



## **Dr. Ethan Danahy**

Research Assistant Professor, Department of Computer Science  
Engineering Research Program Director, Center for Engineering Education and Outreach  
Tufts University School of Engineering

# Leveraging Educational Technologies to Capture, Share, and Interact with Students' Ideas

HGSE T561, Fall 2016

October 17<sup>th</sup>, 2016



Center for Engineering  
Education and Outreach







# Research Interest

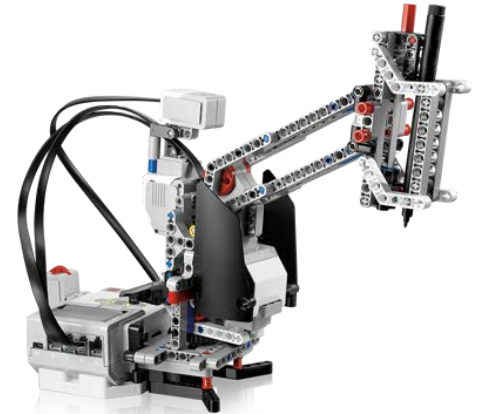
Developing and analyzing educational technologies and environments for supporting STEM learning



<http://en.community.dell.com>



<http://web.uri.edu>



<http://education.lego.com>

# Research Area

- Educational Technologies: new hardware, software, interfaces for teaching and learning
- Focus on STEM (science, technology, engineering, and math) subjects, from K to primary to secondary through university
- Special emphasis on **creativity** in engineering, on **documentation** of student work (the process), and on **collaboration**



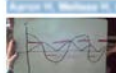
InterLACE Tufts Center for Engineering Education and Outreach

Overview Acceleration Font Size: 15 px

On that same graph, draw a sketch of what you think the X-acceleration looks like. Do this in a third color. Explain your thoughts.

[Add New Idea](#) [Refresh](#) New: 0

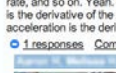
**Question 11, Worksheet 11, Answer 11**



It accelerates at a constant rate, then decelerates at a constant rate, then accelerates and that rate, and so on. Yeah. Its also because velocity is the derivative of the x position, and acceleration is the derivative of the velocity.

1 responses [Compare](#) [Highlight](#)


**Question 11, Worksheet 11, Answer 11**



our old one was wrong.


[Respond](#)

**Question 11, Worksheet 11, Answer 11**



Red is velocity, Black is position, and Green is acceleration. As the

**Question 11, Worksheet 11, Answer 11**



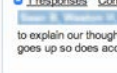
$A(t) = -\sin(t)$  and  $v(t) = \cos(t)$

1 responses [Compare](#) [Highlight](#)

to explain our thoughts we thought as velocity goes up so does acceleration.

[Respond](#)

**Question 11, Worksheet 11, Answer 11**



The pendulum accelerates and decelerates at a constant rate during the period of swing

0 responses [Compare](#) [Highlight](#)

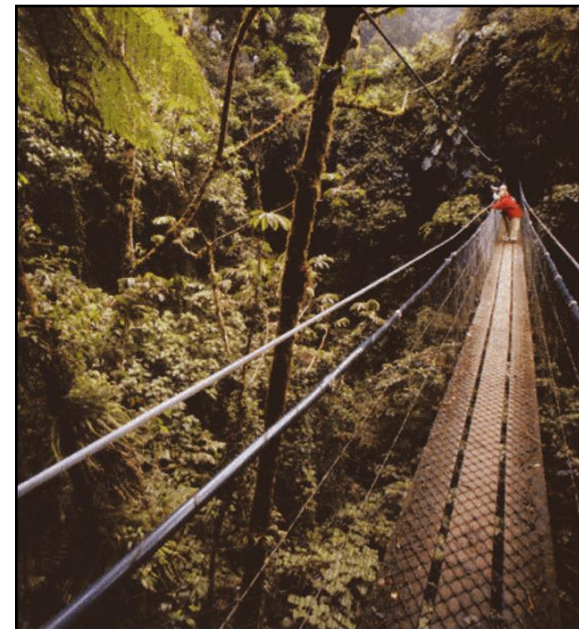
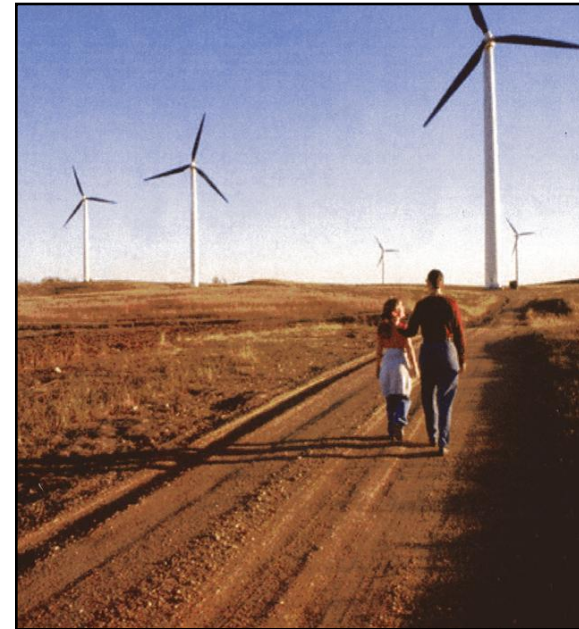
[Respond](#)

## TEACHING PRACTICES:

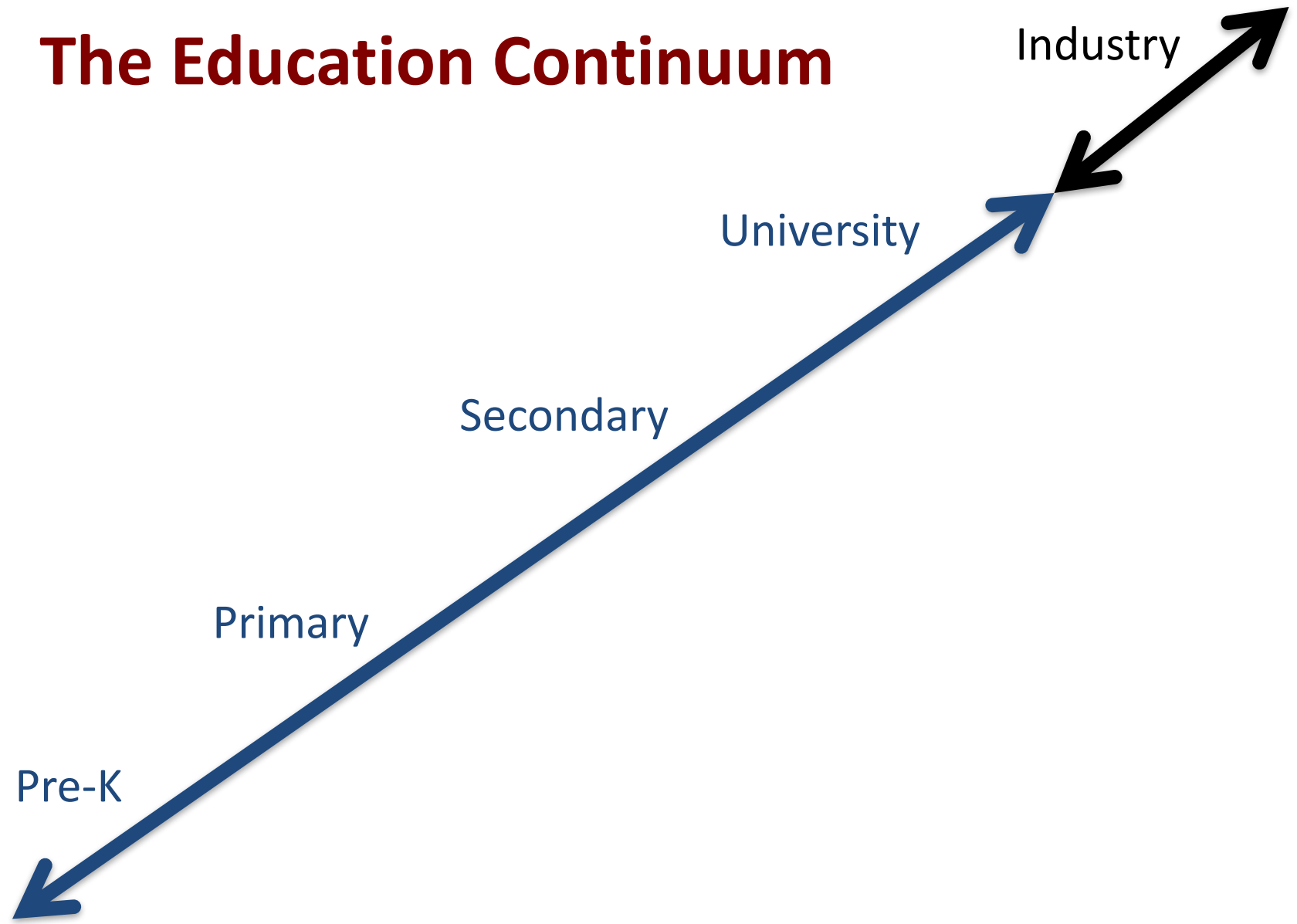
- Science, Technology, Engineering, Math (STEM)
- Hands-on activities
- Project Based Learning
- Engineering Design Process
- “Real-World” Applications

## RESULTS:

- Increase technological literacy
- Peak curiosity
- Stimulate creativity
- Build self-confidence
- Instill passion for learning



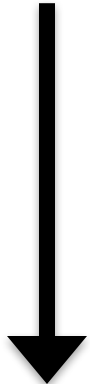
# The Education Continuum



**S. T. E. M.**



Science



Technology



Engineering



Math



**S. T. E. A. M.**



Science



Technology



Engineering



Arts



Math

PROBLEM: WE HAVE 100,000 SF BUILDING + 50,000 SF PARKING AREA ON A 10 ACRE LOT.  
WHAT IS THE IMPERVIOUS LOT COVERAGE?

$$\frac{150,000 \text{ SF}}{43,560 \text{ SF}} = \frac{150,000 \text{ SF}}{1} \times \frac{1 \text{ ACRE}}{43,560 \text{ SF}} = 3.44 \text{ A}$$

IMPERVIOUS AREA = 100,000 SF + 50,000 SF = 150,000 SF

TO CONVERT SF TO ACRES:

1. LIST THE NUMBERS YOU KNOW = 3.44 AC
2. FIND & LIST THE CONVERSION FACTOR
3. CANCEL UNITS & DO THE ARITHMETIC

150,000 SF

3.44 AC

10 AC

PROBLEM:

WE HAVE A "DEADMAN" (A WEIR WITH THE HOE CONCRETE?)

