Author's Name: PJ Nguyen
Host Organization: Arias Research Group, Flexible Electronic Devices Laboratory, UCB
ETP Type: ETP Option 2, Enhance Existing Curriculum Content
Subject Area: Grade --- Physics, 11th graders
Coach Name: Tom Knight
Date: 2015 August 5th

Educational Transfer Plan (ETP) Title Conservation of Energy and Organics Photovoltaic Research

0. Abstract

In this activity, students will learn that energy changes from one form to another, and that the total amount of energy in a closed system remains constant. Students will also examine some technologies for renewable energy and the research about organics solar cells at the University of California, Berkeley.

I. Standards/Skills/Objectives/Assessment

1. Focal Standard or Skill:

NGSS HS-PS3-1. Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. [Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.] [*Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.*]

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2. Measurable Objective(s):

Measurable Objective(s): Students will apply the law about energy conservation to verify the height of a pendulum bob in a ballistic pendulum experiment. Student calculate and measure the kinetic energy KE and the gravitational potential energy GPE of the pendulum bob b and the projectile p where $\square\square = \frac{1}{2}\square_{\square}\square_{\square}^{2} + \frac{1}{2}\square_{\square}\square_{\square}^{2}$ $\square\square\square\ \square\square\square = (\square_{\square} + \square_{\square})\square\square$.

The above measurable objective aligns with the focal standard.

Focal Standard or Skill: NGSS HS-PS3-1. Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

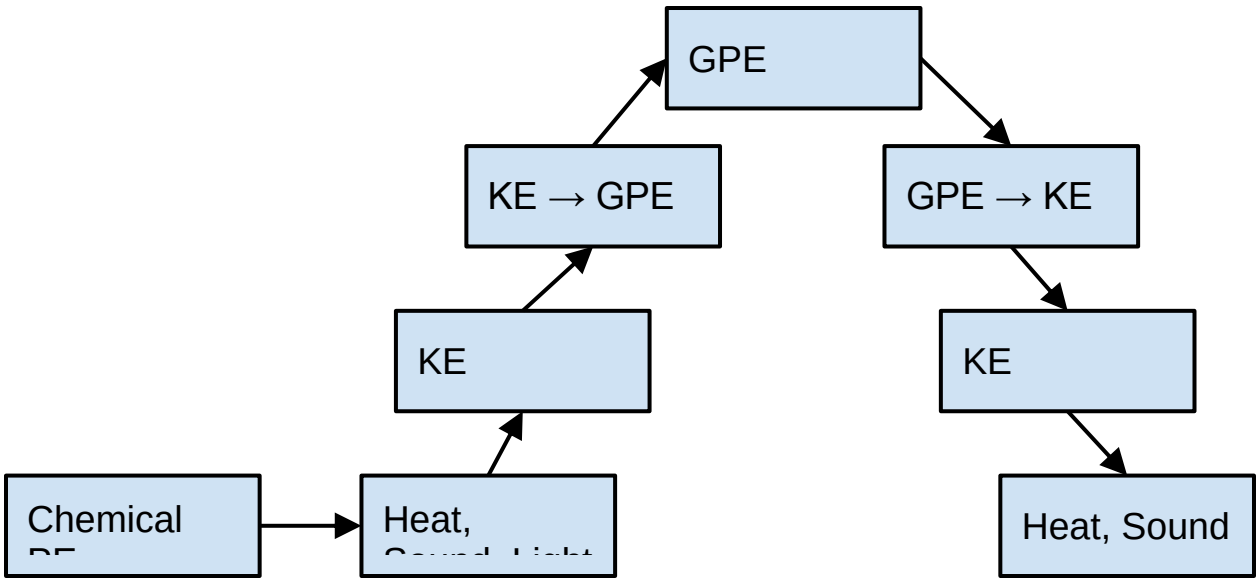
3. Assessment:

Students will participate in a Think-Pair-Share Kahoot dash 30-second game. In this Kahoot game, students will compete for the correct answers to conceptual questions about energy forms and the conservation of energy. Here is an example:

Insert the appropriate words into the diagram.

