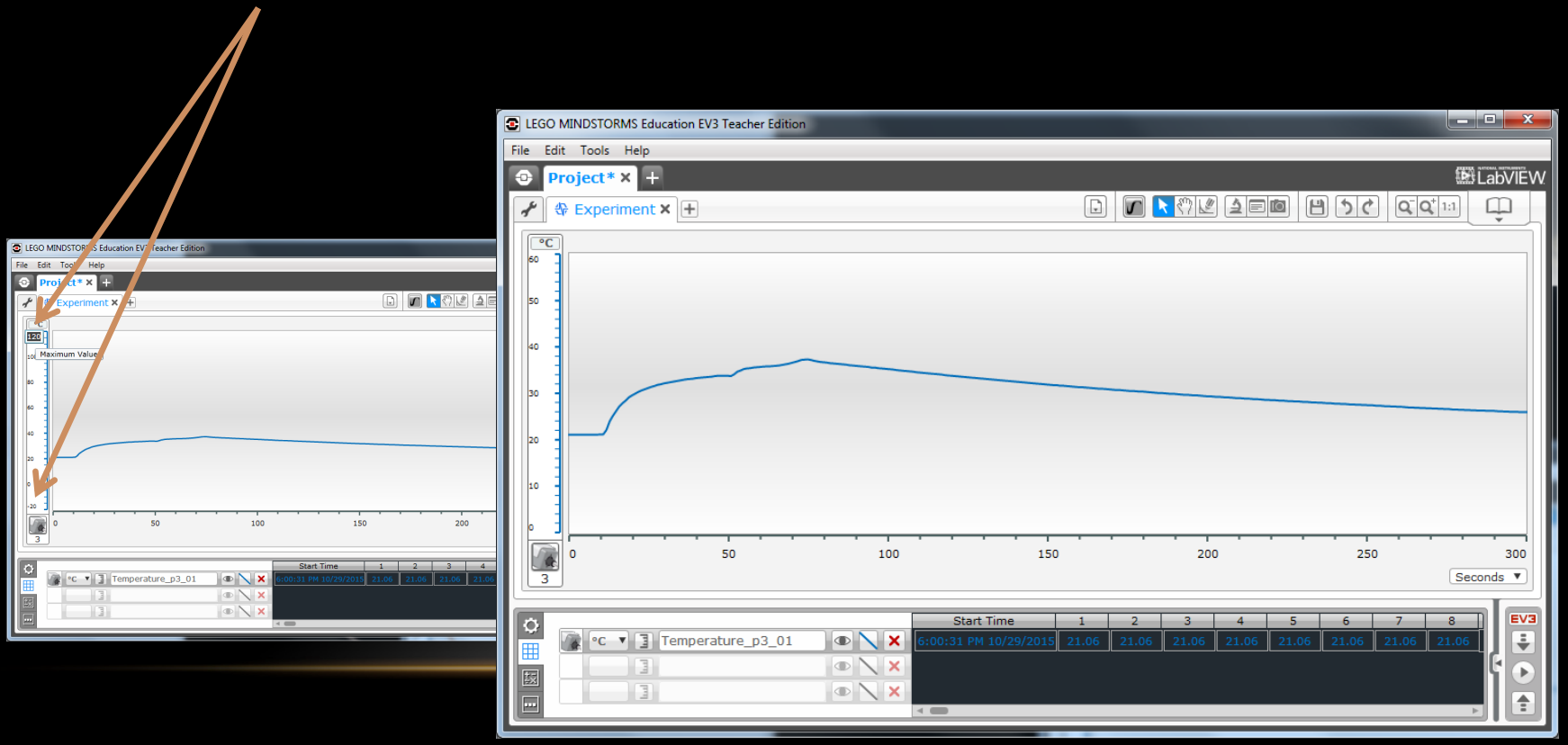
- You can change sensor condition (like F or C)



CHANGING THE MAX/MIN OF THE AXIS:

