BIRDEE Unit 1 Lesson Plans

Unit 1 Modules & Themes tinyurl.com/birdeeunit1LP

Module 1 Launcher: Connecting Nature to the Engineering Design Process				
Connect Nature to Engineering	**Empathy & Customer Discovery**	**Reverse Engineering & Requirements**	**Define Problem Requirements**	**Ideate a Solution for Conceptual Design 1**

Module 2 Launcher: The Lotus Effect				
Benchtop Prototyping	**Testing the Lotus Effect**	**Conceptual Design 2**	**Design Review**	**Introduce EDPL**

Module 3 Design Challenge: Identify & Understand				
Design Challenge Intro: BID & EDP	**Understanding the Problem and EDPL**	**Understanding Existing Engineering Systems with SFM**	**Product Analysis and Reverse Engineering**	**Existing Products and Ideate**

Module 4 Design Challenge: Heat Transfer & Thermal Regulation				
Understanding Thermoregulation Systems in Nature with SFM	**Conceptual Design 1**	**Thermal Regulation Experiment Part 1: Intro & Setup**	**Thermal Regulation Experiment Part 2: Analyze Data**	**Thermal Regulation Part 3: Additional Data/BID Analogy**

Module 5 Design Challenge: Ideation & Evaluation				
Design Challenge Part II	**Conceptual Design 2**	**Ideate: Learn about the Morpho Matrix**	**Conceptual Design 3: Morpho Matrix**	**Evaluate to Prototype 1**

Module 6 Design Challenge: Prototype & Test				
Prototype 1: Build	**Prototype 1: Requirements Evaluation**	**Elaborate to Prototype 2**	**Prototype 2: Build**	**Finalize Design**

Module 7 Design Challenge: Communicate Solution

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Create a Pitch Presentation	**Class Presentations**			

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Unit 1 Module 4: Design Challenge Heat Transfer & Thermal Regulation	Materials
Module 4 Overview: 1.4.1 Understanding Thermal Regulation Systems in Nature with SFM 1.4.2 Conceptual Design 1 1.4.3 Thermal Regulation Experiment Part 1: Introduction and Setup 1.4.4 Thermal Regulation Experiment Part 2: Analyze Data 1.4.5 Thermal Regulation Experiment Part 3: Additional Data &BID Analogy	**1.4.0. EDPL Map**

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1.4.1. Understanding Thermoregulation Systems in Nature with SFM

In 1.3.4. and 1.3.5, students looked at existing food thermal regulation solutions/systems and brainstormed structures in biology that perform similar functions. In this lesson, students will look to nature for thermoregulation systems and will practice guided SFM on these systems.

Engage: 5 min

View: 1.4.1. BID WOW!

- What can anthills and termite mounds inspire?
- **Class Discussion** on what students think
- **Play video:** Termite Mounds and Air Conditioning (in ppt)
- **(Optional) Play video:** Termite Mounds and AC (in ppt)

Explain: 10 min *(Presentation)*

We are going to learn about how to use the SFM tool with thermoregulation systems. Thermoregulation systems are similar to thermal regulation systems, but are biological thermal regulation systems instead of man-made thermal regulation systems. We will practice SFM with polar bear fur. *(**Teacher Note:** NGSS crosscutting concept)*

View: 1.4.1. Polar Bear Fur: SFM

View: BIDI Graphic

Now, we are going to start Biologically Inspired Design Ideation. First, we are going to do our biological search in nature by looking at organisms in nature that thermoregulate. Then, we will understand the biological mechanism of the relevant biology we find using the SFM tool, like we just did with the polar bear.

Explore: 25 min *(Individual)*

Digital Gallery
We have narrowed down your biological search by selecting some biological thermoregulation systems for you to analyze using a guided version of SFM. We are in the Ideate stage of the EDP!

Teacher Note: There are 6 posters: Western Honey Bee, Whale, Jack Rabbit, Arctic Hare, Camel, and Emperor Penguin. Students may view the color posters by sharing the link. Alternatively, you may choose to print out 3-4 of each poster and create stations for students. We have provided printable versions in both color and Black & White.