UP TO 1 TON, DEADMAN (3'x3'x3')

3 TONS

WE KNOW CONCRETE WEIGHS ABOUT 150 LBS/CF

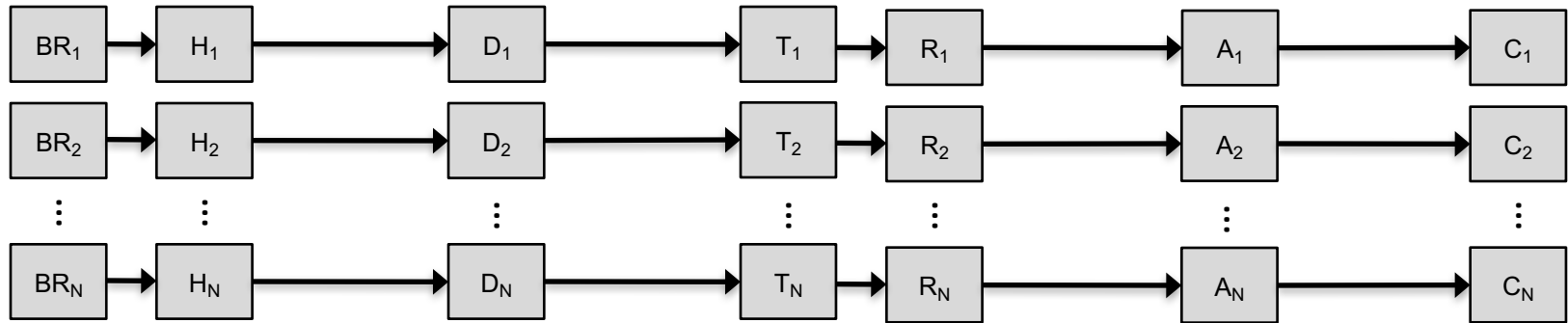
SO WE GUESS AT A CUBIC YARD DEADMAN DOES A 28,000 BTU HEATER COST TO OPERATE FOR 10 HOURS AT 9 CENTS/KW HR?

$$\frac{1 \text{ CY}}{1} \times \frac{27 \text{ CF}}{1 \text{ CY}} \times \frac{150 \text{ LBS}}{1 \text{ CF}} \times \frac{1 \text{ TON}}{2000 \text{ LBS}} \times \frac{2.013 \text{ KW}}{3412 \text{ BTU}} \times \frac{\$0.09}{\text{KW HR}} \times 10 \text{ HR} = \$5.28 \text{ TO OPERATE FOR THE 10 HOURS}$$

SO 1/2 CY WILL WEIGH ABOUT 1 TON, DEADMAN SIZE 3'x3'x1 1/2'

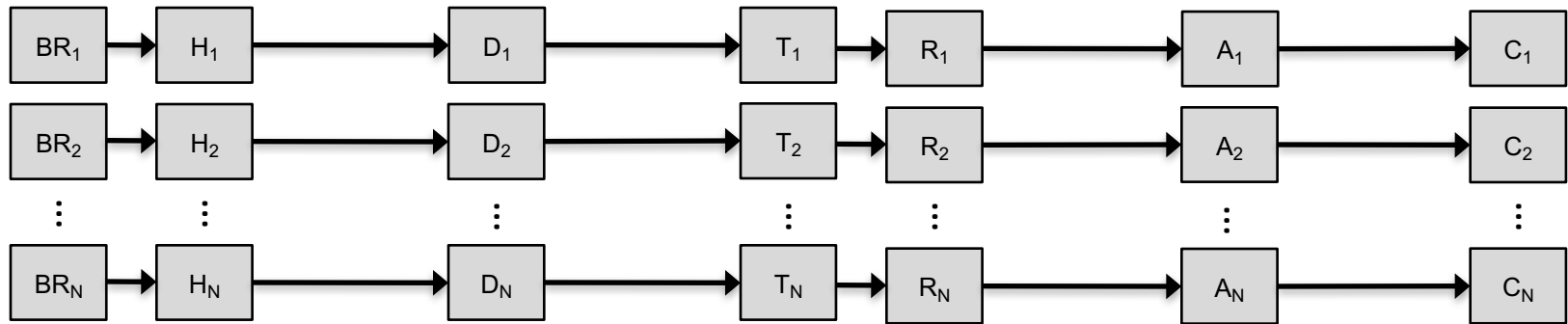


# Individual Groups Working Independently

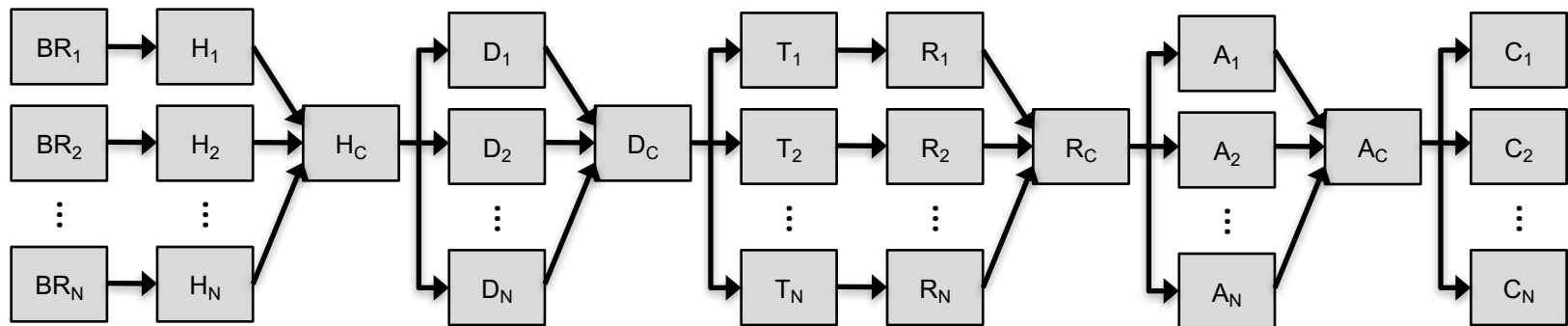
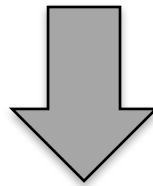


Background Research (BR) → Hypothesis (H) → Design (D) → Test (T) → Results (R) → Analysis (A) → Conclusion (C)

# Individual Groups Working Independently



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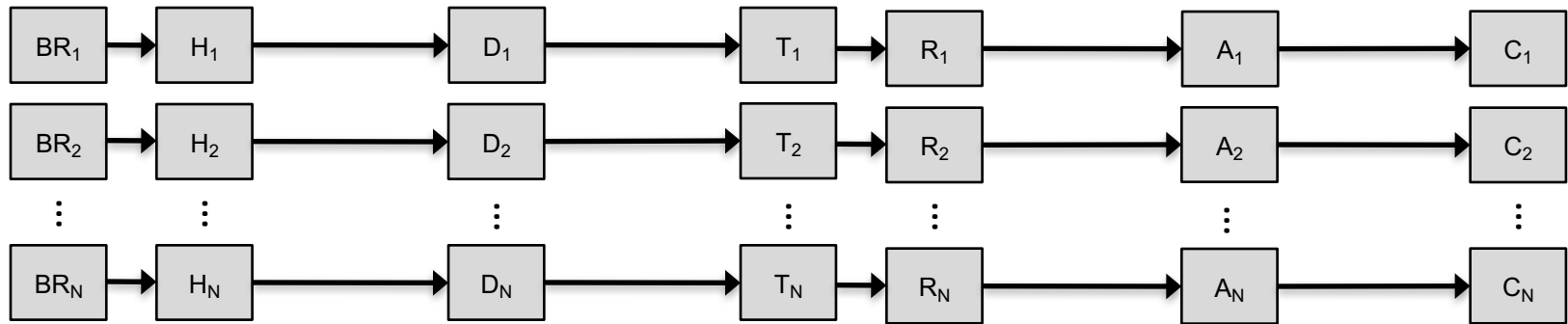


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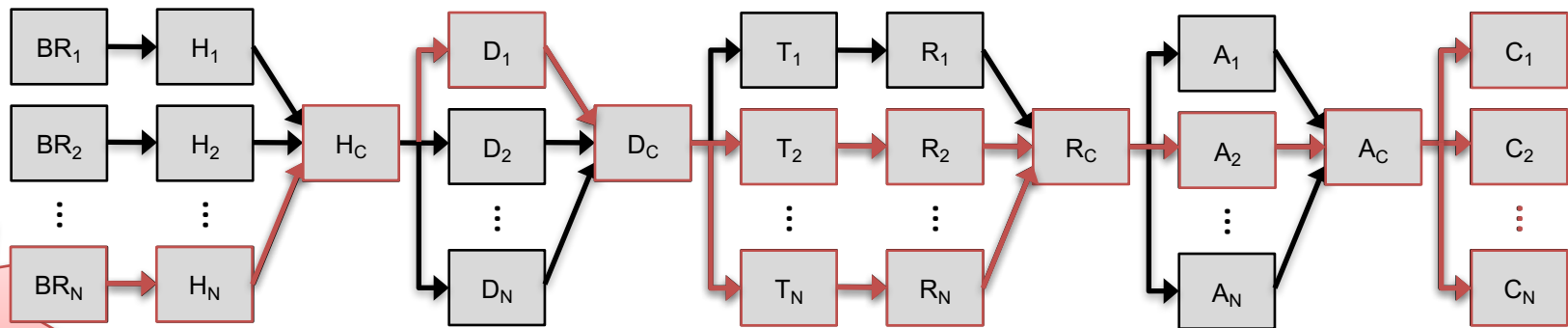
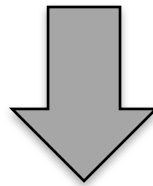
## Periodic Cross-Group Sharing Resulting in Collaboration



# Individual Groups Working Independently



Background Research (BR) → Hypothesis (H) → Design (D) → Test (T) → Results (R) → Analysis (A) → Conclusion (C)



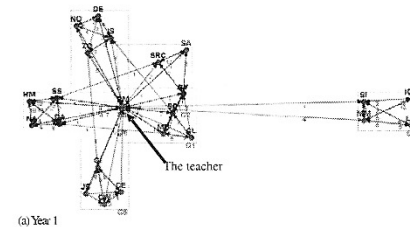
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Periodic Cross-Group Sharing Resulting in Collaboration

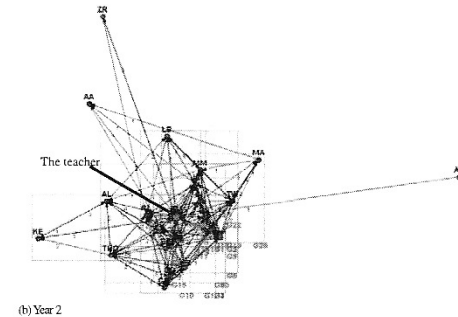
# Social Network Analysis (SNA)

SNA Diagrams from Zhang et. al. (2009)

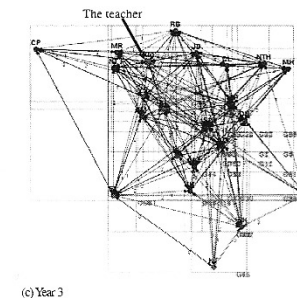
Teacher-centric class with small  
fixed-groups



