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 1: Launcher Connecting Nature to the Engineering Design Process	Materials/Notes
Module 1 Overview 1.1.1 Connect Nature to Engineering 1.1.2. Empathy & Customer Discovery 1.1.3 Reverse Engineering & Product Requirements 1.1.4. Define Problem Requirements 1.1.5 Ideate a Solution **Important:** Students should save all completed handouts, sketches, brainstorming, notes, and prototypes as this will be the basis for their Engineering Design Process Log (EDPL).	**1.1.0. EDPL Map**

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1.1.1. Connecting Nature to Engineering

Students will bring in and analyze an object from nature using structure, function, and mechanism. They will be introduced to BID and how it relates to the Engineering Design Process. They will Identify a problem by brainstorming things that get dirty.

Before the Lesson:

- In preparation for the unit, students will explore nature outside of the classroom and bring in an artifact that they think is **interesting** or **unusual** for lesson 1.1.1. Examples include pinecones, mushrooms, nests, seedpods, flowers, leaves. Be sure to instruct students to do this before starting the unit.
- Teachers may want to make a classroom poster of the **EDP Flowchart Detailed** for reference throughout the unit.
- Teachers will need to determine how they want to group their students (teacher choice, student choice, or random) to create project groups. They will remain in these groups for the next 2 weeks. Students will be responsible for entering data in the EDPL as a group. Any hard copies of Individual and group work should be saved, with group work kept in a designated folder in the classroom.

Engage: 5 min

View: 1.1.1. BID WOW!

Teacher Note: *Images of a bullet train and Kingfisher bird should be displayed on the Smartboard as students enter the classroom.*

1. *After the bell rings and attendance has been taken, ask the students:*
   - ***What do you see in the images below?***
   - ***How are the things in the images similar? How are they different?***
2. *Advance to the next slide, the **Kingfisher Train Morph GIF** of the Kingfisher's beak and the bullet train will play.*
3. ***Play video:** **Kingfisher Bullet Train example (BBC video)***
4. ***Class Discussion:** What is your reaction to the video? Were you surprised that a bird beak could inspire a train? Did you expect the bird beak to morph into a train?*

Nature can inspire some really cool things!

Explain: 10 min (*Presentation)*

Natural Object Analysis

- You were asked to go into nature and find a natural object that is intriguing or unusual. Today we will model an investigation and analysis of a yellow jacket wasp in terms of its Structure, Function, and Mechanism. *(**Teacher Note:** **NGSS crosscutting concept**)*

View: 1.1.1 Natural Object Analysis PPT

Student Handouts:

1.1.1. Natural Object Analysis: SFM Organizer

1.1.1. Identify a Problem Brainstorming Organizer

Student Materials:

N/A

Instructional PPT's & Materials:

1.1.1. BID WOW!

1.1.1. Natural Object Analysis PPT

1.1.1. BID & EDP PPT

Teacher Resources:

1.1.1. SFM Nature Examples-TEACHER Resource PPT

Web Resources:

Kingfisher Train Morph GIF
Kingfisher Bullet Train video
Kingfisher Color Image
Kingfisher Graphic Image
EDP Flowchart Detailed
BIDI Graphic
EDP Simple
EDP plus BIDI Simple

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Explore: 10 min *(Individual then share)*

Natural Object Analysis

View: 1.1.1. Natural Object Analysis: SFM Organizer Image

- Now it is your turn! Working independently, you will use 1.1.1. **Natural Object Analysis: SFM Organizer** handout to analyze your found object in terms of its physical **Structure,** basic **Function,** and **Mechanism (**within its own biological system and within the larger ecosystem).
- **Share:** When you are finished analyzing your object, share your investigation with your group.

Explain: 10 min *(Presentation)*

What is Biologically Inspired Design? How is Biologically Inspired Design Connected to Engineering and the Engineering Design Process?