Chemical Potential Energy	Kinetic Energy (KE)	Sound Energy	Light Energy	Kinetic Energy (KE)
Heat Energy	Gravitational Potential Energy (GPE)	KE becoming GPE	GPE becoming KE	Heat Energy and Sound Energy

A toy rocket burns its fuel to launch itself up from the ground. It then rises to a height h and then falls back to earth. The following diagram shows the energy transformations that occur in this series of events.



II. Fellowship Connections

1. 21st Century Skill(s):

ENVIRONMENTAL LITERACY

- Demonstrate active and considered participation aimed at solving problems and resolving issues *(the focus is on particular sub item)*

2. 21st Century Skill(s) Application:

Learning and Innovation Skils
Collaborate with Others

- Assume shared responsibility for collaborative work, and value the individual contributions made by each team member (*each member has role)*

ITC Literacy
Apply Technology Effectively

- Use technology as a tool to research, organize, evaluate and communicate information (*use GoogleDoc to record data and collaborate)*

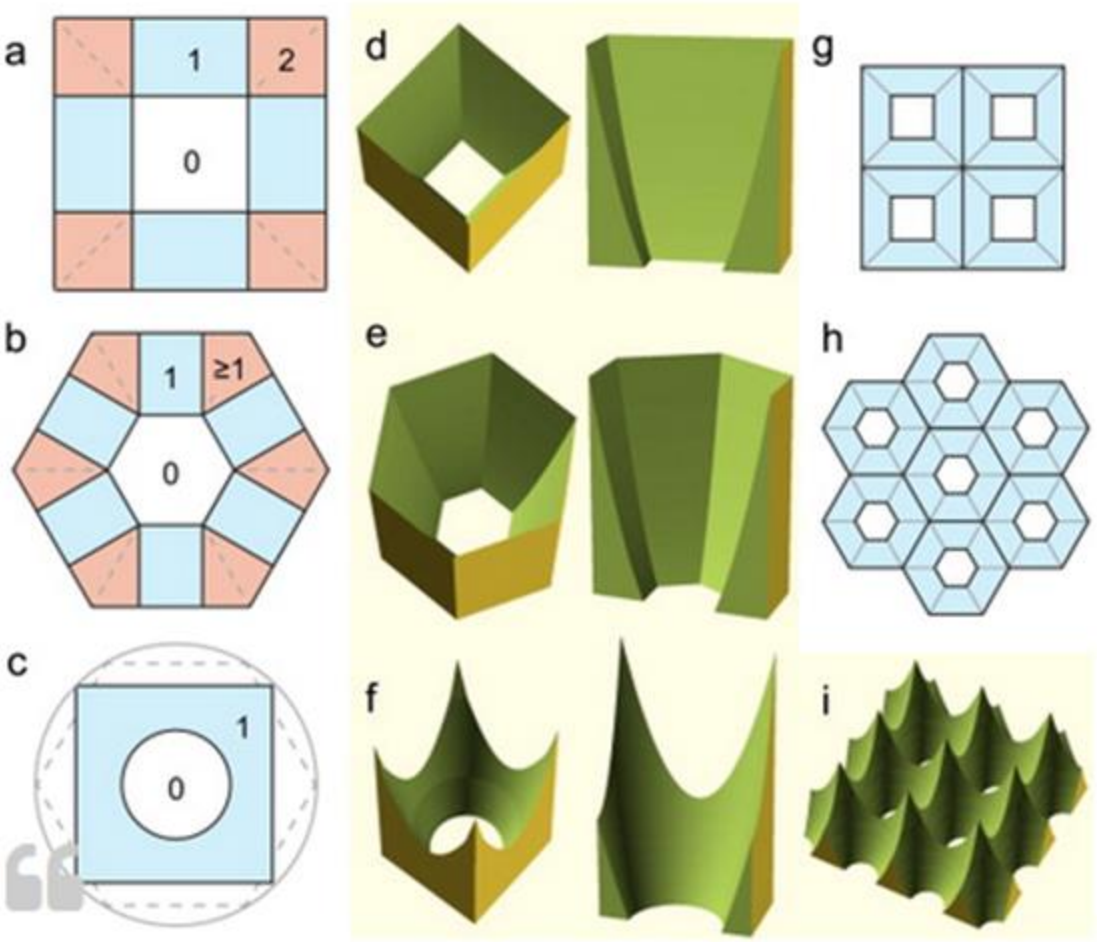
3. Fellowship Description:

The Arias Research Group Flexible Electronic Devices Laboratory focuses on the design and optimization of polymer solar cells. My fellowship involves (i) the preparation of substrate; (ii) the application of hole-transport layer, active layer, electron transfer layer; and (iii) the measurement of efficiency. I am using skills that include (i) mixing chemical solutions; (ii) operating ultrasonic cleaner, glovebox, spin coater, characterization simulator, and blade coater. I am exposed to career types in scientific pure research (chemistry, chemical engineering, electrical engineering, process engineering, and physics). My sponsor is currently conducting experiments regarding the efficiency of printable solar cells at low light environment.

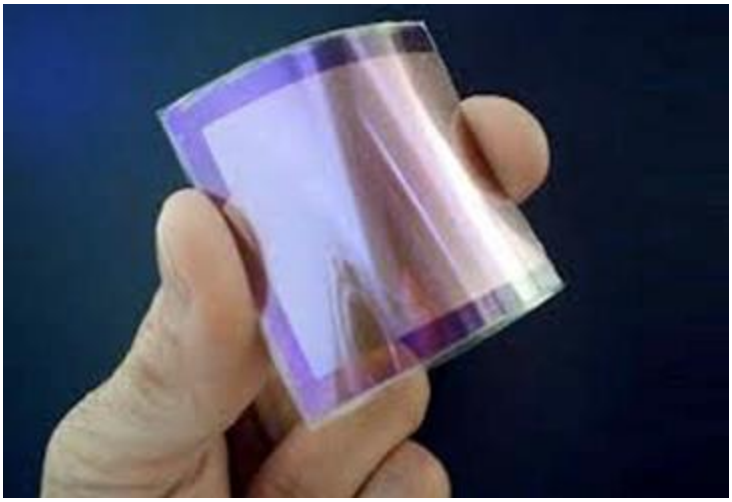
4. Fellowship Connection to School/Classroom:

I plan to use my experience at Arias Lab to infuse best practices of scientific research fundamentals (e.g., safety, precision, repeatability) into high school physics lab activities. I will also illustrate how scientific research could advance the social goals of sustainable development and environmental management. I plan to use my smartphone and video-record my work at the lab, then do some editing (trim, sound, special effects) to jazz up the footage. I will show the edited clip to students so they could have a personalized virtual tour of an organic photovoltaic OPV production process. The focal standard [conservation of energy] is relevant here as OPV is about using a relatively limitless energy source (the sun) and convert it into usable electrical energy.

In addition to the class activity, I may go beyond the scope of this ETP and collaborate with the art teacher. For example, we could aim for a STEAM project. STEAM = science, technology, engineering, art, mathematics. Students will learn origami and design a light-collector accessory that could supplement solar panel. Among the possibilities are (i) use adhesive to glue flexible solar cells to origami designs; (ii) use mylar as the material for origami.

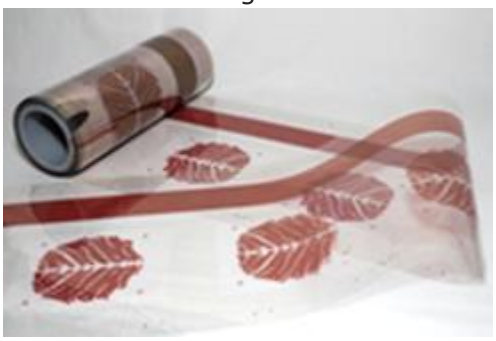


Going even further, I may apply for a grant to acquire a 3D printer for the school. Students will use the printer to generate OPV. This is likely the most difficult option to implement as I will need to acquire the printer and the appropriate materials for the manufacturing of OPV. I need materials that are relatively inexpensive. At our school, we have a TechBridges program in which female students are encouraged to study STEM. I will likely coordinate with these students to commercially manufacture [Unity flexible solar panel]. It would look something like this



with the Unity logo on it.