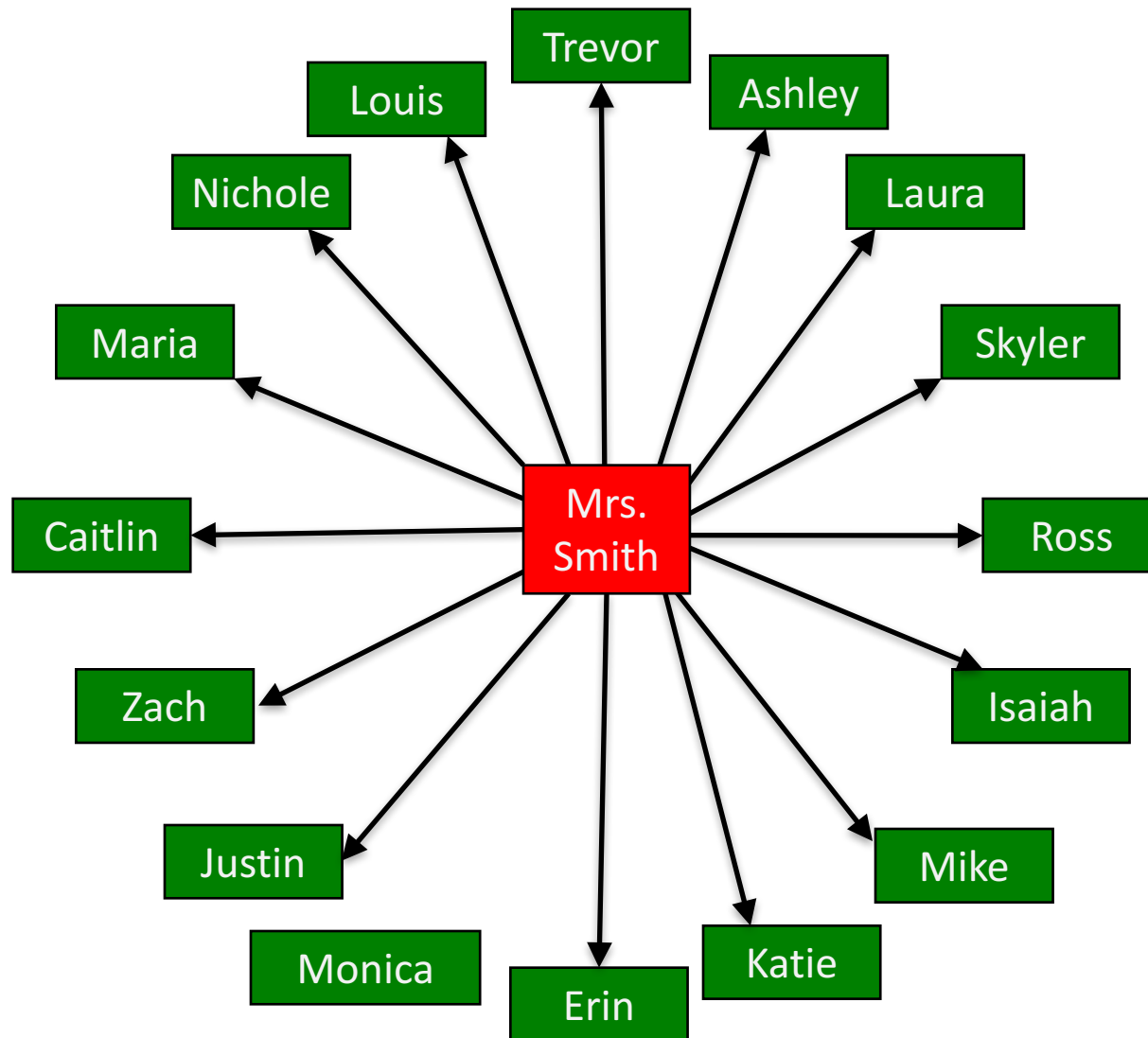
Interacting groups



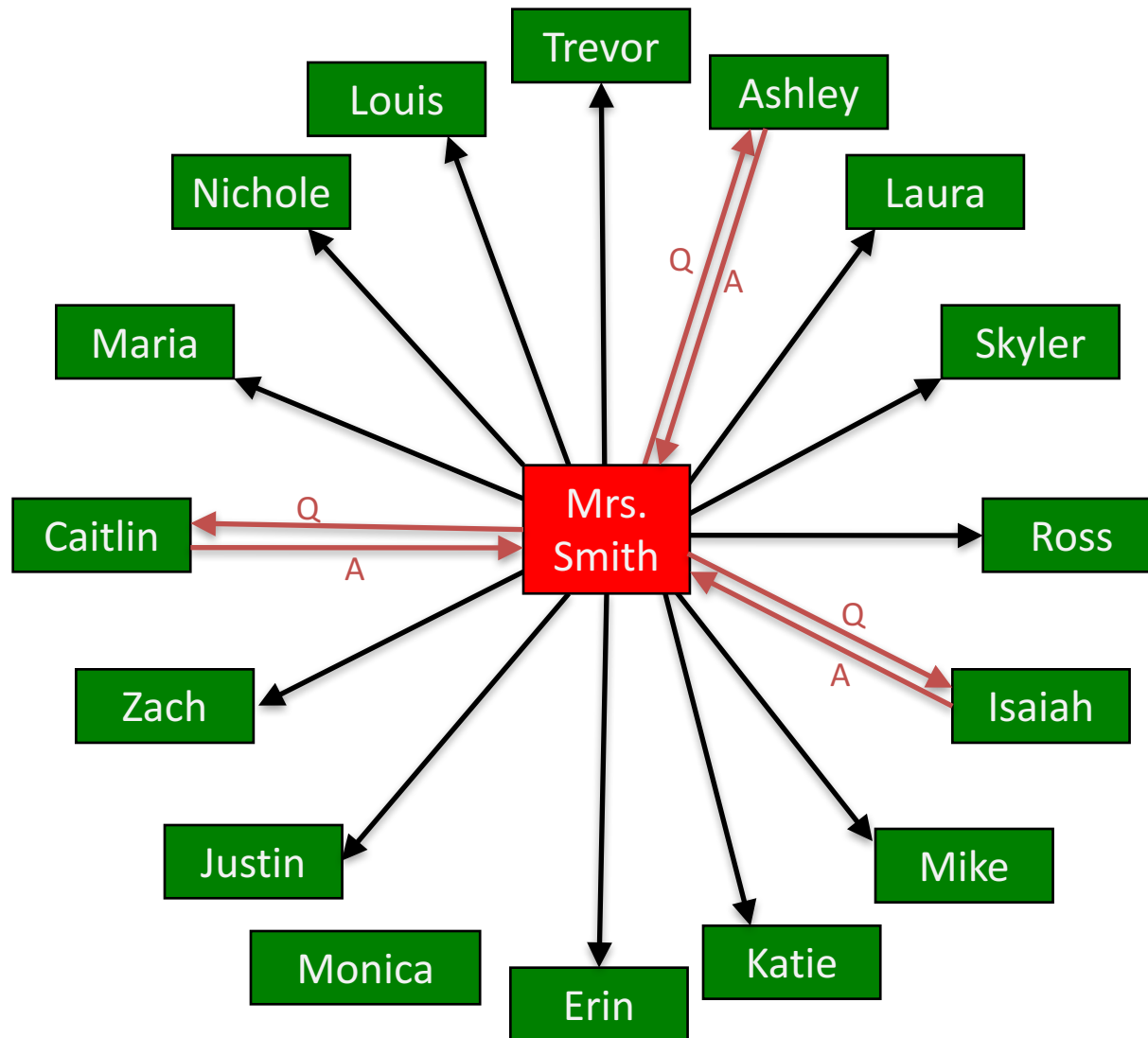
Opportunistic collaboration



# SNA: Lecture Style

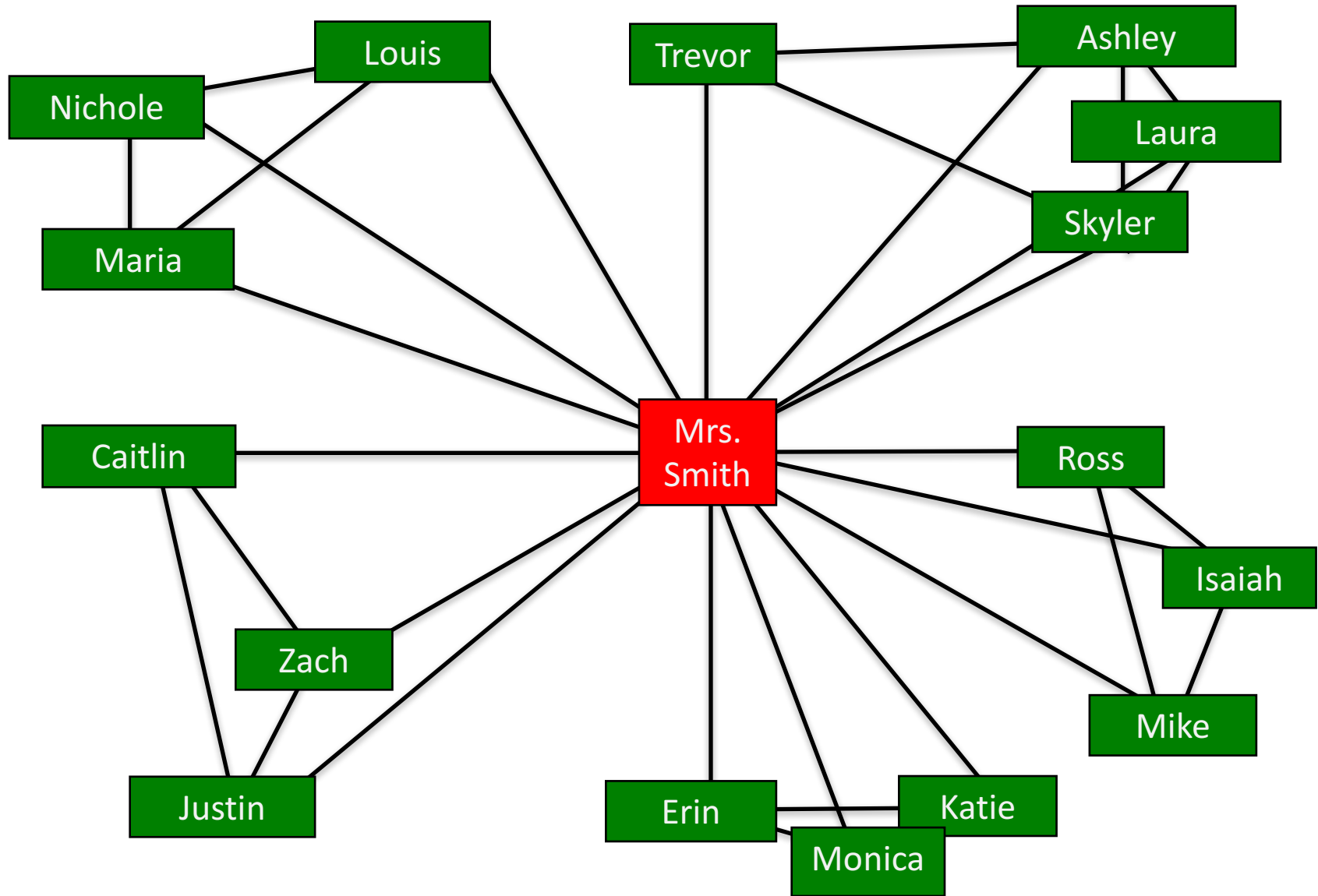


# SNA: Lecture Style + Q&A

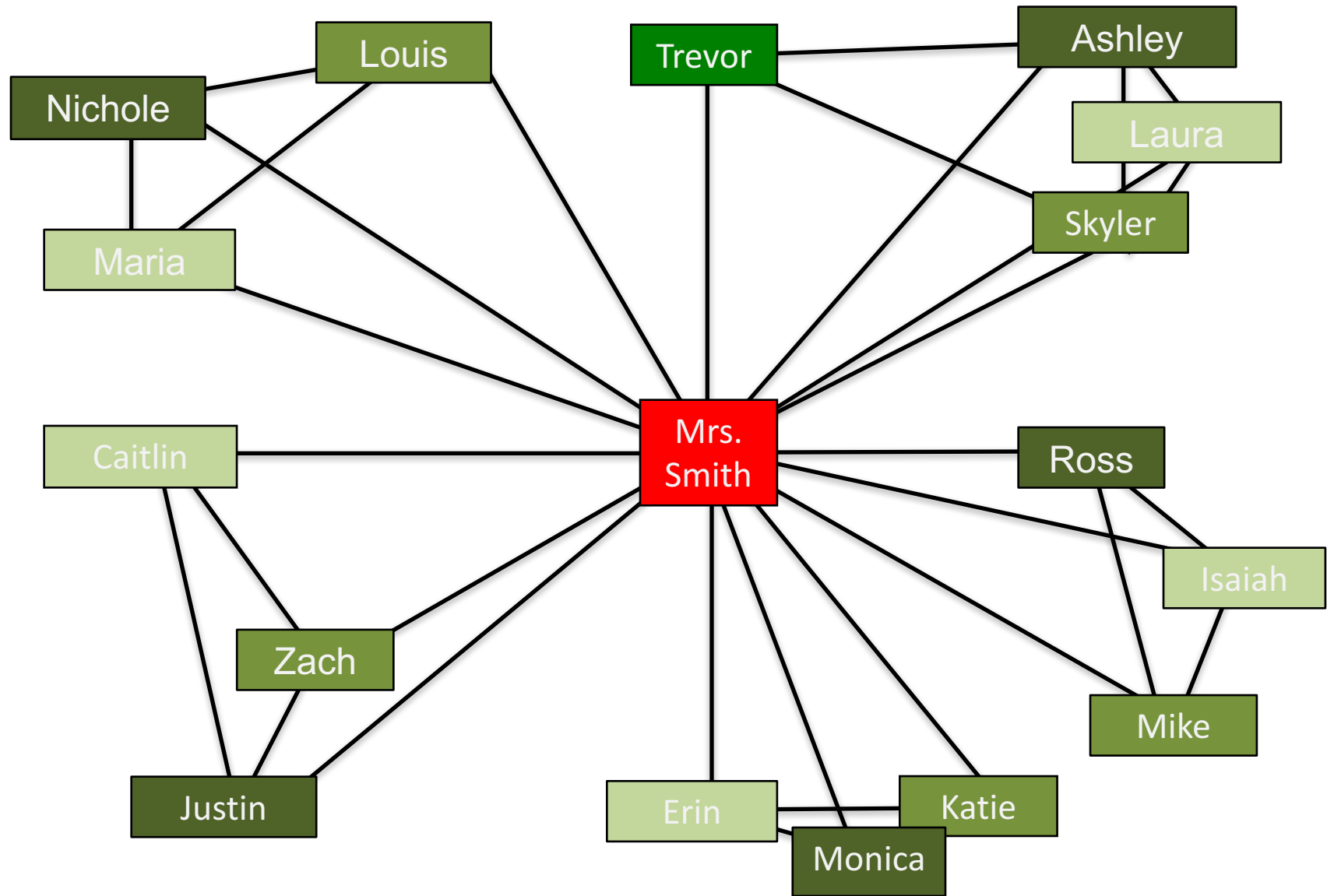




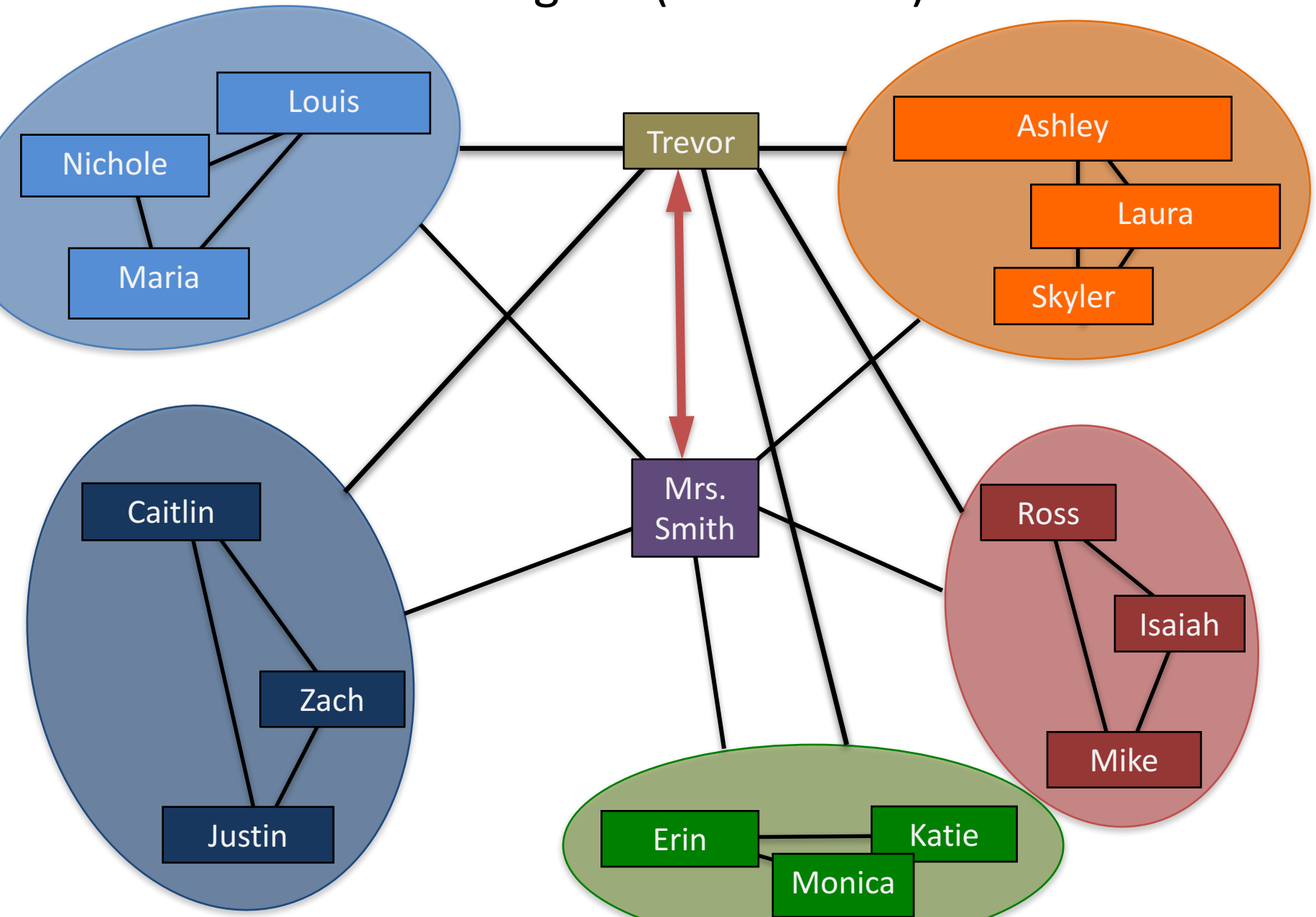
# Idealized Small Group Social Network



# Idealized Small Group Social Network with Individualized Roles within Groups



# Idealized Small/Individualized Group Social Network with “Rogue” (moderator)



# InterLACE: Interactive Learning and Collaboration Environment

InterLACE

Tufts  
UNIVERSITY

Center for Engineering  
Education and Outreach

Home Current Class Help Contact Us Present your raw data Next Logout

Make a data table of your results, with period in one column and the independent variable (such as length, mass, angle, gravity, friction) in the other column. You can create your data table by hand and upload a photo. OR you could make your data table in EXCEL or another spreadsheet program and upload either a JPEG or PNG file using the Browse feature of InterLACE. Make sure your data table has a title, labels, and units. If you notice any trends in the data, comment on them.

New Idea

How Length Affects Period

Period (s)	Length (m)
1.7	0.5
1.9	0.75
2.2	1
2.4	1.25
2.7	1.5
3	1.75
3.2	2
3.4	2.25
3.6	2.5

Hypothesis

Aug 28 7:30 pm

Period appears to increase at a regular rate with length.

Aug 28 7:30 pm

1

Also the title of my table is: The Effect of Different Factors Acting on the Period

Aug 28 7:30 pm

How Length Affects Period

Trial	Length (m)	Period (s)
1	0.5	1.47
2	1	2.09
3	1.5	2.56
4	2	2.95
5	2.5	3.29

The increase in period was pretty much linear with the increase in length. For the most part, period increased roughly half a second per half-meter increase in length.

Aug 28 7:30 pm

How Length Affects Period

Length (m)	Period (s)
0.5	1.4713
1	2.0542
1.5	2.5084
2	2.893
2.5	3.2273

The first column is length of pendulum (m), and the second is period (s)

Aug 28 7:30 pm

Length (m)

Period (s)

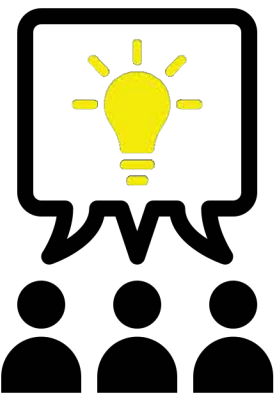
As length increases,



# Design Principles

- Facilitate student discussion, argumentation, and negotiation to empower students to share, develop, and build ideas, theories, and designs collectively.
- Promote collaboration among individual students, student groups, and the teacher.
