



Create It Lab

The Electric String Orchestra

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Create It Lab

The Electric String Orchestra

- A pilot program jointly developed by *Hiawatha Elementary School (Essex Jct., Vermont)* and *Create It Lab*, working in conjunction with the *IBM Technical Education Outreach* program.

Goal: To enhance 3rd grade education

**In such a way that
all participating students are
motivated**

**So that
they are better prepared for
Design/Build challenges in
middle school...**

...and in the real world



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The Electric String Orchestra

Educational Design Components:

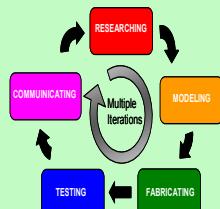
(1) Motivate with Hands-on Demos & Activities exploring Vibration, Waves & Sound



(2) Engage nearly all students by integrating

Arts into **STEM** => **STEAM**

(4) Introduce the Design Cycle as the form of the Scientific Method for Project-based Learning



(5) Coach students Brainstorming and Design Focusing



(6) Teach students Fabrication Skills



(7) Provide real-world application of

Mathematics

$$L = d_2 - d_1$$



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The Electric String Orchestra

Hands-on Demos:

- Resonance Rod



- Singing Rod



- Slinky Waves



- String Thing



- Resonant Tones



- Piezoelectricity

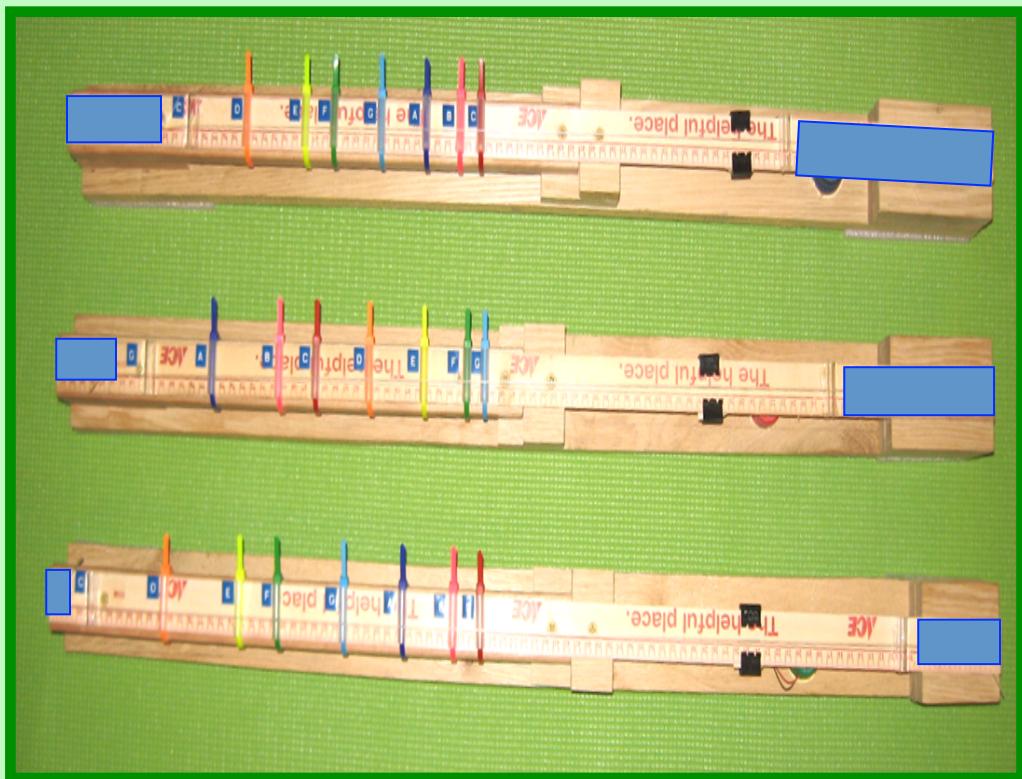




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The Electric String Orchestra

The Electric String is a tabletop chordophone designed to be easy to play and build. It incorporates an adjustable fret system with a built-in length measurement that allows easy tuning and scale changes. In addition it is augmented by a piezoelectric sensor for electric amplification, mixing and special effects.