View: 1.4.1. Thermoregulation Posters Color
1.4.1. Thermoregulation Posters B&W

Student Handouts:

1.4.1. SFM Analysis Thermoregulation Digital Gallery Notes

Student Materials:

1.4.1. Thermoregulation Posters Color

1.4.1. Thermoregulation Posters B&W

Instructional PPT's & Materials:

1.4.1. BID WOW!

1.4.1. Polar Bear Fur: SFM

Teacher Resources:

1.4.1. BID Thermoregulation System SFM Examples Teacher Guide

1.4.1. SFM Analysis Digital Gallery Notes TEACHER KEY

Web Resources:

BIDI Graphic

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• You will peruse the poster collection of thermoregulation systems from nature and choose 1-2 (depending on time) systems to analyze using the guided SFM worksheet **1.4.1 SFM Analysis Thermoregulation Digital Gallery Notes**. • After completing your analysis on your two systems, find a classmate who chose the same examples as you and compare your analysis to their SFM analysis. • You will add any notes from what you learned from your classmate to your worksheet. **Extend: 5 min** *(Group)* **EDPL:** Update Research Notes as needed based on what you learned today.	

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1.4.2. Conceptual Design 1

Students will use the brainwriting technique to ideate ideas for the design challenge. They will share their ideas with their group and create their first conceptual design for this design challenge.

Engage: 5 min

View: 1.4.2. BID Ideation

- You are trying to design and build a laboratory-treehouse in the rainforest. What in nature could you draw inspiration from for your treehouse?
- What functions would your treehouse need to have to be successful? List at least three functions. Brainstorm 2-3 organisms that could inspire each function your treehouse needs to have.
- **Class Discussion** on what students brainstormed

Engage: 5 min

Teacher Note: *Teachers will engage students in a brief refresher about the design challenge and everything the students learned in Module 3 and 1.4.1 before having them complete the conceptual design worksheet*.

- What is our design problem? Who is the client?
  - Creating a food delivery system for EatEZ.
- What are some of the requirements that we came up with for our design problem?
  - Must keep food hot/cold for a certain amount of time
  - Must be easy to carry
  - Etc.
- What are some of the thermal regulation systems we learned about? These can be from nature or examples in the human world.
  - Air conditioning, car engine coolant, insulation for a house, etc.
  - Termite mound, polar bear fur, blubber, honeybee, etc.

Explain: 5 min

Now, we will ideate more solution ideas for our design challenge using the Brainwriting Technique that we used for our dirty shoes problem.

Remember to consider what you know about the client's problem, existing solutions, and BID when ideating ideas. The sketches don't have to be perfect, just sketch what comes to mind no matter how out-there it may seem. A sketch can be a complete solution or part of a solution.

Teacher Note:

- *Encourage students to review all the activity materials they have worked on this Module to get ideas for their design. Also, remind students of the good sketching practices they learned with the dirty shoes design challenge.*

Student Handouts:

N/A

Student Materials:

*notebook paper or sticky notes for brainwriting

Instructional PPT's & Materials:

1.4.2. BID Ideation

Teacher Resources:

N/A

Web Resources:

BIDI Graphic

- *Additionally, teachers should emphasize the iterative nature of the EDP. Sometimes throughout the EDP you get new information that results in different design ideas. Since we've done a conceptual design, we've learned about thermoregulation in nature. Let's revisit our design ideas and see if we can come up with more given our new knowledge.*

View: BIDI Graphic

Remember, if you choose to incorporate some of the biology we explored yesterday in your design, follow the BIDI steps. Select the biology concept you want to incorporate into your design and then integrate it into your design.

Explore: 15 min *(Guided Brainwriting)*

Teacher Note: *Teachers will guide students through the brainwriting technique by putting timers up on the board and reminding students what the steps of the technique are.*

Brainstorming: Brainwriting: (*individual)*

- **2-Minute Write/Sketch:** You will have 2 min to write down ideas for how to solve the design problem or sketch a solution to the problem. You can do this on sticky notes or notebook paper. (Do not include your name.)
- **3-Minute Talk:** Share your ideas with your group by posting your sticky notes on a wall or sharing your paper on the table. Select the top ideas.

Repeat 1.5x. Sketch, talk, sketch.

View: 2 Minute Video Timer

Extend: 15 min *(Group)*

Conceptual Design 1
Look at your ideas from the brainwriting activity and your idea from 1.3.5. Work together with your group to create conceptual design 1. A conceptual design is a complete design, where ideas can be either a complete design or a partial design.

EDPL: Upload your conceptual design 1 to the EDPL "Ideate" tab. Add any Research Notes, if needed.