- Enable the teacher to act as a facilitator of the above two principles, as well as to allow them to focus on student thinking.
- Flexible environment that can be customized to fit the culture of the classroom.





# Visual Classrooms

**Visual Classrooms** Teacher Dashboard About Newtons Third Law Mr. James

We have been learning about mass and gravity. Using the sketch tool, draw a graph that you think captures the relationship between mass and force.

Once your peers have posted their ideas, arrange them in a way that makes sense to you. When you SAVE ARRANGEMENT be sure to include your arrangement strategy.

[New Idea](#)

**Navigation:** Draw The Graph

**Arrange:** [Icons for arranging ideas]

**Options:** [Icons for options]

**Notifications:** [Icon for notifications]

**Student Ideas:**

- Dylan O, Rebecca S:** [Graph showing a curve]
- Sam F, Ingrid H:** [Graph showing a curve]
- Jon T, Wu Z:** [Graph showing a curve]
- Alex J, Robert M:** [Graph showing a curve]
- Sam F, Ingrid H:** [Graph showing a curve]

**Comments:**

- Alex J, Robert M:** Not direct
- Sam F, Ingrid H:** Looks correct to us, we like it
- Sam F, Ingrid H:** We redid it, think it is linear

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Teacher Dashboard

**Session**

Contrib	Posts	New
SmGrp	12	2
Indiv	26	0
Indiv	0	0
Indiv	3	0
SmGrp	11	0

**Recent Posts**

- Mr. James** 10/23/2015 1:27 PM  
[Graph showing a curve]  
[Draw The Graph in Newtons Third Law](#)
- James H, Michael P** 10/23/2015 12:18 PM  
It goes up  
[Video and Hypothesis in Newtons Third Law](#)
- Howard J, Latisha G** 10/23/2015 10:37 AM  
We realized that the relationship was more complex than initially thought. The relationship between the mass of the 2 objects is the key  
[Reflect in Newtons Third Law](#)

[Collections](#) [Groups](#)

<http://VisualClassrooms.com>

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150,000 SF

3.44 AC

10 AC

PROBLEM:

WE HAVE A "DEADMAN" (A WEIGHT WITH THE HOE) CONCRETE?

UP TO 1 TON,

AN (3'x3'x3')

3 TONS

TO BRACE FORMS) THAT WE CAN MOVE WITH F

WHAT SIZE MAKES A TON OF CONCRETE

SO 1/2 CY WILL WEIGH ABOUT 1 TON, DEADMAN SIZE 3'x3'x1 1/2'

WE KNOW CONCRETE WEIGHS ABOUT 150 LBS/CF

SO WE GUESS AT A CUBIC YARD DEADMAN DOES A 28,000 BTU HEATER COST TO OPERATE FOR 10 HOURS AT 9 CENTS/KW HR?