Prototype 1-Octave Soprano, Tenor and Bass Electric Strings with adjustable frets for tuning and scale changes



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The Electric String Orchestra

Vocabulary - Instruments

Electric String



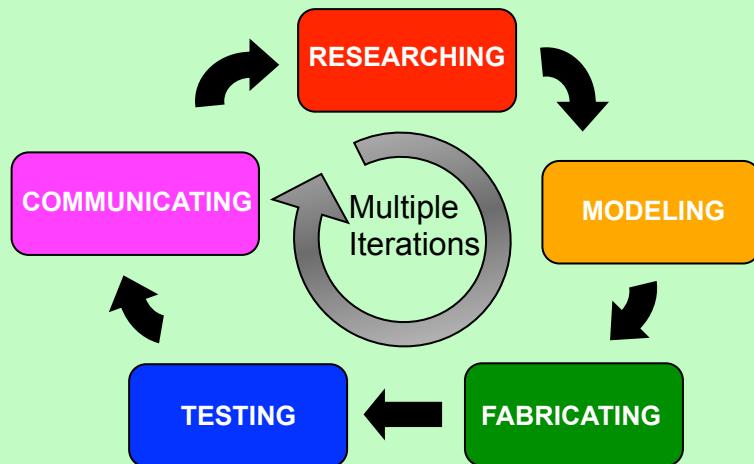
Guitar





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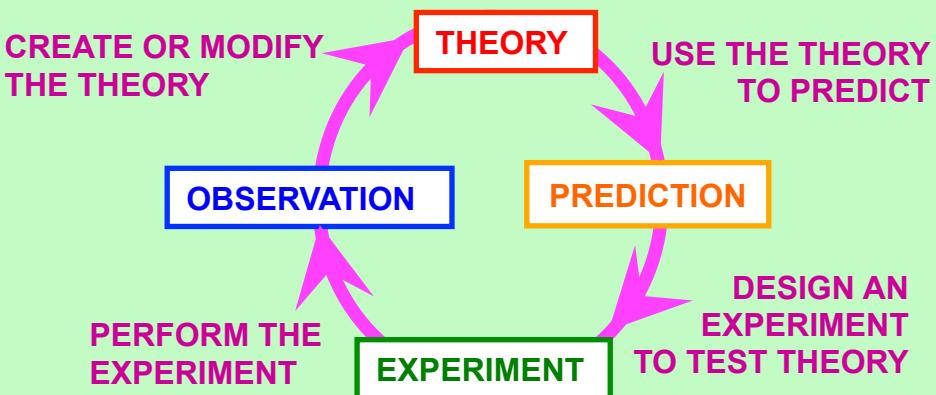
The Electric String Orchestra Design Cycle!



- The Design Cycle is a Natural Fit for Project-based Learning ⁽¹⁾

(1) Product Design Funda!, Importance of Research in Engineering Design, 4/23/12,
<http://www.productdesignfunda.com/technology/importance-of-research-in-engineering-design>

Scientific Method⁽²⁾



(2) <http://www.tomatosphere.org/teacher-resources/teachers-guide/principal-investigation/scientific-method>



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The Electric String Orchestra Brainstorming !

Question: What things would you add so that you would buy this instrument?

Some Answers:

- Handle
- Painting
- Shape Changes
- Guitar Pick or Slide
- Wheels
- Lights
- Music Stand
- Special effects



Brainstorming Electric String upgrades...

How should it look? ?
Can it be easier to move or
store? ? Could it be
easier to play? Does it
need something extra? ?



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The Electric String Orchestra Design Focus !

Question:
What is the value and the difficulty for each idea?