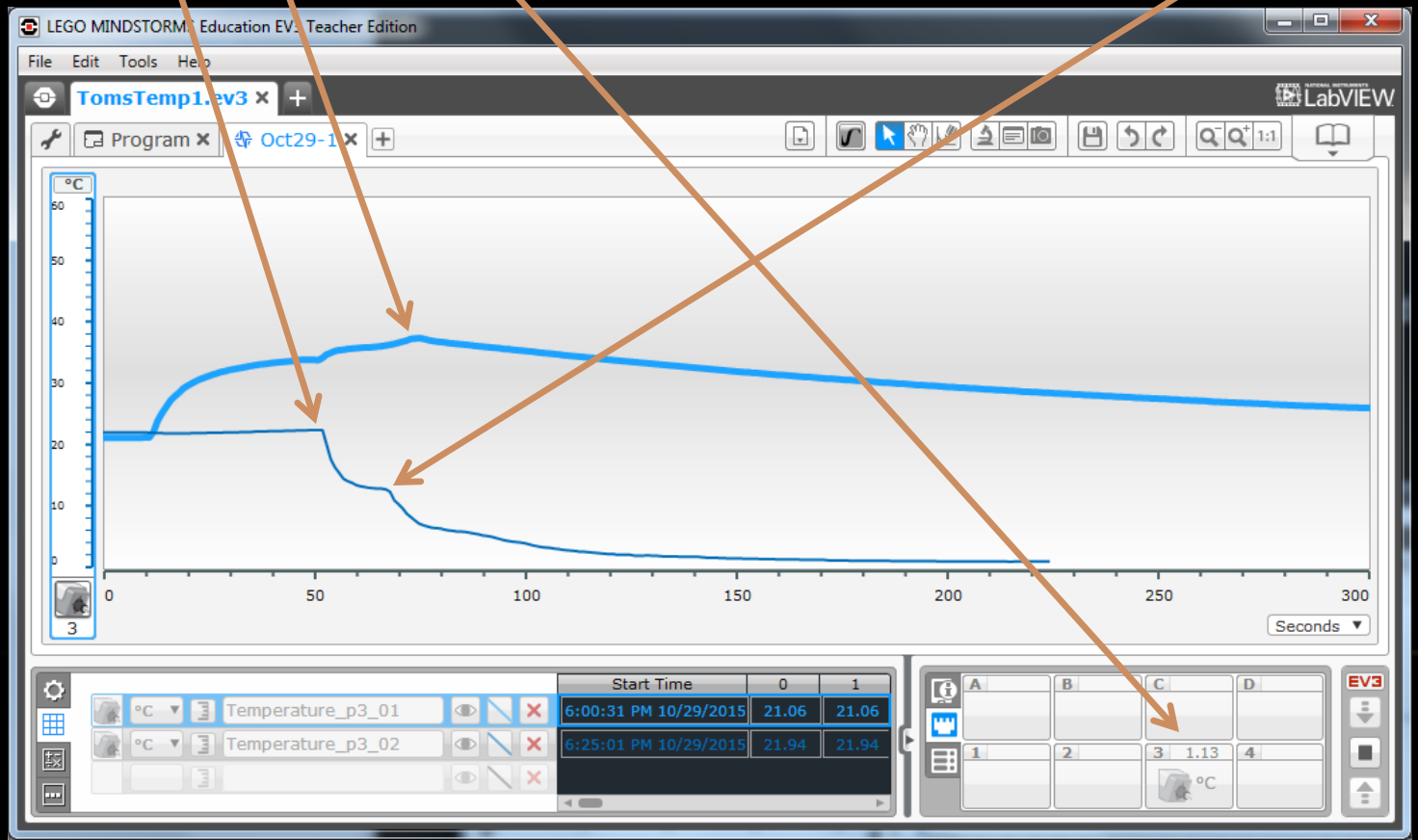
Click on the minimum or maximum value shown on an axis (more than one can be shown) and you can change the value.