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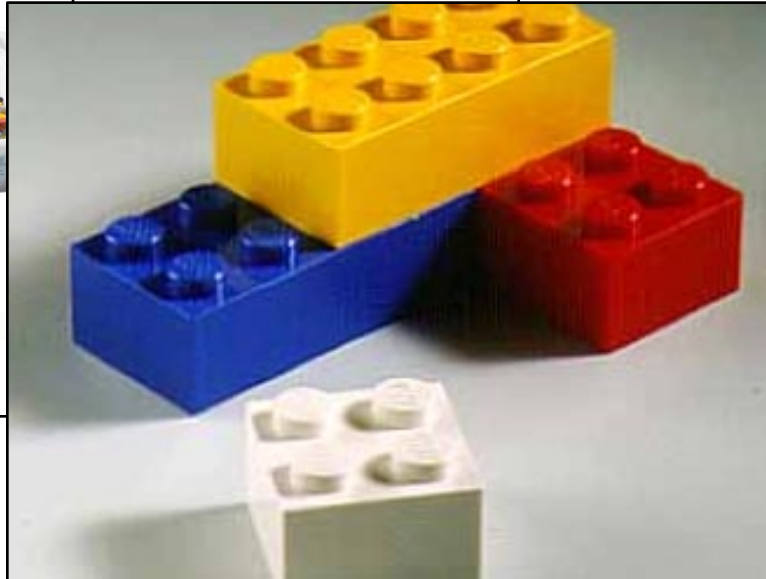
SO 1/2 CY WILL WEIGH ABOUT 1 TON, DEADMAN SIZE 3'x3'x1 1/2'



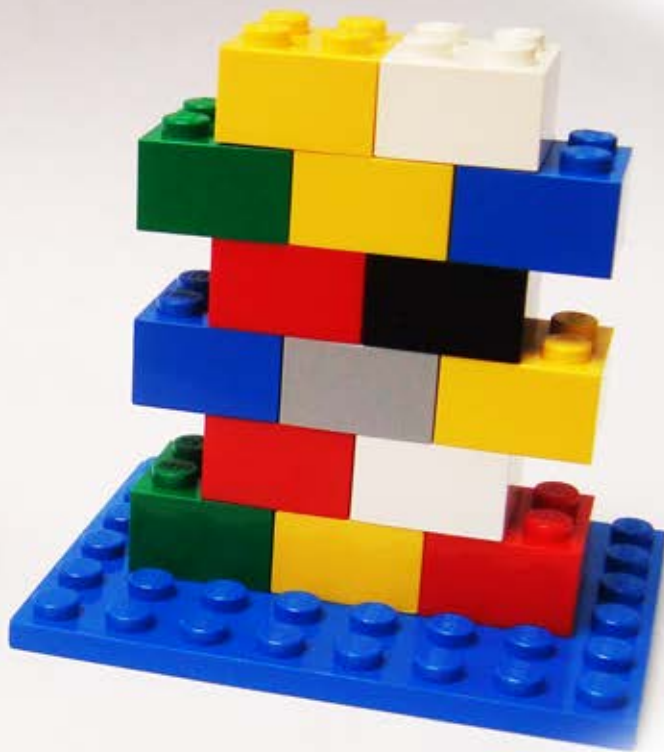
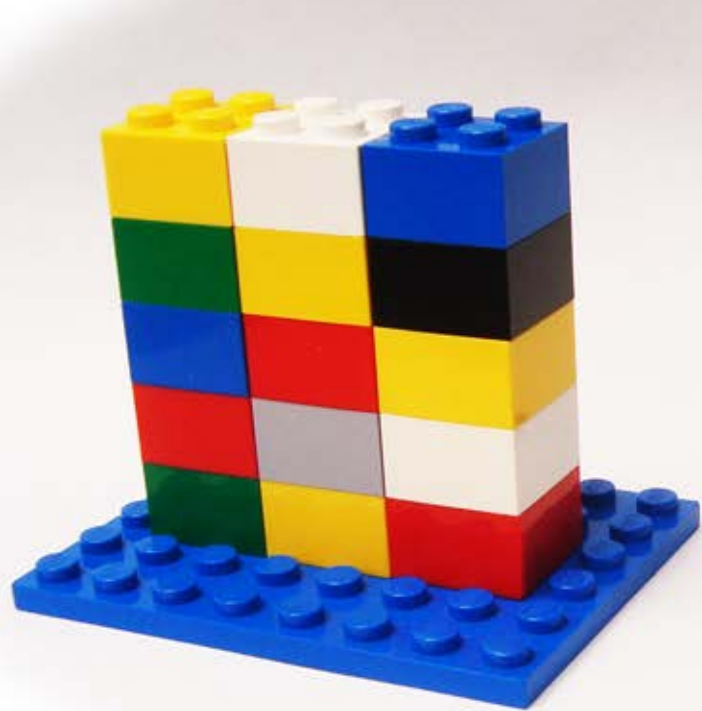


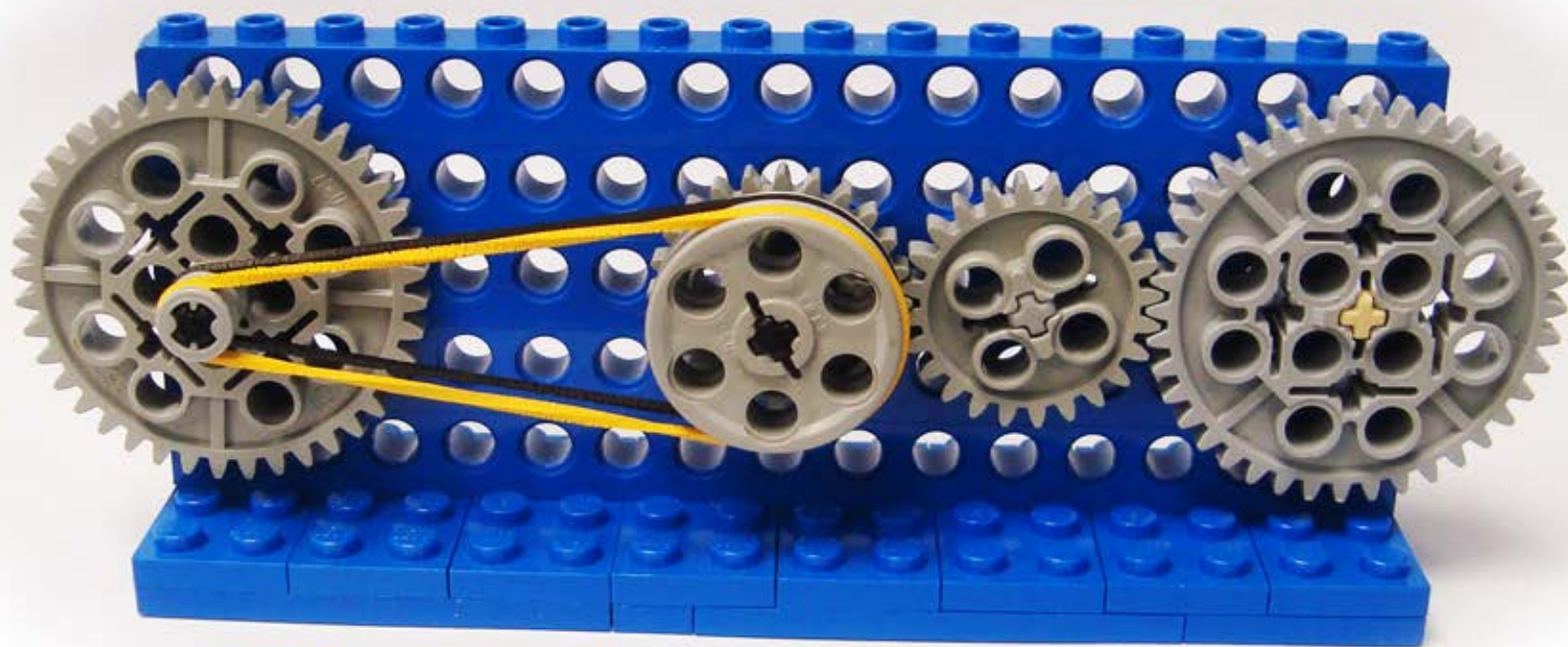


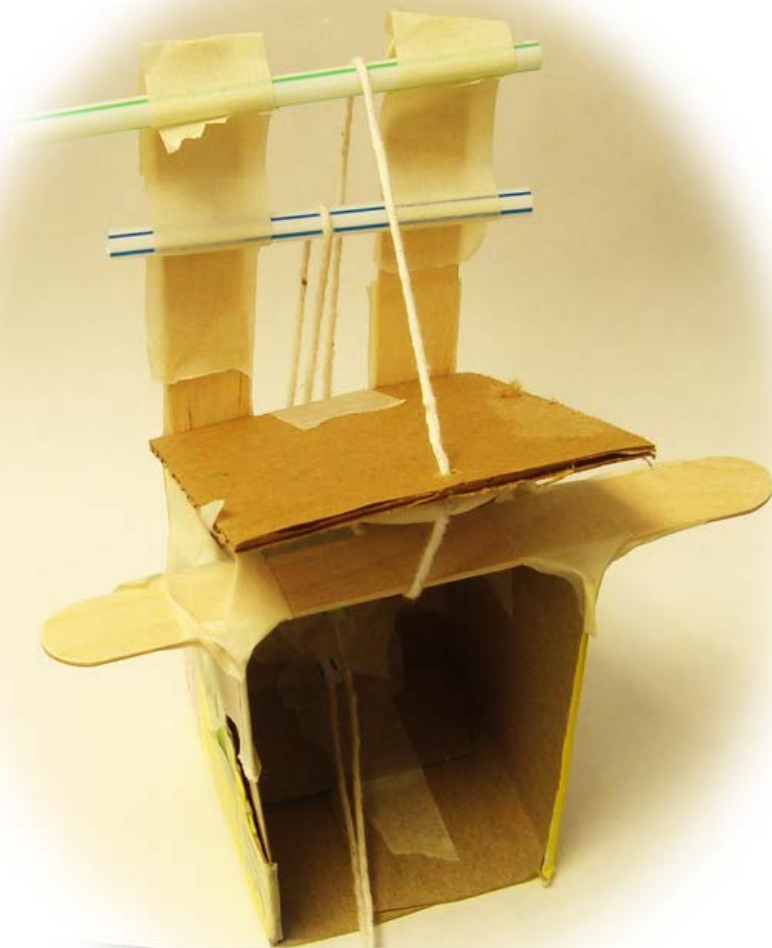
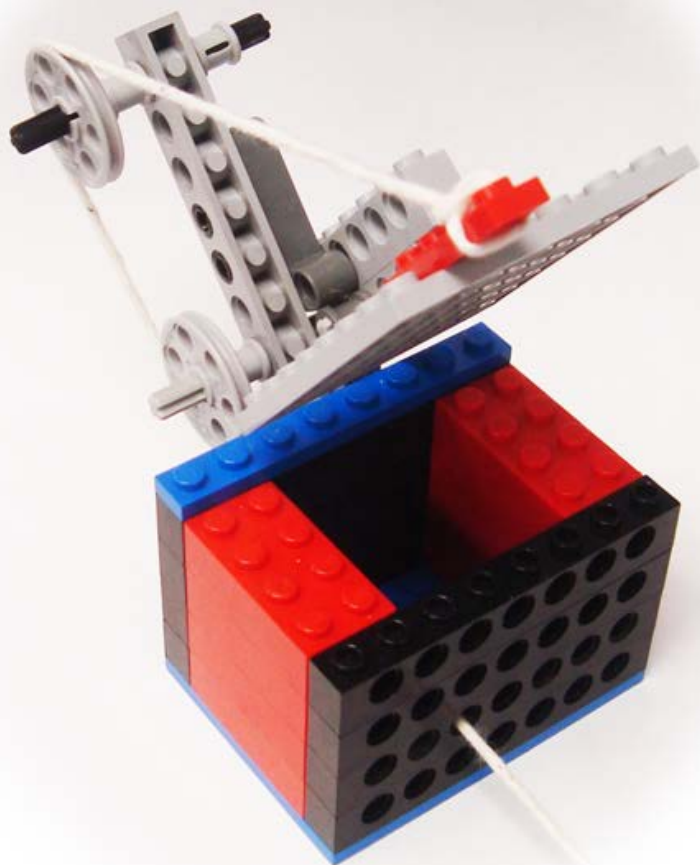
# education