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1.4.3. Thermal Regulation Experiment Part 1: Introduction & Set Up

Students will explore the concept of Thermal Regulation by conducting an experiment using a jar filled with ice and a temperature sensor to record data. Teachers will model the lesson by preparing the "control" jar.

Prior to the lesson: Teachers should become familiar with the experiment and Set-Up Instructions outlined here: **1.4.3. Thermal Regulation Experiment TEACHER DIRECTIONS PPT**

Teachers should also obtain the experiment supplies:

- 8 oz. Wide mouth plastic jars
- Govee Temperature sensors
- Velcro tape
- Ice
- Cotton
- Bubble wrap
- aluminum foil
- Tape
- Scissors

Engage: 15 min *(Presentation)*

Now, we are going to go back a step in the EDP to Understand. We've already worked on understanding existing solutions, understanding our client's needs, and understanding our problem requirements. We are going to do an experiment to help us understand the science behind our problem, specifically how good different materials are at keeping something at a constant, stable temperature aka thermal regulation (which we have talked about before) and the scientific concept of thermal regulation: heat transfer.

View: 1.4.3. Thermal Regulation Experiment Part 1: Introduction & Set Up

Teacher Note: *All items are included in the PPT with instructions in speaker notes.*

Explore: 20 min *(Group)*

Experiment Set-up
Materials (per group): plastic Jar, ice, Govee sensor, 1 insulator (student's choice)

- **Step 1:** Prepare your workstation with one jar and one insulator.
- **Step 2:** Attach the Govee sensor to the inside of the jar lid using Velcro
- **Step 3:** Place 3 ice cubes in your jar (avoid broken ice cubes to ensure consistency). It should be ½ full and not touching the sensor.

Student Handouts:

N/A

Student Materials:

8 oz. Wide mouth plastic jars
Govee Temperature sensors
Velcro tape
Ice
Cotton
Bubble wrap
aluminum foil
Tape
Scissors

Instructional PPT's & Materials:

1.4.3. Thermal Regulation Experiment Part 1: Student Intro & Set Up

Teacher Resources:

1.4.3. Thermal Regulation Experiment TEACHER DIRECTIONS PPT

Web Resources:

N/A

● **Step 4:** Cover your group's jar in your choice of insulator. ● **Step 5:** Allow time for the ice to melt. We will analyze the data tomorrow. ***Teacher Note:*** *Make sure that students use only one layer of one material for each jar.* **Wrap Up: 5 min** We will export our data and visualize it in our next class.	

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1.4.4. Thermal Regulation Experiment Part 2: Analyze Data

Students will analyze data from the Thermal Regulation experiment. They will use Excel or Google Sheets to plot and interpret data.

Prior to the lesson: Teachers should export control jar and student data according to the directions linked here: **1.4.4 Thermal Regulation Part 2: Analyze Data TEACHER DIRECTIONS**. Teachers should share the individual .csv data files with each student team using the teacher's preferred communication tool. Teachers should also use this link to the **Sample Padlet Link**, make a copy and share your class link with students.

Engage: 5 min

View: 1.4.4. BID Ideation

- You are trying to design and make a robot that must traverse rough terrain, so it can't have wheels.
- Brainstorm at least three organisms that traverse rough terrain. Choose one organism, describe the type of terrain it traverses, and sketch the structure that allows it to traverse this terrain.
- **Class Discussion** on what students brainstormed

Yesterday, we explored the science behind our problem (thermal regulation) by conducting an experiment using a jar filled with ice and a temperature sensor to record data. Today we will analyze that data and compare it to the "control" jar. Engineers engage in collecting and analyzing data to aid them in making decisions on their projects. In this thermal regulation experiment, we collected data about different materials. We will use this data to understand which material is better at thermal regulation.