Here we've changed the range from -20 to 120 C to just 0 to 60 C



LOOKING AT MULTIPLE DATASETS:

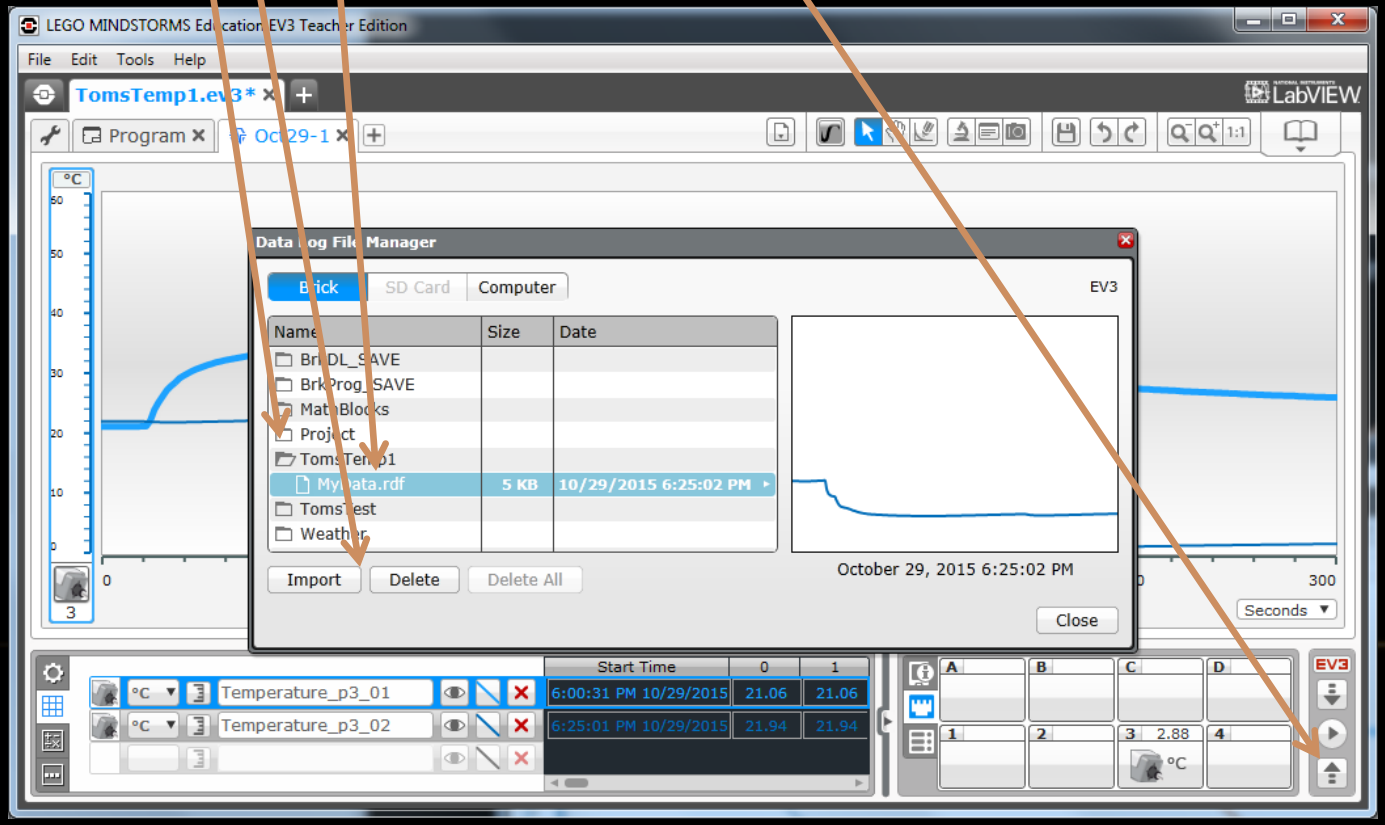
- You can see two datasets on this screen. Set one was heated in a hand and then let go after about 80 seconds.
- The second one was immersed in an ice bath at about 50 seconds, and stirring started at about 70 seconds.
- The temperature at the time of the picture was 1.13 degrees C.