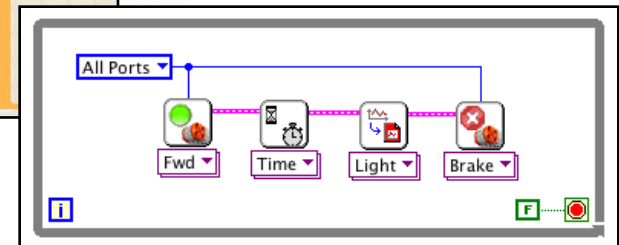
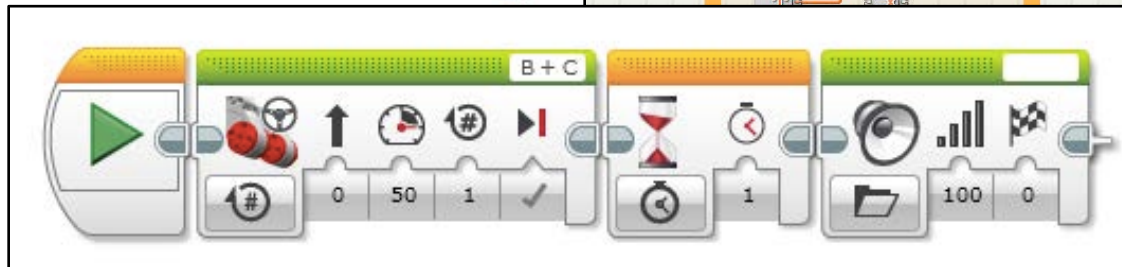
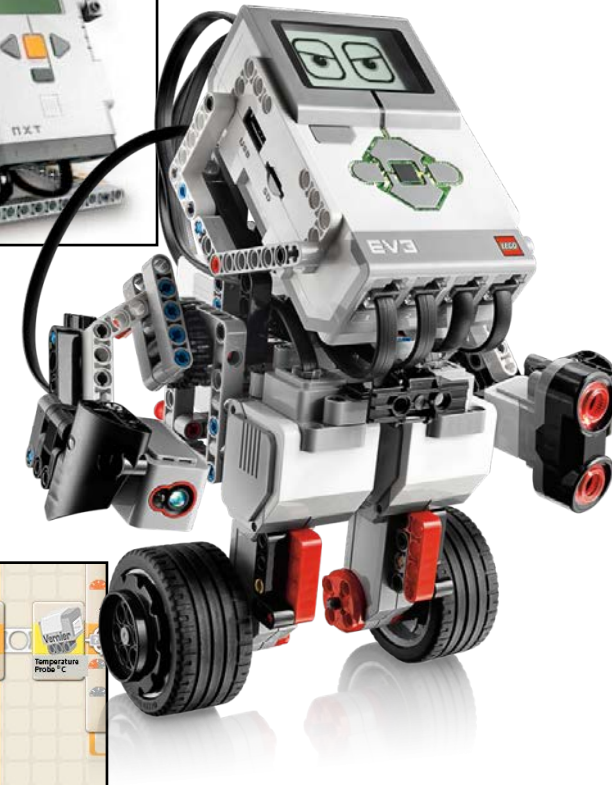
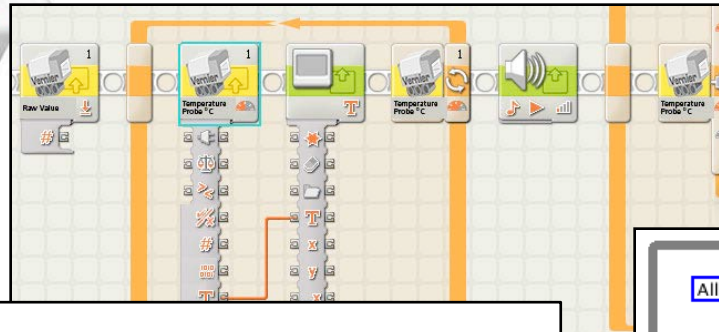
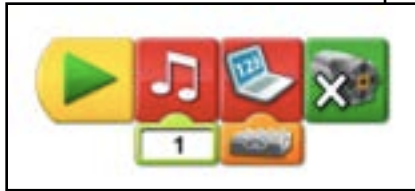




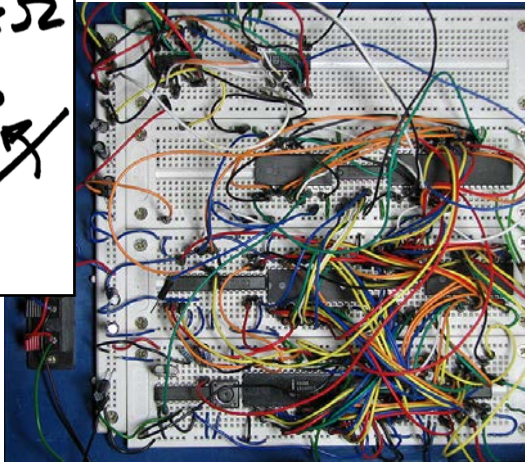
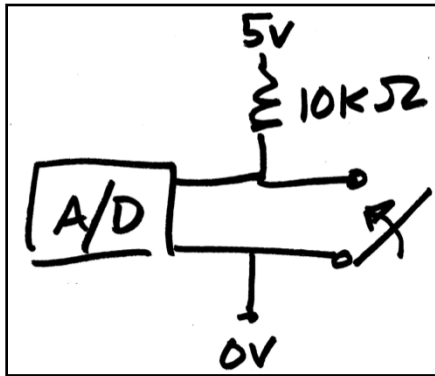








# 1990's: Learn to Build a Robot

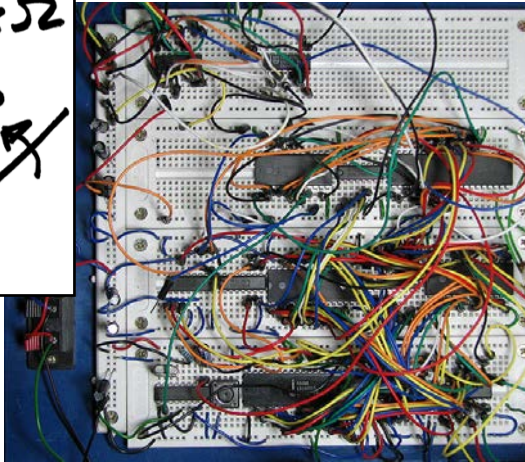
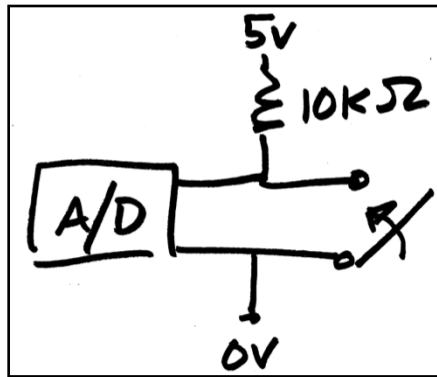


```
declare variables
  al l,r,f,edgef,edgeb
  al cnt,state

Get sensor information
=GetSensor(320)
=GetSensor(40)
=GetSensor(0)
dgef=GetGroundSensor(0)
dgeb=GetGroundSensor(180)

State selector
if state==0 Then
  If f>.7 Or l>.7 Or r>.7 Then
    state=1
```

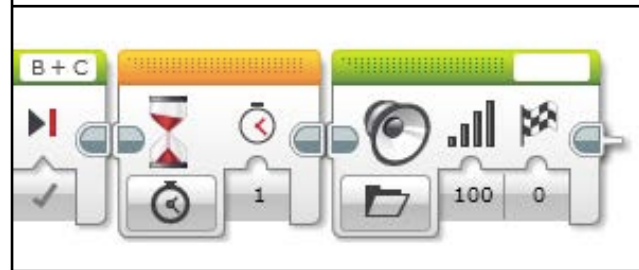
# 1990's: Learn to Build a Robot



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declare variables
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  al cnt,state

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State selector
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```



# 2000's: Design and Create a Robot



# The Education Continuum

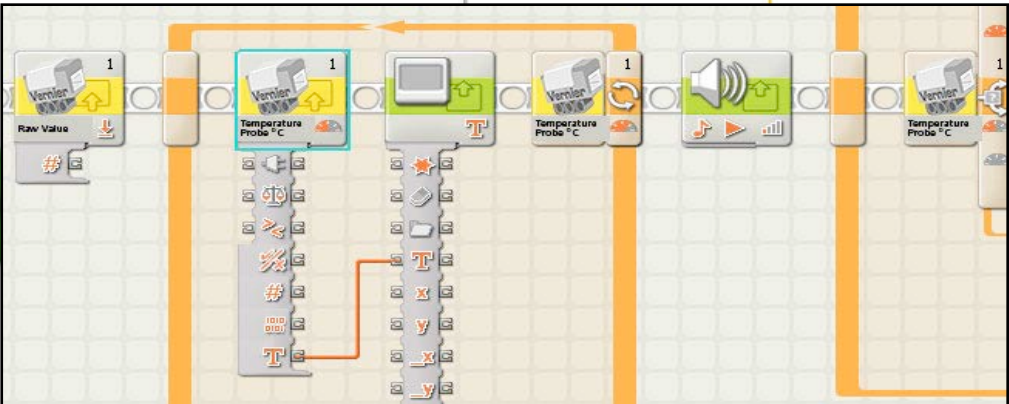
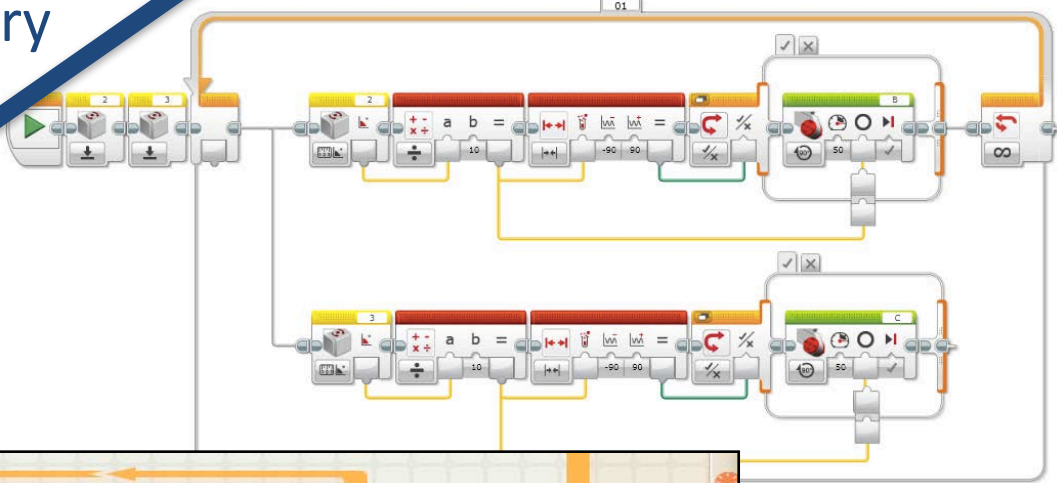
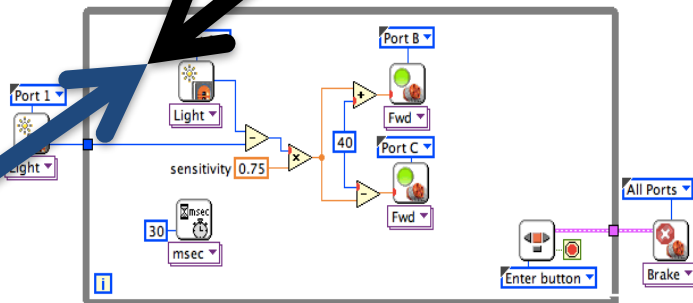
Industry