Do It:

- Painting
- Handle

Could Do It:

- Shape Changes
- Guitar Pick

Work On It:

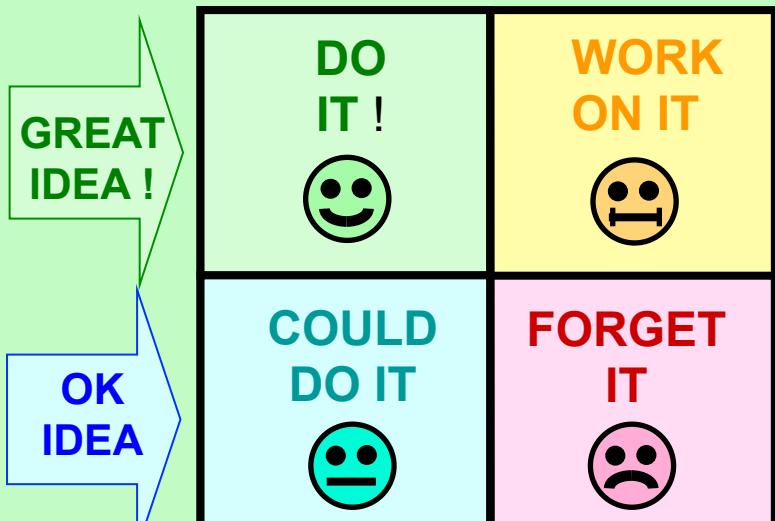
- Music Stand
- Wheels ?

Forget It:

- Lights
- Audio Effects



PICK Chart



EASY TO DO

HARD TO DO



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The Electric String Orchestra Build Process Flow

Primary Build	Parallel Activities
Brainstorming	
Cut Neck Board & Tape Frame together	Web Scavenger Hunt
Start Frame Assembly	Web Scavenger Hunt (Making Guitar Picks)
Final Frame Assembly	Bowline Knot Tying (Making Guitar Picks)
Add Frets & String	Bowline Knot Tying
Start Tuning	Adding Decorations
Final Tuning	Adding Decorations & Design Features
Final Assembly & Measure Fret Lengths	Adding Design Features
Class Picture/Longer is Lower Graph	



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The Electric String Orchestra Fabrication Skills



Safe Sawing



Safe Drilling

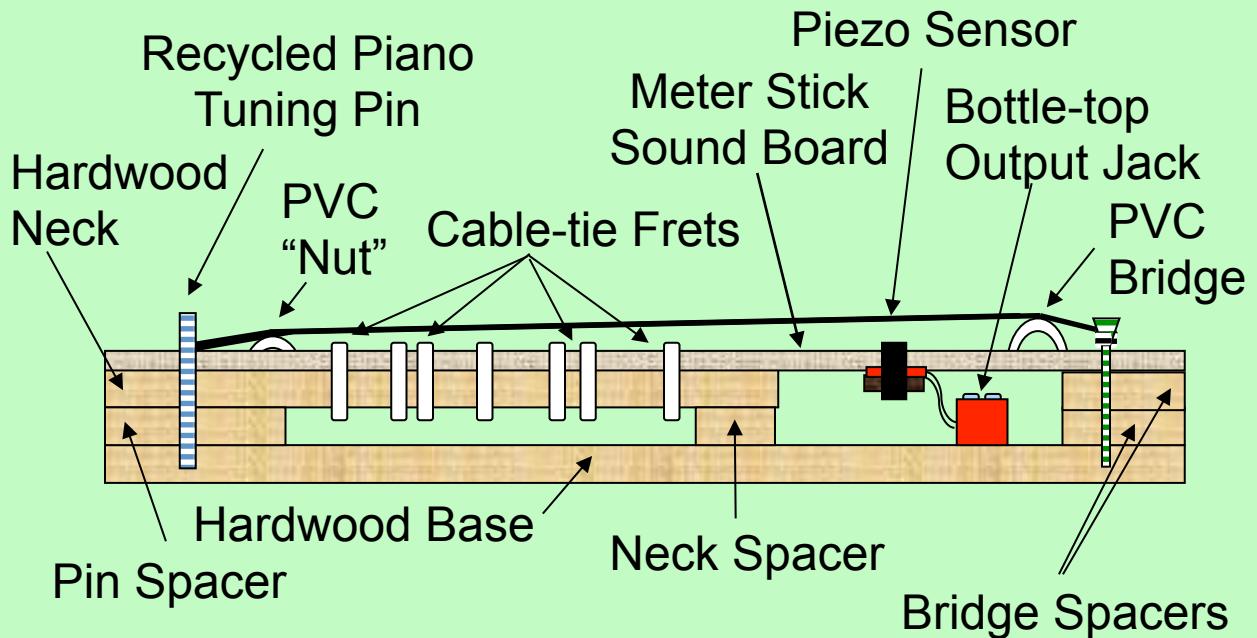
Safely Teaching Fabrication Skills

Tool	Student	Volunteer
Wood Saw	Heavily supervised	
Clamps	YES	YES
Drill Press	Heavily supervised	
Screwdriver	YES	YES
Soldering iron	NO	YES
Hot Glue	NO	YES
Music Tuner	YES	YES