EXPORTING DATA TO THE COMPUTER:

- Use the upload button on the lower right corner
- Then select Project name (click it)
- And select data set by date/time
- Then click the IMPORT button

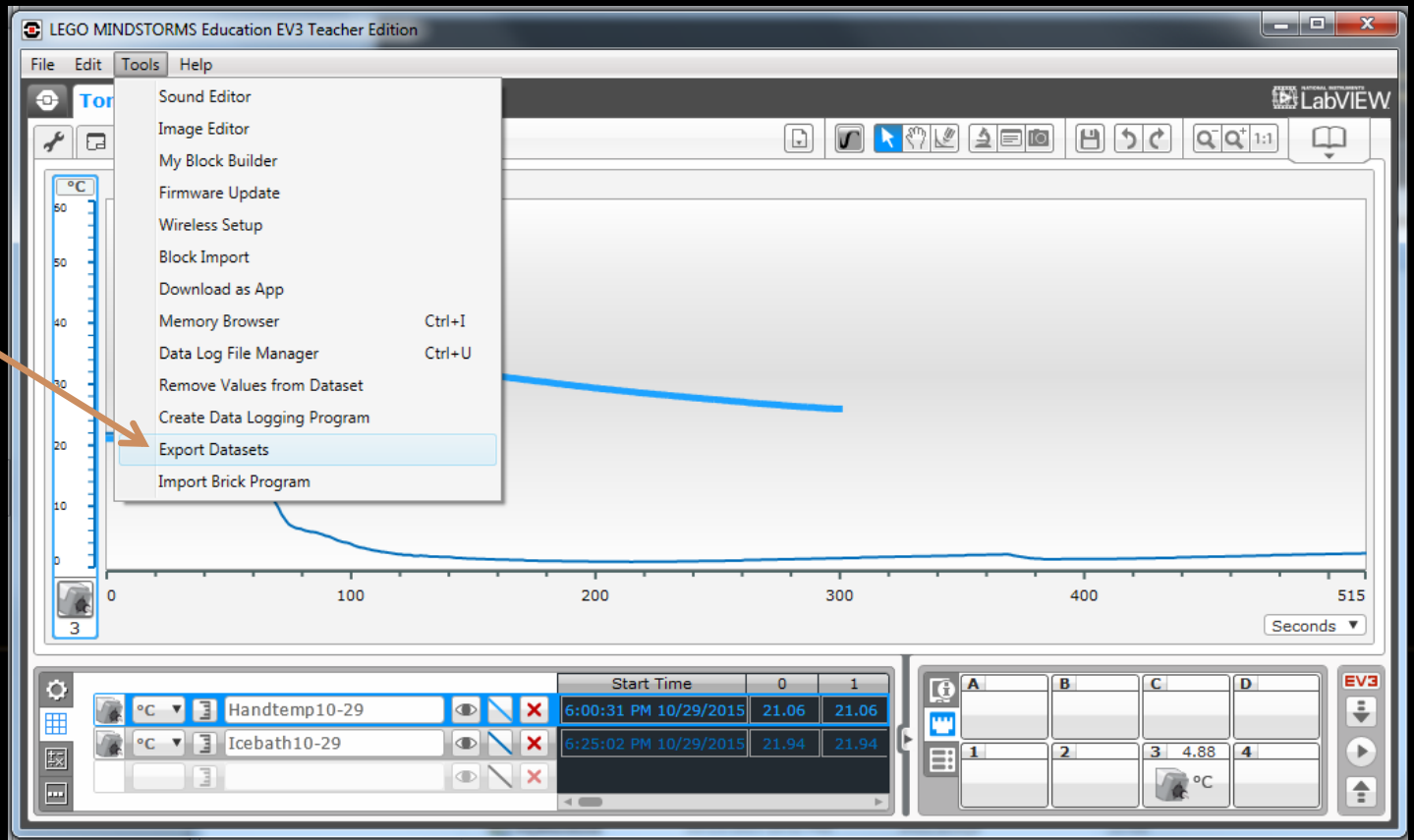
Skip this step if data logging was done while connected to the computer, data has already been shared.