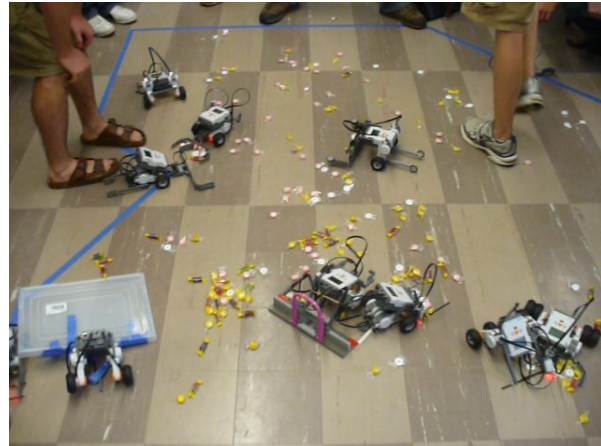
University

Secondary

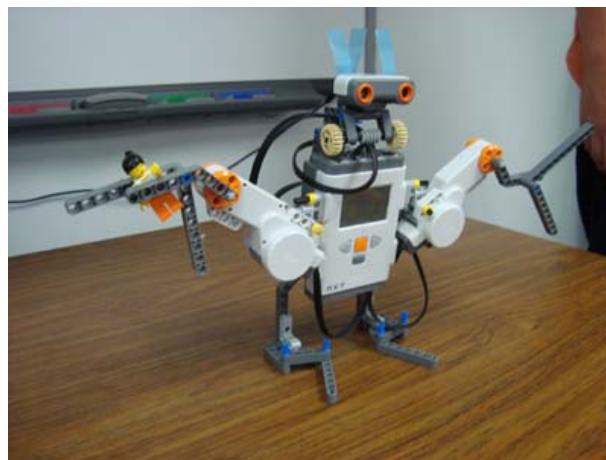
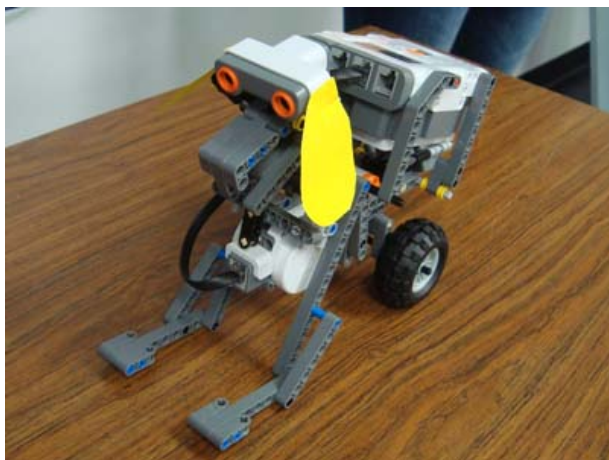
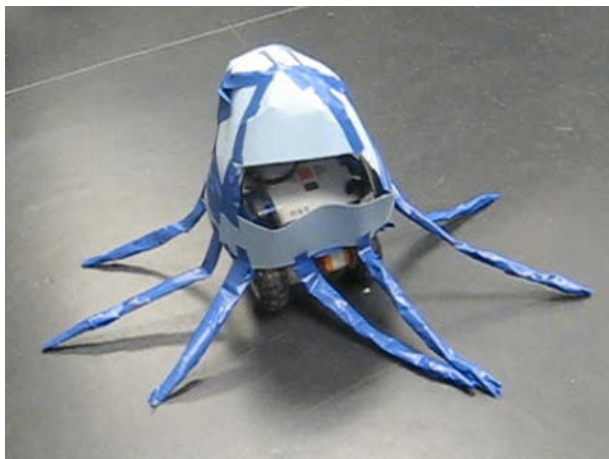
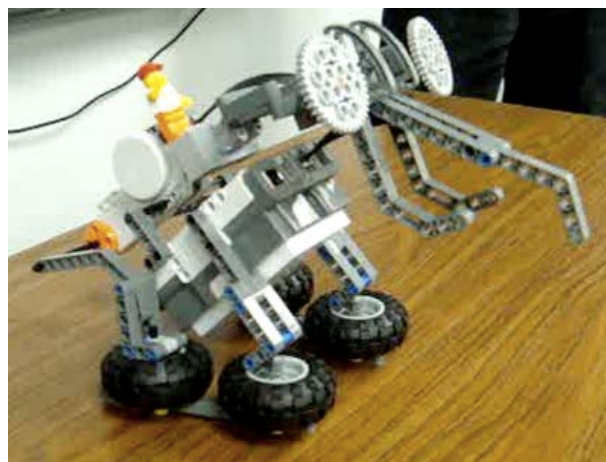
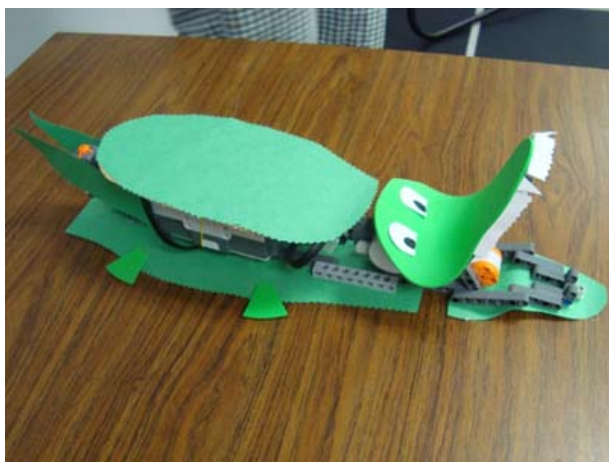
Primary

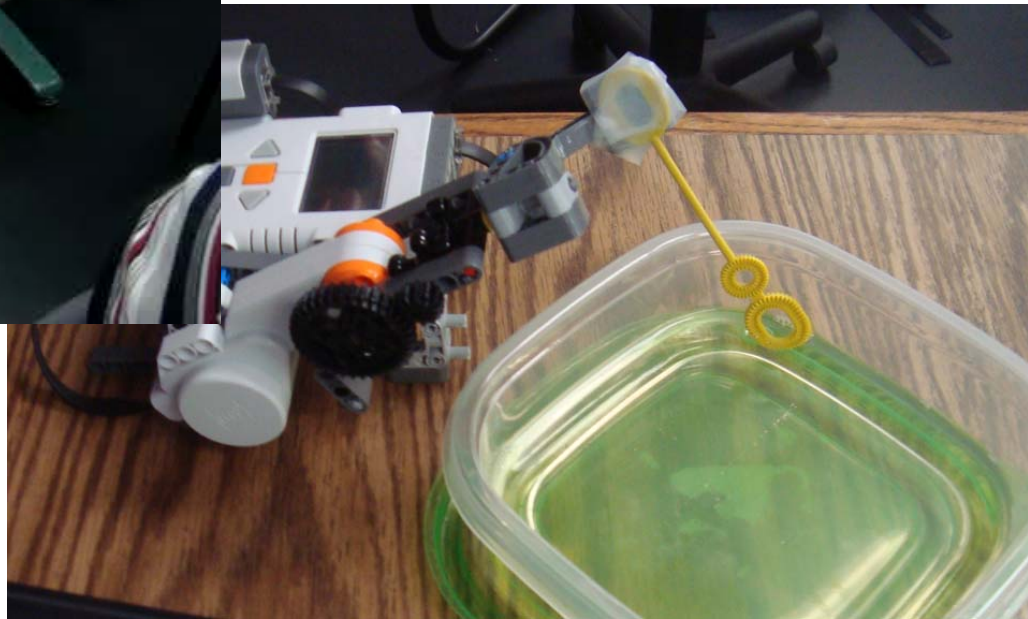
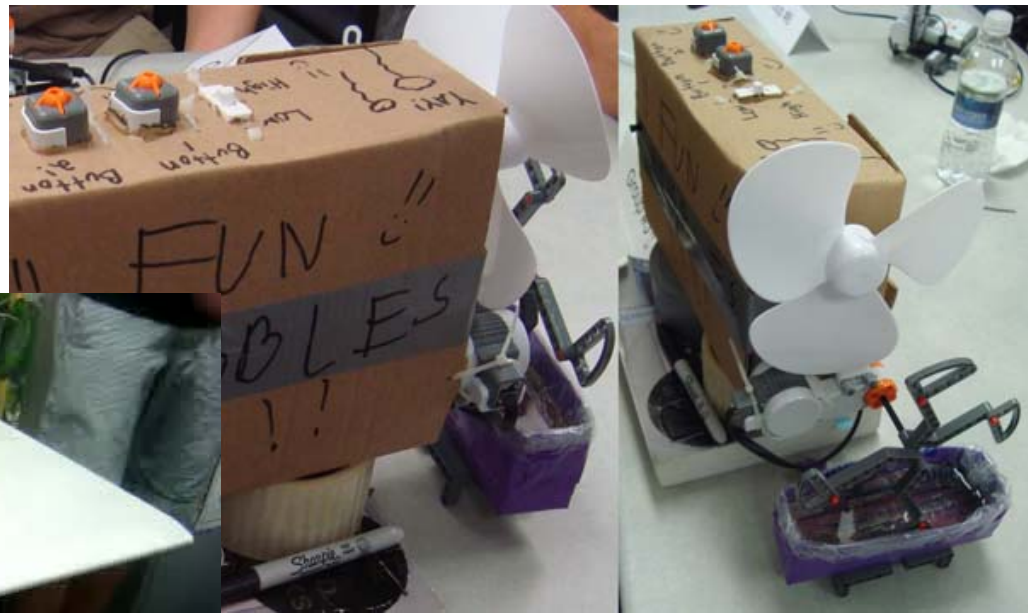
Pre-K