We would be using conductive ink and print roll of panels, like this



and sell the panel at a few bucks a piece, mostly as souvenir. All proceeds go to students. So students would practice their skills not only in technology, but also in entrepreneurship. In the likely event that an affordable 3D printer solution is not available, an alternate option is for students to assemble a solar charger by using commercial off-the-shelf solar cells and USB connector.

Note:[text highlighted in green] = out of scope with respect to the ETP, but I may try anyway. The following item (III Instruction) will not be about the origami option nor the souvenir option. The following item (III Instruction) will only refer to the class activity regarding conservation of energy (to be done in one session). I will proceed to do research about the origami option and the souvenir option but details about those options will be provided elsewhere as those options are out-of-scope for this ETP..

III. Instruction

1. Instructional Plan:

Time required: (1- 2 50 minute periods, or 1 90 minute block)

1.1. Opening/Hook: Forms of Energy, Research at UC Berkeley…. (10 minutes)

In this opening, students will learn that energy changes from one form to another, and that the total amount of energy in a closed system remains constant (formative assessment). Students will also examine some technologies for renewable energy and the research about organics solar cells at the University of California, Berkeley.

I plan to use my experience at Arias Lab to infuse best practices of scientific research fundamentals (e.g., safety, precision, repeatability) into high school physics lab activities. I will also illustrate how scientific research could advance the social goals of sustainable development and environmental management.

We will start by reviewing the content of previous session for energy forms (connecting to existing experience). The review provides the initial step for how the focal standard will be taught.

See attachment for details.

I then describe my summer fellowship at the Arias Research Lab, UC Berkeley, particularly on the lab safety procedure and the relevancy of the research with respect to energy and the environment.

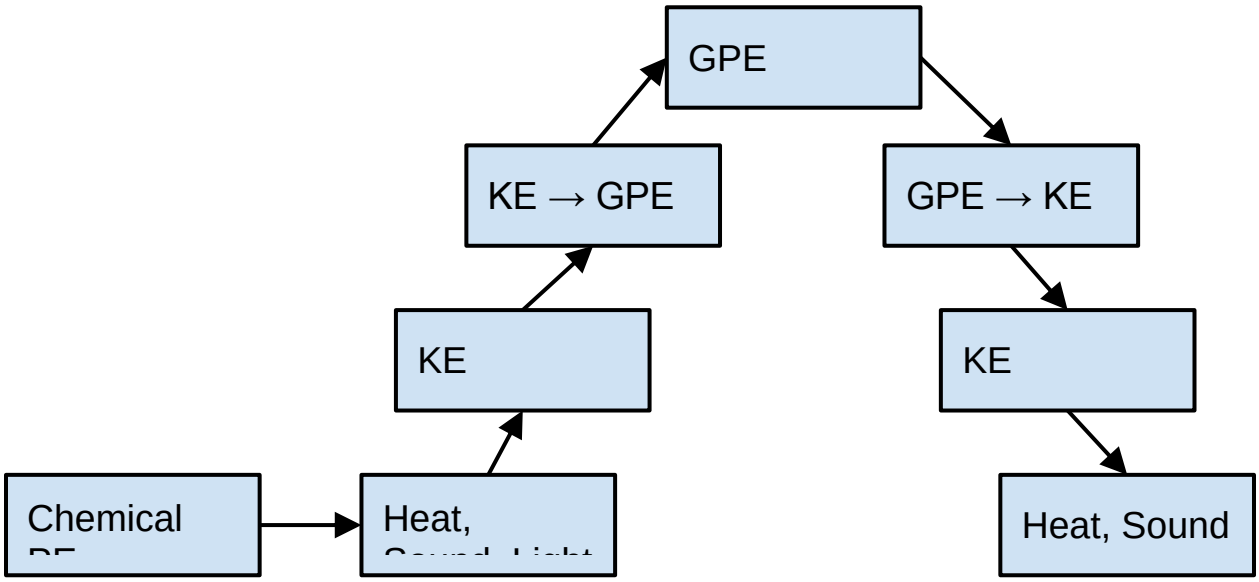
1.2. Build/Check For Understanding (formative assessment): Rocket Launch (10 minutes)

Students will discuss in small groups and answer conceptual questions about energy forms and the conservation of energy. Here is an example:

Insert the appropriate words into the diagram.