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The Electric String Orchestra Construction!



Prototype Electric String with adjustable frets



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The Electric String Orchestra Tuning!



**Adjusting the Open
String Frequency**

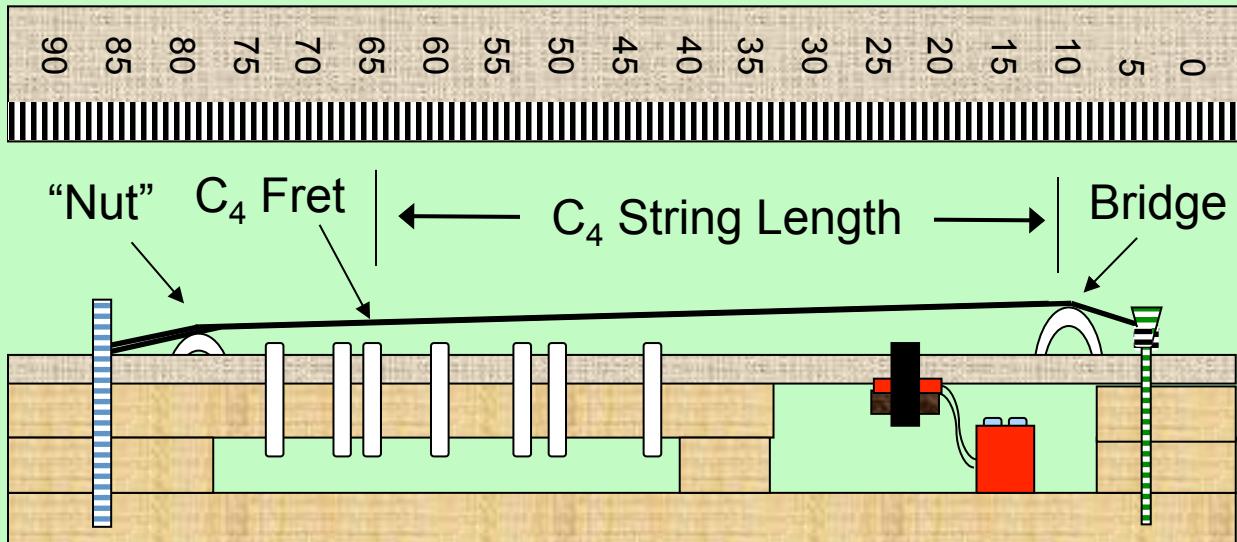


**Adjusting the Location
of Frets for Each Note**



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The Electric String Orchestra Math & Measurements!



Note	Fret Position (cm)	String Length (cm)	Fret Frequency (Hertz)
G ₃ *			196
A ₃			220
B ₃			247
C ₄			262
D ₄			294
E ₄			330
F ₄			349
G ₄			392

Bridge Position = _____ centimeters

$$\text{String Length} = \boxed{\text{Fret Position}} - \boxed{\text{Bridge Position}}$$