**S. T. E. A. M.**



Science



Technology



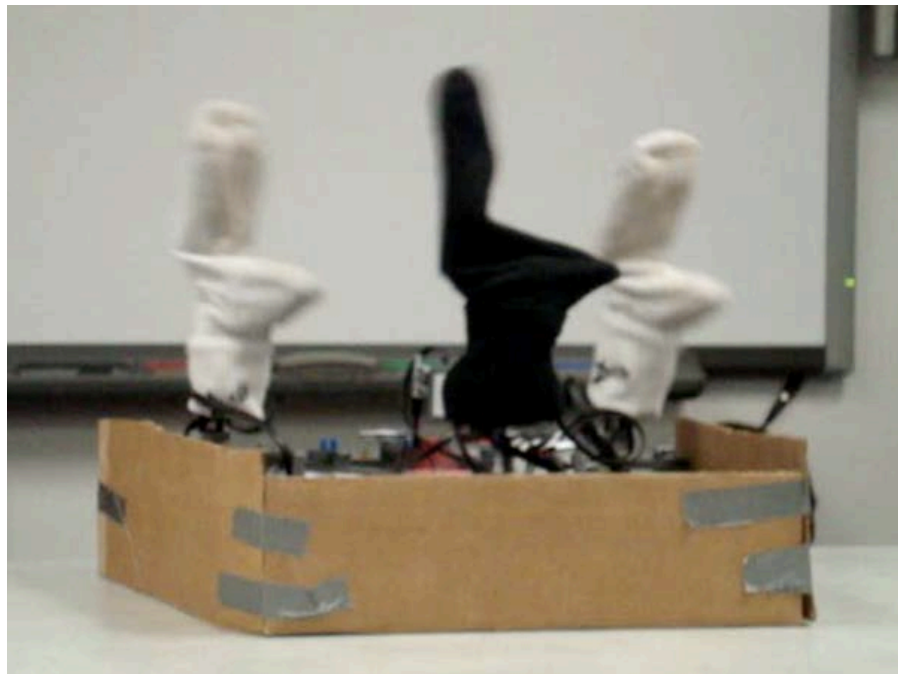
Engineering



Arts

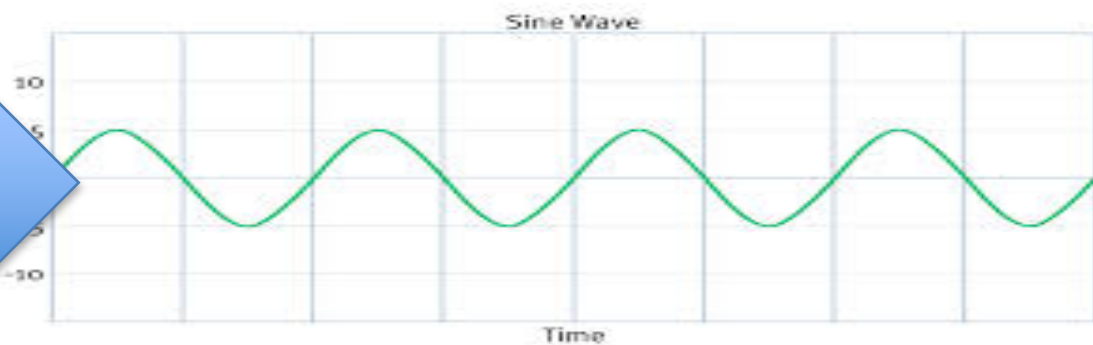


Math

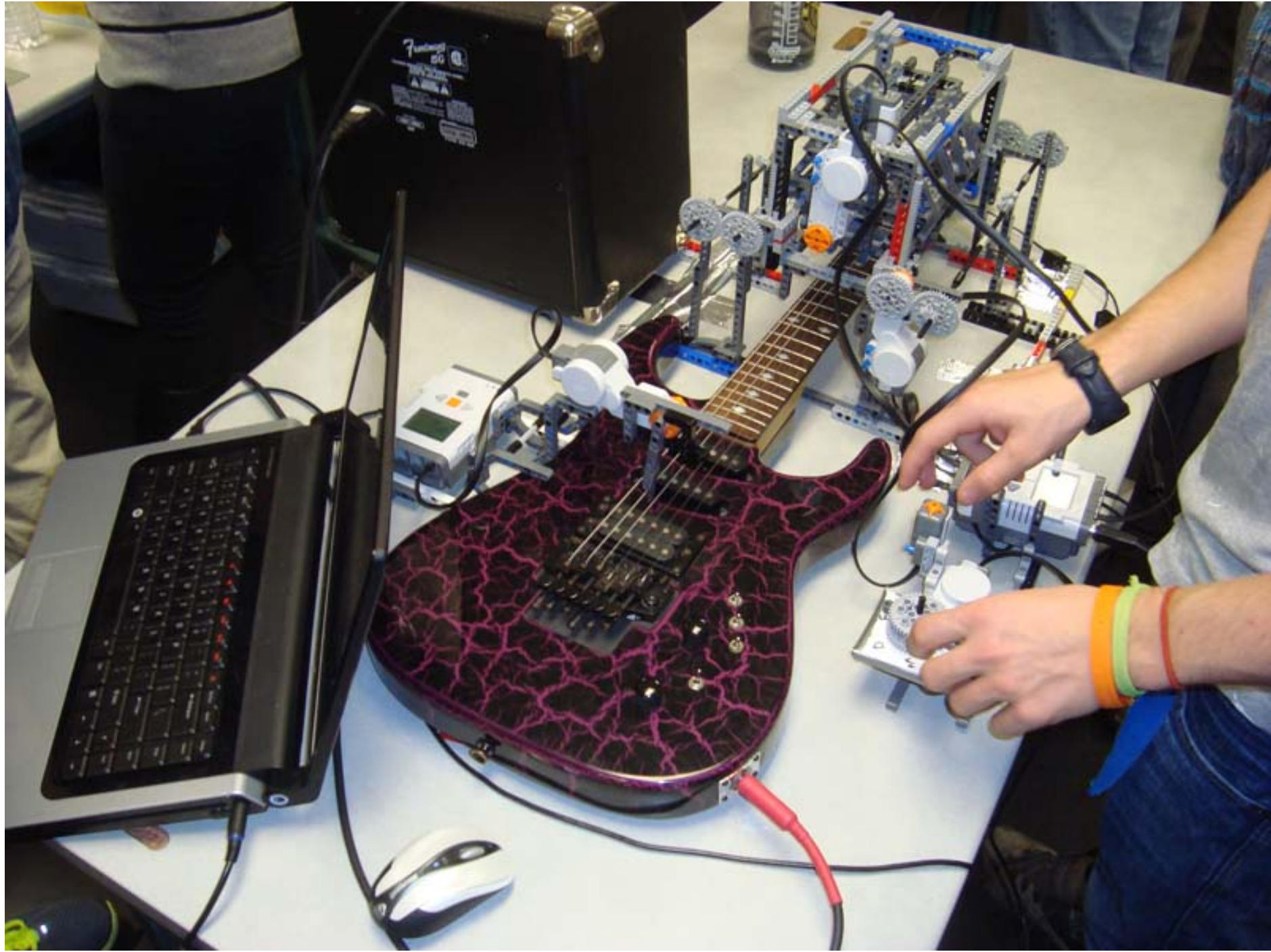


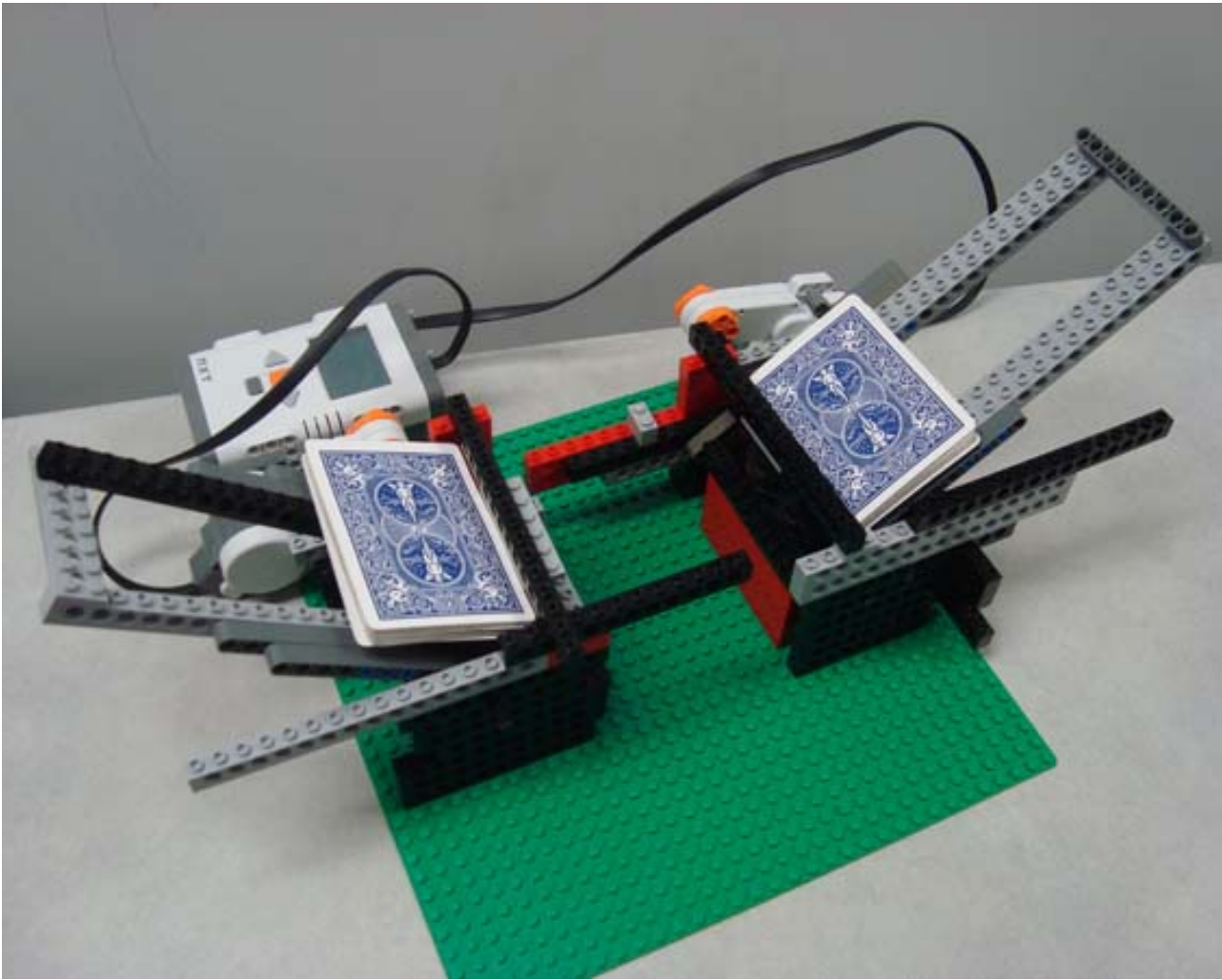














# What I didn't show...



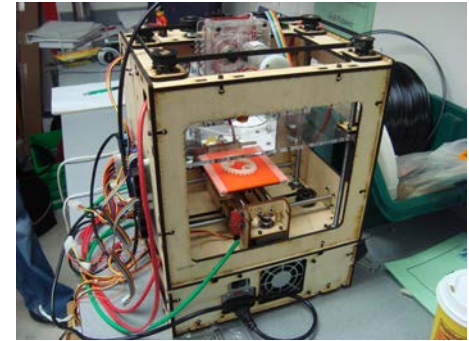
Physics Glasses



iPad & mobile devices



Alternative Platforms  
(URAPI)



Maker Movement



Touch Table Interfaces

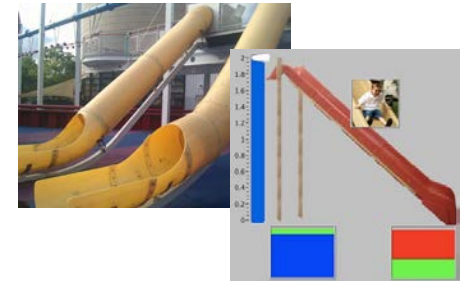


I.E.L.

Integrating Engineering  
and Literacy



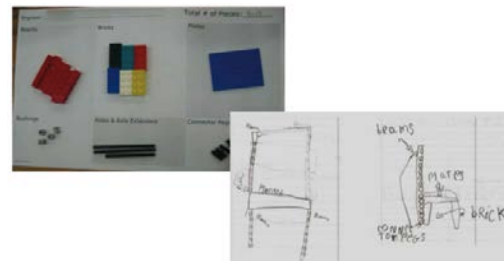
Teacher Professional  
Development



Interactive Playground  
Science (SciGames)



Conferences/Workshops



Education Research



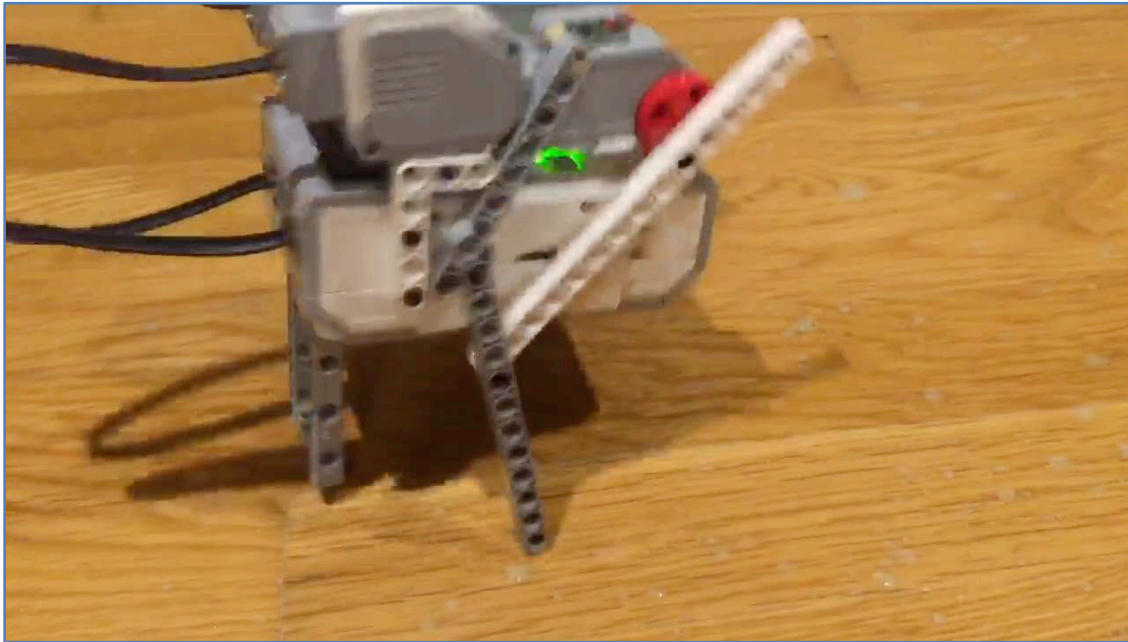
Paper Robots



RoboBooks

and more...

**Dr. Ethan Danahy** - [ethan.danahy@tufts.edu](mailto:ethan.danahy@tufts.edu)



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