View: 1.1.1. BID & EDP PPT

Teacher Note: *This PPT connects the concepts of BID and the Engineering Design Process. Teacher notes are included in the speaker notes section of the powerpoint.*

- ***How to view a presentation with speaker notes***
  - *Open a presentation in Google Slides.*
  - *In the top right corner, next to Slideshow , click the Down arrow .*
  - *Click the Presenter view.*
  - *Click Speaker notes.*

Elaborate: 10 min *(Individual)*

Identify an Engineering Design Problem

- **View: EDP Flowchart Detailed** (or on poster if printed out).
- The first step of the engineering design process is identifying a problem.

- **View: 1.1.1. Identify a Problem Brainstorming Organizer Image**
- Today you will use 1.1.1**. Identify a Problem Brainstorming Organizer** to brainstorm the problem of dirty shoes:
  - What types of shoes get stained or gather dirt
  - How do shoes Get Dirty? What materials stain shoes?
  - Who has a problem (people or groups) with dirty shoes?

- You will have 2 min to list ideas for each prompt (one in each column on the worksheet). The goal is to be fluid with your ideas - come up with as many as you can. There are no “bad” ideas. Do not evaluate or criticize, this will waste time and eliminate unique or different ideas.

View: **2 Minute Video Timer**

Teacher Note: *The 2 minute timer linked above can be used to keep time on the board as students come up with ideas for each prompt on the worksheet.*

Evaluate: 5 min *(Individual)*

Analyze your responses to choose a problem you want to focus on and write this problem at the bottom of the 1.1.1 Brainstorming Organizer. Include the "thing" that gets stained or dirty, what it gets dirty with, and the people/group who have problems with it getting dirty.

- Categorize people—who has the problem?
- Look at the social impact of the problem—how many people have the problem?
- What are the types of "dirt" you identified?
- What does "dirty" mean in each context?

1.1.2. Empathy & Customer Discovery

Different users have different needs. How do engineers understand users' needs? How do engineers design WITH users rather than FOR them? Tools that can help engineers understand users' needs are surveys and interviews. Students will respond to a customer survey and analyze results to define a relevant problem.

Before the Lesson: This lesson contains a Customer Survey. Teachers will need a Google account to make a working copy for each class. Click here to access the **1.1.2. Birdee Customer Survey Teacher Directions.**

Teacher Note: Empathy is when you can feel what another person is feeling. **Empathy** is the foundation of a human- centered **design** process; by deeply understanding people we are better able to **design** for them. We **empathize** to discover people's expressed and latent needs so that you can meet them through your **design** solutions. - Stanford d. School

Engage: 5 min

View: 1.1.2. BID Ideation

- You are trying to design and make a new musical instrument. What could you look to in nature for inspiration?
- List as many things and organisms from nature as you can that you'd like to inspire an instrument in your new band.
- **Class Discussion** on what students brainstormed

Engage: 15 min *(Teacher led Discussion & Analysis)*

What is empathy?
What is the role of empathy in design/engineering?

Play Video: Jitterbug Video

After watching the video, teachers will ask students:
What are your thoughts/reactions to this product?

Student Handouts:

1.1.2. Write an Initial Problem Statement

Student Materials:

Birdee Customer Survey

Instructional PPT's & Materials:

1.1.2. BID Ideation

Compare Phones T Chart

Vanderbilt Makeathon video

Teacher Resources:

1.1.2. Birdee Customer Survey Teacher Directions.

1.1.2. Birdee Customer Survey Questions PDF

1.1.2. Compare Cell Phones T-Chart Teacher Guide

1.1.2. Write an Initial Problem Statement Teacher Key

Web Resources:

Jitterbug Video
IPhone Video
Compare Phones T Chart
1.1.2. Identify User Needs Chart

View: Compare Cell Phones T-Chart
Teachers will guide a discussion to complete the T chart for the Jitterbug:

- Who is the Intended USER of the phone? Describe 3 characteristics.
- What are the features of the Phone?
- Do these Features meet the user's needs? Indicate with star/checkmark.