Chemical Potential Energy	Kinetic Energy (KE)	Sound Energy	Light Energy	Kinetic Energy (KE)
Heat Energy	Gravitational Potential Energy (GPE)	KE becoming GPE	GPE becoming KE	Heat Energy and Sound Energy

A toy rocket burns its fuel to launch itself up from the ground. It then rises to a height h and then falls back to earth. The following diagram shows the energy transformations that occur in this series of events.



These conceptual questions provide further steps for how the focal standard will be taught.

1.3. Model: Pendulum, KE, GPE (10 minutes)

This activity aligns with the 21st Century Skill Application.

21st Century Skill(s) Application: Collaborate with Others

- Assume shared responsibility for collaborative work, and value the individual contributions made by each team member

Role A and Role B (Tech)	Role C (Analyst)
Setup the lab. • **Calibrate** the pendulum so that the fired steel ball is embedded in the pendulum bob. • **Measure** the velocity V of the steel ball as it is fired, using the photogate. • **Measure** the height h_m when the pendulum is at its highest point.	Ø **Calculate** the Kinetic Energy KE of the system when the pendulum is at its lowest point. Ø **Predict** the Potential Energy PE of the system when the pendulum is at its highest point. Ø **Predict** the height h_p when the pendulum is at its highest point.

Students will apply the law about energy conservation to verify the height of a pendulum bob in a ballistic pendulum experiment. Student calculate and measure the kinetic energy KE and the gravitational potential energy GPE of the pendulum bob b and the projectile p where $\square\square = \frac{1}{2}\square_{\square}\square_{\square}^{2} + \frac{1}{2}\square_{\square}\square_{\square}^{2}\ \square\square\square\ \square\square\square = (\square_{\square} + \square_{\square})\square\square$.

The measure of KE and GPE provides quantifiable step for how the focal standard will be taught.

1.4. Guided Practice: Set up and Measure (with teacher support).... (30 minutes)

Role A and Role B: Setup and Measure
1. Place the ballistic pendulum on a flat, level surface. Use the Bubble Level to verify that it's flat. If needed, make adjustment by placing paper underneath corner to ensure it is flat. 2. Line up the launcher with the pendulum so that the steel ball is caught by the pendulum. Test fire the steel ball several times. Make adjustment by loosen the thumb screws near the top of the supporting rod, then raise/lower or rotate the pendulum as needed. 3. The short prying rod at the front of the apparatus is for dislodging the caught steel ball. 4. Put on your goggles. 5. Partner_A to hold the pendulum bob at 30^0. 6. Partner_B to load steel ball, place the photogate at end of nozzle, and fire steel ball.

7. Record the velocity V in data_table_A at column [velocity_kh].
8. Release the pendulum bob to its lowest height.
9. Reset the angle measure gauge.
10. Fire steel ball proceed to next step only if steel ball is embedded into pendulum bob. Else re-align to ensure that the fired steel ball is embedded.
11. Record value of in column [θ].

Role C: Calculate

1. Convert velocity from km/h to m/s and record the converted value at column [velocity_ms].

2. Calculate Kinetic Energy KE of the system when the pendulum is at its lowest point, using the equation $\square\square = \frac{1}{2}\square_{\square}\square_{\square}^{2} + \frac{1}{2}\square_{\square}\square_{\square}^{2}$

where $\square_{\square}$=7.64g; $\square_{\square}$ = 80.57g, $\square_{\square}$=[velocity_ms]; $\square_{\square}$= 0 m/s.