Example:

$$\text{C}_4 \text{ Fret Position} = 64 \text{ centimeters}$$

$$\text{Bridge Position} = 12 \text{ centimeters}$$

$$\text{C}_4 \text{ String Length} = 64 - 12 = 52 \text{ cm}$$

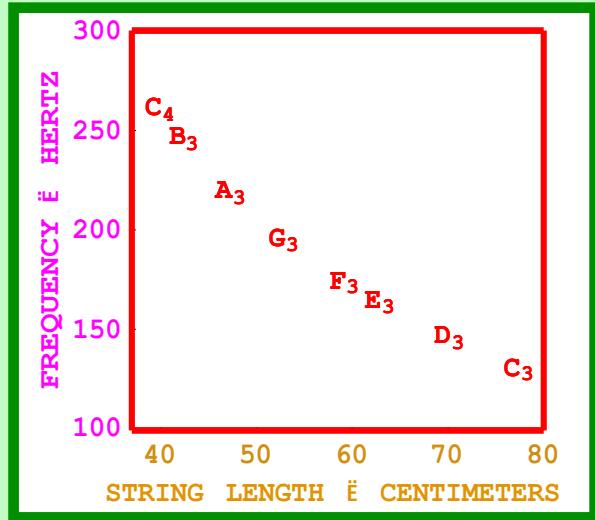
* The G₃ Fret position is the center of the "nut"



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The Electric String Orchestra Math - “Longer is Lower”

Graphing Introduced by Role Playing

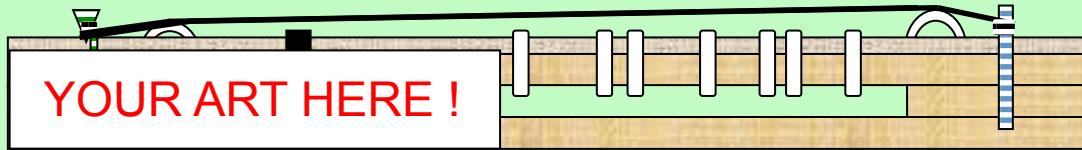


The Hiawatha 3rd Grade Students Demonstrate the “Longer is Lower” Relationship by Forming a Human Plot of Frequency vs. String Length



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The Electric String Orchestra Artwork!



**Side panel becomes a palette for student artwork
(e.g., metal foil work, Escher-like tessellations)**



Electric Strings with Individualized Artwork



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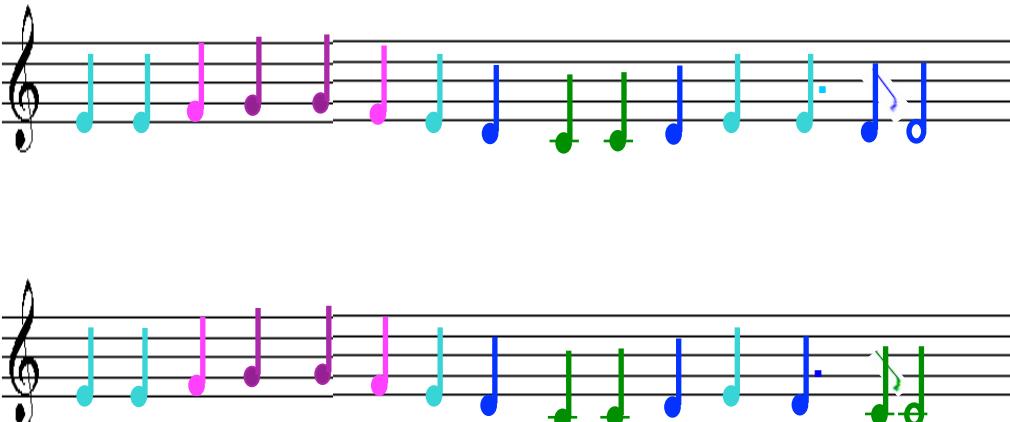
The Electric String Orchestra **Music!**

- Developmentally appropriate music selections
- Parts arranged for soprano, tenor and bass Electric Strings
- Modified standard notation
 - Color coded notes



Example:

Ode To Joy Ludwig van Beethoven
Arrangement: CiLab





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The Electric String Orchestra Assessment



Final Performance by 3rd Grade Students at Hiawatha Elementary School, Essex Junction, VT *

Deliverables:

- (1) Completion of Electric String instrument
- (2) Completion of front panel artwork
- (3) Participation in group performance using soprano, tenor and bass Electric Strings in three-part harmony

* Picture Provided by Dave Contois,
Contois School of Music





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The Electric String Orchestra **Thanks!**

Electric String Guides:

S. Ayotte
C. Christiansen
N. Clore
C. Croteau
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M. Hauser
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