Play Video: IPhone Video
Teacher adds iPhone information to the T chart with participation from students.

- Which phone would you rather use? Why?
- It is important to understand the needs of your customer so that you can design a solution that actually solves the problem your customer has.
- To fully understand the user's needs **you have to stand in their shoes and that is empathy.**

Explain: 15 min *(Class Activity)*

Empathy and the Engineering Design Process
Engineering problems can be discovered through empathy—by attempting to understand the needs, challenges, and cultures of other people and societies. Empathy allows us to truly understand and uncover the latent (hidden) needs and emotions of the people we design for.

Thinking back to the phone, there are many users with different needs that use a phone. The Jitterbug phone was made for specific users and the iPhone was made for specific users. As a class we will identify 3 characters from books/movies that have different cell phone feature needs (example: The Weasley's from Harry Potter, Wonder Woman, Percy Jackson, character from Star Wars).

View: 1.1.2. Identify User Needs Chart

Teacher Note: Class Discussion *The teacher will list 3 different characters based on student suggestions, then solicit cell phone features for each user.*

Now you've brainstormed needs FOR someone else who uses a phone. How would you make sure these are **actually** the needs of your customer? How would you design WITH your user?

Design For vs. Design With
How do engineers understand users' needs? Here is an example of how engineers considered users' needs to make a product for the user.
Play Video: Vanderbilt Makeathon for Disabled Kids (3:28)

- Inspired by a challenge to make a child's life better through engineering and design, students from Vanderbilt, occupational therapists, and professional engineers worked for three days to build inventions that would make life a little easier for a child with special physical needs.

- Engineers design WITH users by observation, interviews, and surveys.

Explore: 10 min *(Individual)*

Birdee Customer Survey

Teacher Note: *In order to use the survey with your students, you will need a Google account. This will enable you to make a working copy for each of your classes. Go ahead and login to your google account within your browser.*

Now, we are going to move away from our phone activity and return to identifying a problem of something/things that get dirty. You've listed what you think are problems and needs for things that get dirty. You will complete a survey to further investigate this problem and what the actual needs of the users are. Then, you will write a problem statement based on the new information you've gathered from the survey. You are practicing how to design with rather than design for.

Teacher Note: *Students take the web based survey - visualizations will be provided automatically through the Google Form survey/Track survey results.*

Evaluate: 10 min *(Class Discussion)*

Visualization & Analysis
Teacher Note:

- *Show Visualization of survey data by clicking on the Responses tab in the Google Form.*
- **Class Discussion:**
  - Which of the items on the list is of biggest concern to the most students?
  - Who addresses these problems?
  - How often is it the students themselves versus others?
  - In the discussion, ask students to share their personal experiences. Try to elicit more details about their frustrations and the problems.

Extend: 5 min *(Individual)*

Initial Problem Statement

View: 1.1.2. Write an Initial Problem Statement

- Write a problem statement containing a clear need and a target audience/user. How does empathy play a role in your assessment of the problem? Answer on the worksheet.

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1.1.3. Discover the Requirements

Students will examine existing products to discover the product requirements using the Four-Box method. Students will understand that engineers research prior and existing solutions to improve existing products and people's evolving needs.

Before the lesson: 1.1.3. Product Cards can be printed (2 sided) to distribute to students, shared with students digitally, or posted on the smart board.

Engage: 5 min

View: 1.1.3. BID Inspiration

- What is happening in these images?
- What products could this inspire?
- **Class Discussion** on what students think
- **Play video:** Cleaner Shrimp Video (in ppt)
- **Play video:** Dirty Job? A bug that cleans Hippos (in ppt)

Explain: 15 min *(Presentation)*

After identifying a problem, we must work to make sure we understand the problem (point to EDP Chart if printed out). This includes research to see if there are products that already address the problem and the needs of our user. These are called existing solutions. Engineers often analyze existing solutions 1) to understand how the current solutions work and 2) to understand if the existing solution is not fulfilling customer needs (and if so, why).