EXPORTING DATASETS:

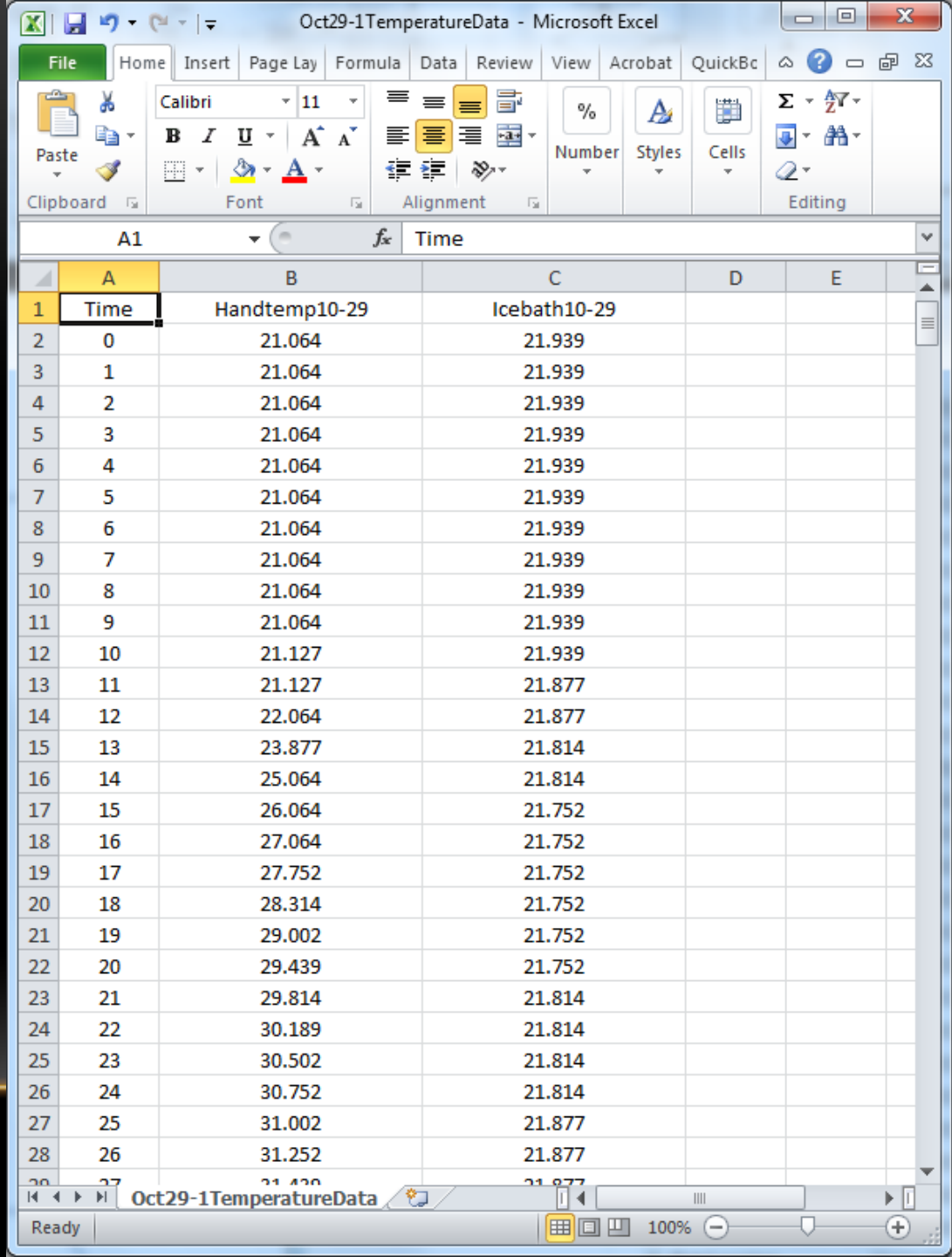
- Go to TOOLS on the top menu
- Select EXPORT DATASETS
- Name it and choose where to save it

- Exported datasets are in CSV format, which should be easy to use in all spreadsheet programs
- (Comma Separated Values)



VIEW DATA IN SPREADSHEET:

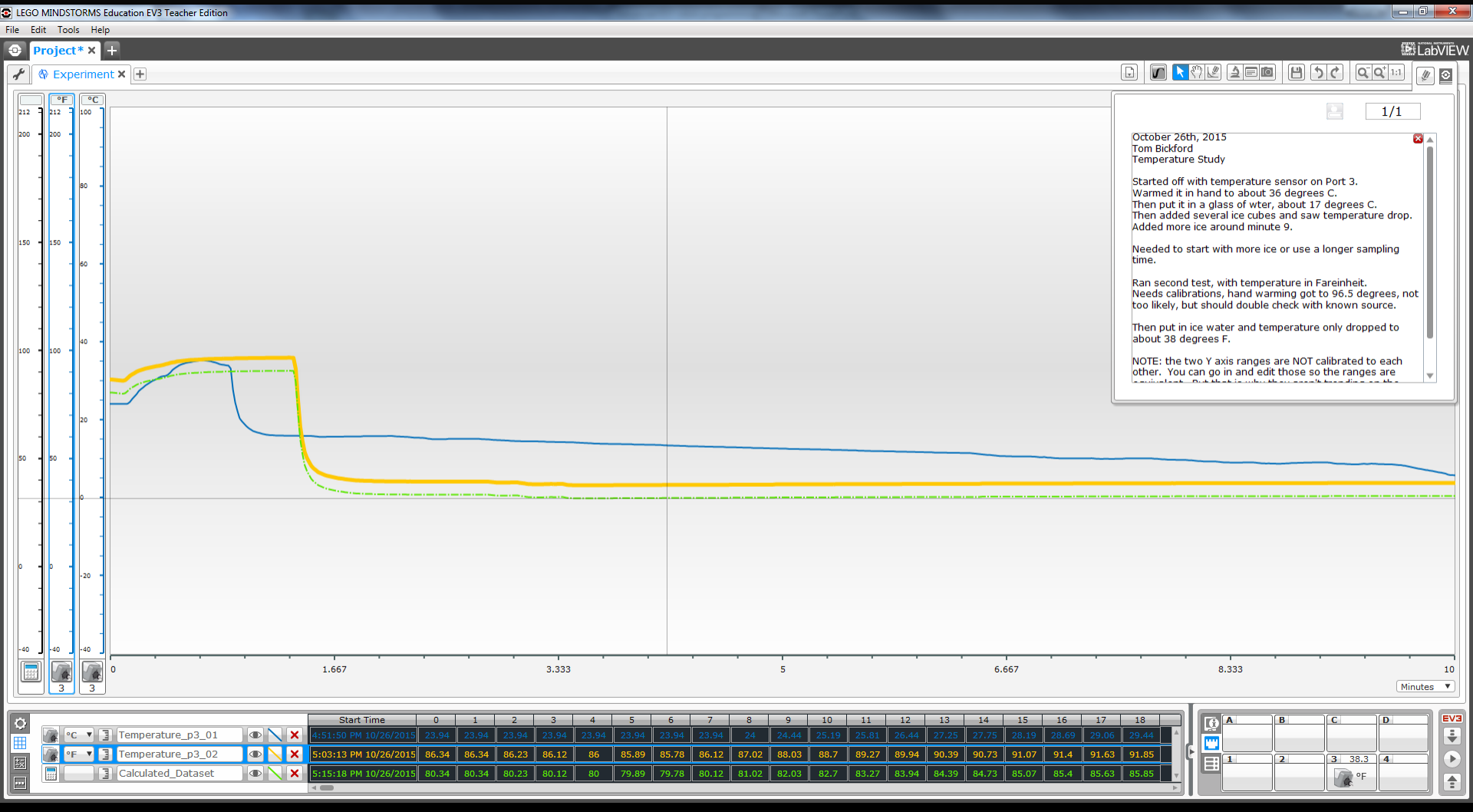
- Use your spreadsheet of choice to view your data set.
- NOTE: Rate information is NOT provided, so your notes will have to tell you that you were sampling at 1 sample per second
- Also note it doesn't give you information about units, so you need to know that your dataset was in degrees Celsius or Fahrenheit.
- Manipulate away!