Explain: 15 min *(Guided Presentation)*

Teacher Note: *Prior to the lesson, the Teacher will share the individual .csv data files with each student team using the teacher's LMS. The teacher will pull up the PPT below to guide students in analyzing the data.*

View: 1.4.4. Thermal Regulation Experiment Part 2: Analyze Data PPT

(in ppt) **Steps for analyzing sensor data using either Excel OR Google Slides. The procedure is the same for both methods:**

- Download the Excel file
- Prepare A Scatter Chart
- Review Your Graph
- Narrow Your Data
- Change the Format
- Make Observations based on the data

Student Handouts:

1.4.4. Thermal Regulation Part 2 Analyze Data

Student Materials:

Microsoft Excel or Google Docs

Instructional PPT's & Materials:

1.4.4. BID Ideation

1.4.4. Thermal Regulation Experiment Part 2: Analyze Data PPT

Teacher Resources:

1.4.4. Thermal Regulation Part 2: Analyze Data TEACHER DIRECTIONS

1.4.4. Expected Data Visualization Image

1.4.4. Sample Padlet Image

Sample Padlet Link

Web Resources:

1.4.4. Expected Data Visualization Image

1.4.4. Sample Padlet Image

Explore: 15 min *(Group)*

Data visualization
You will now work in your groups to use the **1.4.4. Thermal Regulation Part 2 Analyze Data handout** handout to analyze your results from the experiment.

Extend: 15 min *(Group)*

Post your data on Padlet
You will now share your data from the experiment on Padlet with your classmates.

- ***Teacher Note**: **Sample Padlet Link**. Make a copy and share the new link with students.*
- Click on the link to the Padlet to document how their material performed as a thermal insulator compared to the Control Jar.
- Each group will posts their graph, students will compare each result to observe how different materials affect thermal insulation

EDPL: Update Research Notes as needed with information learned in the thermal regulation experiment.

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1.4.5. Thermal Regulation Experiment Part 3: Additional Data & BID Analogy

Students will learn about the principles of heat transfer. They will apply this knowledge to examine additional data provided from jars with multiple layers of material. They will then make a BID analogy to how the layers of fur and skin keep the polar bear warm.

Engage: 5 min

View: 1.4.5. BID WOW!

- How can trees help create more stable structures–buildings, houses, etc.?
- What part of a tree helps them on windy days?
- **Class Discussion** on what students think
- **Play video:** Trees and Roots (in ppt)

Explain: 15 min *(Presentation and Class Discussion)*

Now that we've done our thermal regulation experiment, we are going to learn about the scientific concept behind thermal regulation: heat transfer.

View: 1.4.5. Heat Transfer (Thermal Regulation Experiment) presentation.

Evaluate: 20 min *(Individual worksheets but can work in Groups)*

Evaluate Additional Data
You will now use what you've learned about heat transfer in thermal regulation to analyze some additional experiment data that was previously collected. Then, you will compare what you've learned in the experiment to what you learned about polar bear fur.

View: 1.4.5. Thermal Regulation Experiment Part 3: Additional Data on the Smartboard.

You will use these graphs to complete Part 1 of the 1.4.5. Evaluate Data & BID Analogy handout.

Teacher Note:

- *The worksheet has two parts.*
- ***Part 1: Evaluate Data***
  Students will use the information gathered during Parts 1 and 2 of the Thermal Regulation Experiment, their new knowledge of heat transfer and conduction, and the Thermal Regulation Experiment Part 3: Additional Data to answer the questions.
- ***Part 2: BID Analogy***
  Students will be prompted to connect Heat Transfer principles and what the students learned in the thermal regulation experiment to BID and polar bear fur.

Student Handouts:

1.4.5. Evaluate Data & BID Analogy handout

Student Materials:

1.4.5. Thermal Regulation Experiment Part 3: Additional Data

Instructional PPT's & Materials:

1.4.5. BID WOW!

1.4.5. Heat Transfer (Thermal Regulation Experiment)

Teacher Resources:

1.4.5. Additional Data EXCEL File from Experiment

1.4.5. Thermal Regulation Part 3: Evaluate Data & BID Analogy TEACHER KEY

(optional) Crash Course Video - Heat Transfer

(Extend) Heat Transfer Equation Image

Web Resources:

N/A

- *Part 2 of the worksheet is particularly challenging so the teacher should be prepared to help guide students through this part of the worksheet. The teacher may choose to have a class discussion about Part 2 if needed.*

Extend: 5 min *(Group)*

EDPL: Add information learned from the activity that contributes to your understanding of the problem or Research Notes in the EDPL.

Extend: (optional)

View: Heat Transfer Equation Image

- Which variable in the heat transfer equation changes when the material the jar is wrapped in switches? Explain.
- Which variable in the heat transfer equation changes when the number of layers of material the jar is wrapped in switches? Explain.
- Looking at the heat transfer equation, what variables were constant across all tests (including both the experiments you did and the additional data)?

Play video: Crash Course Video - Heat Transfer