Today we will practice analyzing existing solutions to a variety of products using reverse engineering. Then, we will try to guess the *requirements* that the product was designed to fulfill. Requirements are a set of expectations our design/solution must have to make sure it fulfills the needs of the user and solves our problem.

Identifying requirements help us to make sure we understand the problem we are trying to solve so that we can actually solve the problem. Today we are going to practice deriving requirements from a variety of *products* before creating requirements for our "things that get dirty" *problem* tomorrow.

View: 1.1.3. Discover the Requirements PPT

Explore: 20 min *(Group)1.1.3. Reverse Engineering and Requirements PPT*

Product cards
View: 1.1.3. Product Cards

- ***Teacher Note:*** *Students will work in groups to examine Product Cards and complete the* ***1.1.3. Requirements Analysis - Product Organizer***

Student Handouts:

1.1.3. Requirements Analysis - Product Organizer

Student Materials:

1.1.3. Product Cards

Instructional PPT's & Materials:

1.1.3. BID Inspiration

1.1.3. Discover the Requirements PPT

Teacher Resources:

1.1.3. Product Cards Teacher Key

Web Resources:

Cleaner Shrimp Video
Dirty Job? A bug that cleans Hippos video
1.1.3. Product Cards
1.1.3. Requirements Analysis - Product Organizer

○ Who are the users? Where is the product used? ○ What function(s) does the product perform? ○ What are the performance metrics? ○ What are the specifications? **Evaluate: 15 min** *(Group to Group)* Now, your group will partner with another group to share individual products and requirements. Based on the comments of your peers, your team will revise your requirements.	

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1.1.4. Define Problem Requirements

An engineering design problem involves systematically deriving requirements. Developing robust requirements requires both a structured process for eliciting the requirements and a structure for organizing the requirements for future evaluations and tests of design concepts. Students will be given the problem of dirty shoes and derive requirements for this problem.

Engage: 5 min

View: 1.1.4. BID Ideation
- You are trying to design and make underground living quarters. What could you look to in nature for inspiration?
- Come up with at least 4 organisms in nature that live underground.
- **Class Discussion** on what students brainstormed

Explain: 20 min *(Modeled Investigation)*

We are going to review requirements and the purpose of having requirements (to make sure our solution actually solves the problem). Yesterday, we reverse engineered a PRODUCT and derived the requirements that product was designed to fulfill. Today we will define requirements for our PROBLEM to make sure we design a solution that has the functions, performance, and specifications necessary to meet the user's needs and solve the user's problem.

View: 1.1.4. Problem Requirements PPT

Explore: 20 min *(Group)*

Identify Problem & Requirements

View: 1.1.2. Write a Problem Statement Image
- Share your initial 1.1.2. Problem Statements regarding dirty shoes with your group. **Choose a problem for your group to solve**.

View: 1.1.4. Requirements Analysis - Problem Organizer.
View: 1.1.4. Requirements Image
- Then with your group choose a problem and complete the 1.1.4. Requirements Analysis - Problem organizer by identifying the following:
  - Problem Statement:
  - Operational Environment:
  - Existing Products or Solution:
  - Function + Performance Requirements
  - Physical Constraints/Specifications

Because your group was not given any background information (like in the messy desk example), you will have to work as a team to think about

Student Handouts:

1.1.4. Requirements Analysis - Problem Organizer

Student Materials:

N/A

Instructional PPT's & Materials:

1.1.4. BID Ideation

1.1.4. Problem Requirements PPT

Teacher Resources:

1.1.4. Requirements Analysis TEACHER KEY

Web Resources:

1.1.4. Problem Requirements PPT

1.1.2. Write a Problem Statement Image

the functions and performance requirements that are necessary to solve your user's problem and "how well" you want the problem to be addressed (ex: Does your user want a 100% removal of stains from white shoes? Do they want 90% removal? 30% removal? What is feasible? What does your user want?). **Evaluate: 15 min** *(Group to Group)* Now, your group will partner with another group to share requirements. Based on your peers' comments, you will revise your requirements.	