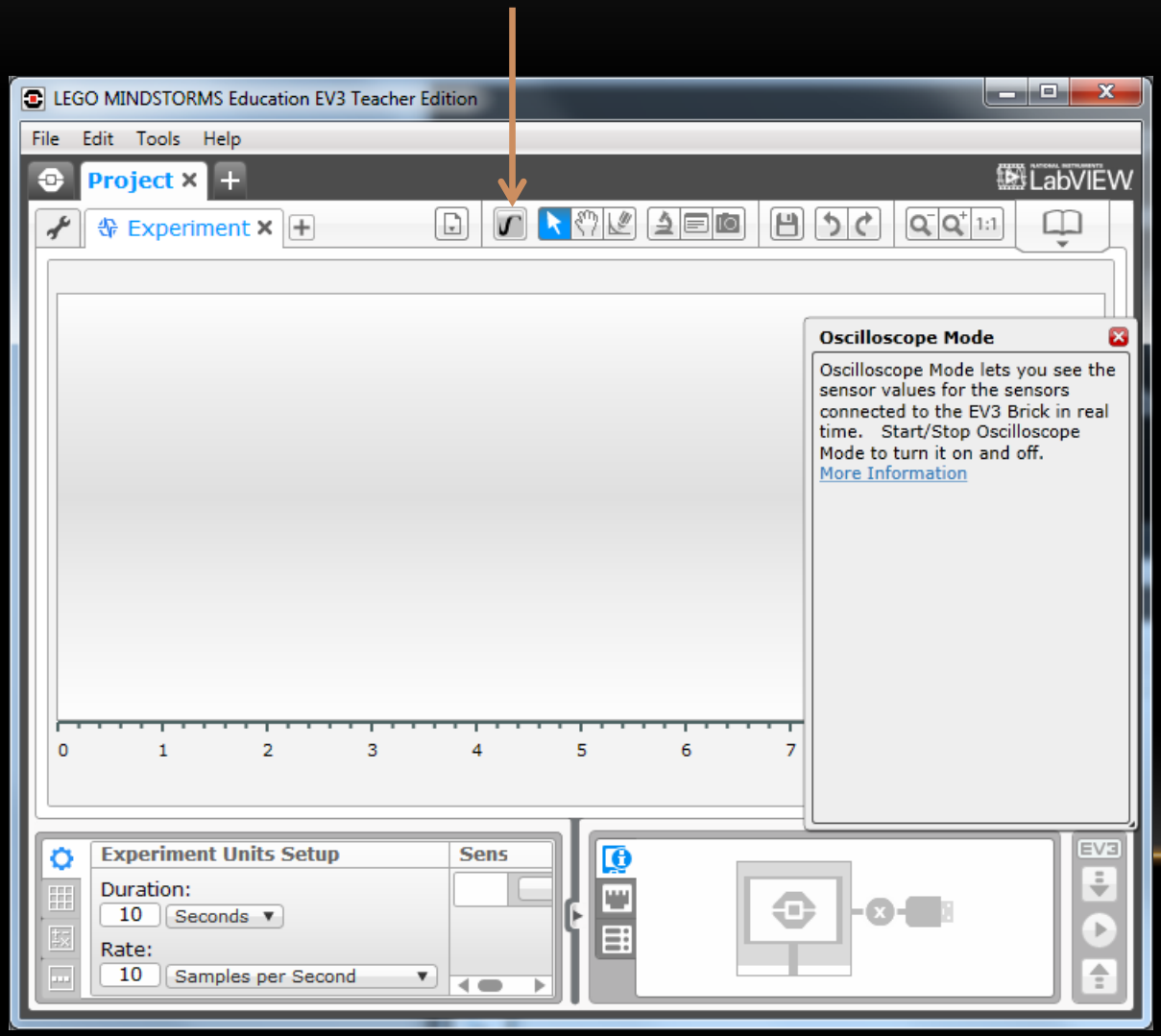
	A	B	C	D	E
1	Time	Handtemp10-29	Icebath10-29		
2	0	21.064	21.939		
3	1	21.064	21.939		
4	2	21.064	21.939		
5	3	21.064	21.939		
6	4	21.064	21.939		
7	5	21.064	21.939		
8	6	21.064	21.939		
9	7	21.064	21.939		
10	8	21.064	21.939		
11	9	21.064	21.939		
12	10	21.127	21.939		
13	11	21.127	21.877		
14	12	22.064	21.877		
15	13	23.877	21.814		
16	14	25.064	21.814		
17	15	26.064	21.752		
18	16	27.064	21.752		
19	17	27.752	21.752		
20	18	28.314	21.752		
21	19	29.002	21.752		
22	20	29.439	21.752		
23	21	29.814	21.814		
24	22	30.189	21.814		
25	23	30.502	21.814		
26	24	30.752	21.814		
27	25	31.002	21.877		
28	26	31.252	21.877		