3. Record your calculated value Kinetic Energy KE at column [KE].

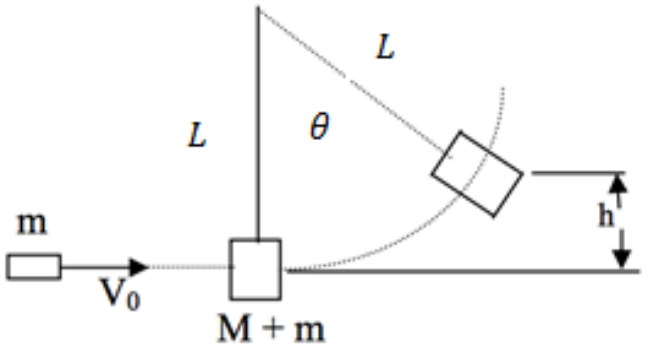
4. Predict the height h_p where the pendulum is at its highest point. Use the law on energy conservation where $KE = GPE$ and $\square\square\square = (\square_{\square} + \square_{\square})\square\square$.and = 9.8 m/s^2.

5. Record your calculated value h_p at column [h_p].

6. Calculate the height h where the pendulum is at its highest point. Use trigonometric rule of cosine where

$$\square\square\square\ \square = \frac{\square - \square}{\square}$$

and $\square$= 0.23m.



7. Record your calculated value h at column [*h*].

1.5. Independent Practice (summative assessment): Data Analysis, Conclusion (15 minutes)

1. **Compare** the difference between h_p and h. Give possible explanations.

_____
_____

2. Does this experiment demonstrate conservation of energy? Explain.

_____
_____

3. What are potential sources of error in this experiment, and how can they be reduced?

_____
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1.6. Assessment (summative): Kahoot (5 minutes)

Once the students have completed their Independent Practice, I will launch Kahoot. This is a software game with multiple choice questions. This is a game that most, if not all, students in my class have been looking forward to enjoy at lesson's end. I will prepare the questions, answers, graphics in advance. Students are to compete in small group, with one member having access to Chromebook, another member with access to resources such as their notebooks. The game is designed to let students share and get feedback on the products of their learning. The game also allows me to assess student understanding and provide corrections.

On their devices, students do not see the question but only a countdown timer. By having all students look up the question on the projector, a sense of community is fostered. That is, we will prevent a scenario in which each team would be operating within their own environment. Instead, everyone is looking at the screen. This will also encourage students to read the question aloud, without any prompt from the teacher. The countdown is about 5 seconds, then the question will appear again on my computer, this time with visual aid and the multiple choices

On their devices, students see only the shapes and colors representing those choices. Students thus share the information on my computer (displayed on projector screen). The sharing of text facilitates a sense of "we are doing this together."

Correct answer is displayed on the shared projector screen…and also on the students' devices (for those students who select the incorrect answer). The display of correct answer provides students with immediate feedback.

On students' devices, ranking is displayed if team selected the correct choice. The ranking introduces the spirit of competition into the game.

3. Supply List:

Figure A: Bubble Level

Figure B: BeeSpi Photogate Timer

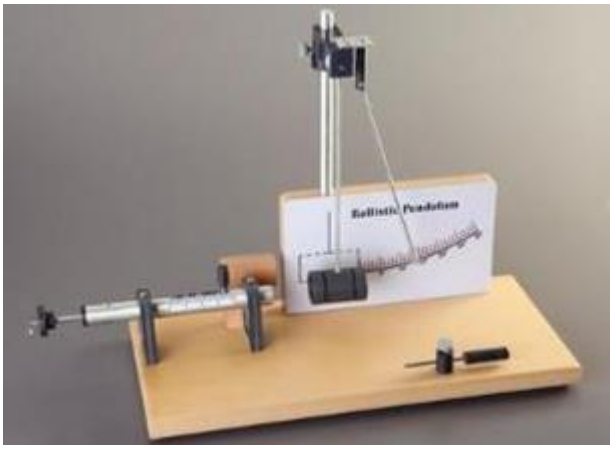

Figure C: Photo of Ballistic Pendulum

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5. Keywords:

Keywords: *energy, conservation, kinetic, potential, solar, electrical, optimization, organic, photovoltaic*

IV. Attachments (Appendices)

1. **sample student document without answer key (pre assessment)**

See attachment.

2. **sample teacher document with answer key (pre assessment)**

See attachment.

3. **sample teacher document with answer key (formative assessment)**

See attachment.

4. **sample homework problem related to Conservation of Energy with answer key (summative assessment)**

See attachment.

5. **Opening: details**

See attachment.