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1.1.5. Ideate a Solution for Conceptual Design 1

Students will use various ideation tools to come up with solution ideas to a design problem. These tools include brainstorming, brainwriting, and SCAMPER. Students will evaluate their ideas based on the requirements given to them for dirty shoes and will integrate their ideas into a one conceptual design.

Before the Lesson: *teachers will need to: make a copy of the* ***Sample Padlet****, get a sharable link, then share with students.*

Teacher Note: Emphasize that all ideas are welcome in the ideation stage. Make sure students understand to withhold judgment of ideas, both their own and those of others.

Engage: 5 min

View: 1.1.5. BID WOW!

- What can be inspired by a cat's tongue?
- How does a cat's tongue work?
- **Class Discussion** on what students think
- **Play video: Cat tongue video** (in ppt)
- **Play video: Cat tongue-inspired hairbrush** (in ppt)

Teacher Note: *The teacher will share the PPT, which contains all of the lessons below:*

View: 1.1.5. Ideation PPT

Explain: 5 min (in PPT) *(Guided Presentation with Activities Embedded)*

The next step in the design process after understanding the problem and writing problem requirements is to ideate solution ideas. The goal of ideation is to generate a large quantity of ideas/solutions to a problem. Ideation tools include sketching, brainstorming, prototyping, and SCAMPER (to name a few).

In our last 2 lessons, we looked backwards at products and defined problems to determine requirements, which helped us to get a better understanding of our problem - dirty shoes. Each group should have different problem statements,depending on what was important to the member of your group. What are some of the problem statements you came up with? Today, we will be ideating solutions that address your group's problem statement.

Explore: 30 min Total (in PPT)

Brainstorming: Brainwriting 10 min: *(Individual)*

- **2-Minute Write/Sketch:** You will have 2 min to write down ideas for how to solve the problem of dirty shoes or sketch a solution to the problem. You can do this on sticky notes or notebook paper.

Student Handouts:

1.1.5. SCAMPER Organizer

Student Materials:

Sticky notes or notebook paper

Instructional PPT's & Materials:

1.1.5. BID WOW!

1.1.5. Ideation PPT

Teacher Resources:

1.1.5. SCAMPER Organizer TEACHER KEY

Link to Sample Padlet: https://padlet.com/juliavarnedoe2/g9hact908uz15rjg

SCAMPER article

Web Resources:

1.1.5. Ideation PPT
Rapid Ideation Video (1:28)
Watch SCAMPER video
1.1.5. Sample Padlet Image

(You should NOT put your name on any of your papers.)

- **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.

Brainstorming: SCAMPER 15 min: *(Group)*
View: **Watch SCAMPER video** (4:22)

- Use the S.C.A.M.P.E.R. technique to develop ideas that solve the problem of dirty shoes/keeping shoes clean. Use sticky notes or the SCAMPER Organizer to explore ideas from the 7 different perspectives.

Elaborate: 10 min (in PPT) *(Group)*

Evaluate your ideas from the previous ideation activities in terms of your group's problem statement and problem requirements you wrote earlier this Module and integrate these ideas into one preliminary conceptual design for a solution. Sketch and label the conceptual design you believe best fulfills the problem requirements.

Evaluate: 10 min (in PPT) *(Group)*
You will share your conceptual design sketch on the Padlet.

View: **1.1.5. Sample Padlet Image**

Student Directions:
Click on the Padlet link to share your team's idea. Use the sample as a guide. Click on the pink plus sign to add the following for your team:

- Name of the Idea/Product/Design
- Image of your Prototype
- Names of team members
- Description of the problem
- How your prototype solves the problem/meets requirements

If time permits, you should provide constructive feedback on the conceptual designs of 3 other groups on Padlet. *(Individual)*