MULTIPLE DATA SETS:

- Data set 1: temperature in air/hand/water/ice water
- Data set 2: temperature in air/hand/ice water (already cooled)
- Data set 3: Data set 2, with a 6 degree adjustment from the dataset calculation page



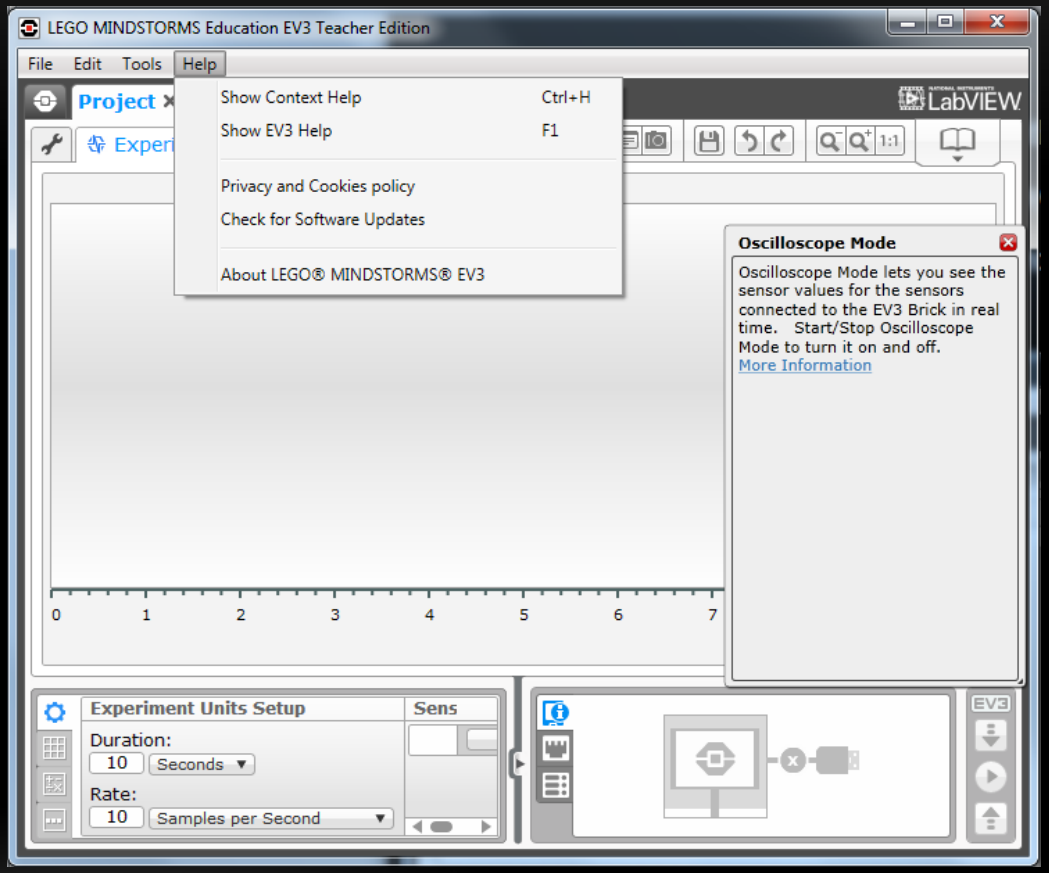
- Oscilloscope Mode:
  - Allows for real time data display (without capturing data)
  - Will be overridden if you hit the “Play” button to start data capture
  - Experiment normally starts in this mode.



HELP?
- Ctrl H
- Or

HELP?

- MineStorms has an extensive HELP system.
- Access using Ctrl H or Apple equivalent
- Or by using the Help Menu at top (select Show Context Help and mouse over item you want help with) or select Show EV3 Help for the entire HTML based help which will open in a browser.



DATA LOGGING:

- The NXT and EV3 can collect and store data on their control units; they can also display both real time data and running averages, minimums, maximums, etc (you have to program it to do these things)
- But the main difference with Data Logging is that you can save the information and bring it back to the computer
- This allows you to do post-collection data manipulation right in the classroom

#