

BIOMIMICRY IN-CLASS ACTIVITY #1

A Chance to Practice

Instructor Notes on Lesson

Expected Time: 30 minutes

When to Implement: Biomimicry, being an ideation methodology, should be introduced as a way to come up with possible design solutions (after painstorming is covered, if it is). This method lends itself especially well to design challenges that may benefit from a nature-inspired design or relate to environment or sustainability (however, it can be used for design challenges of any topic). The Biomimicry video should be shown first and this would be an appropriate in-class activity to immediately follow.

Class Set-Up: Teams of approximately 4.

Materials Needed:

- Scrap paper for students
- White board or chart paper for tracking class ideas
- Students may want access to the internet via computers or phones

Learning Outcomes:

At the completion of this activity, students will be able to:

- Break larger design challenges into sub-challenges
- Describe the relationship between big world problems and existing natural processes

Instructor Guide:

After watching the Biomimicry video, put the class in teams of 4 asking students to get out their own note sheet:

INTRODUCTORY DIALOGUE:

Explain to the class that you are going to do an introductory activity to practice the technique of biomimicry. You will build directly off what was talked about in the video, including the various problems our earth faces.

Part 1. Brainstorm “Big Problems” [4 minutes]

- Have student teams brainstorm “big problems” facing our world today. These should be recorded on their scrap paper. Students should then narrow to the one problem that they want to concentrate on for the remainder of this activity.

Part 2. Break these “Big Problems” Down [4 minutes]

- Now have students break these big problems down. They should list all of the sub-problems or processes related to, or leading to, these “big problems”. Examples might include water quality, waste, transport, etc.

Part 3. Identify Natural Phenomenon to Borrow From [10 minutes]

- Students should then be tasked with identifying natural systems (or processes, organisms) that also use these same processes or deal with these same problems. Minimally each student on the team of four should identify at least one natural system (or processes, organisms) to research in-class. (They will want to briefly discuss so they do not all focus on the same system/process/organism. Student should learn enough to then describe to the team/class how this process naturally works.

Part 4. Share Out [5 minutes]

- Have each team give a 30 – 60 second “pitch” describing if they were a new company trying to solve this “big problem” which nature-inspired solution, from the ones they considered, would they borrow from and why?

Part 5. Wrap Up [5 minutes]

To wrap up this activity, instructors may wish to do one of the following:

- Have students individually, in pairs, or in teams complete the short in-class wrap-up handout.

AND/OR

- Have students individually complete the accompanying Biomimicry Homework 1 assignment packet. This assignment directly extends this activity.

4. Likely
5. Extremely likely

b. If you were told you had to use bisociation, how confident would you be that you could do so effectively (without receiving any additional instruction or practice) use biomimicry?

1. Not at all confident
2. Not very confident
3. Somewhat confident
4. Confident
5. Extremely confident

5. If in our next class you were told that you were tasked with coming up with a new product, service, or process that would benefit your local sustainable agricultural farm:

a. How likely would you be to (without receiving any additional instruction or practice) use biomimicry?

1. Extremely unlikely
2. Unlikely
3. Neutral
4. Likely
5. Extremely likely

b. If you were told you had to use bisociation, how confident would you be that you could do so effectively (without receiving any additional instruction or practice) use biomimicry?

1. Not at all confident
2. Not very confident
3. Somewhat confident
4. Confident
5. Extremely confident

BIOMIMICRY IN-CLASS ACTIVITY #2

From Nature to Application

Instructor Notes on Lesson

Expected Time: 20-25 minutes

When to Implement: Biomimicry, being an ideation methodology, should be introduced as a way to come up with possible design solutions (after painstorming is covered, if it is). This method lends itself especially well to design challenges that may benefit from a nature-inspired design or relate to environment or sustainability (however, it can be used for design challenges of any topic). The Biomimicry video should be shown first and this would be an appropriate in-class activity to follow. If other prepared activities are being used, this should be follow Biomimicry In-Class Activity #1.

Class Set-Up: Teams of approximately 4.

Materials Needed:

- Scrap paper for students
- White board or chart paper for tracking class ideas
- Students should have access to the internet via computers or phones

Learning Outcomes:

At the completion of this activity, students will be able to:

- Describe connections between natural phenomena and application of these phenomenon in human-created design

Instructor Guide:

After watching the Biomimicry video, put the class in teams of 4 asking students to get out their own note sheet:

INTRODUCTORY DIALOGUE:

Explain to the class that you are going to continue to practice the technique of biomimicry. Here you will see some examples of nature-inspired design and think of others too.

Part 1. Introduce the Natural Process [10 minutes]

- Instructors should choose a natural phenomenon of their preference. The suggested one for this activity is “echolocation”
- Have students spend time individually researching and discussing in teams what echolocation is, how it works, and which animals use it and why.

Part 2. Consider Applications [5+ minutes]

- Now have students work in teams to brainstorm and list all of the possible human-driven applications of this technology. Students should list ones that they already know, ones that they find through research, and ones that don’t necessarily exist but are imaginable/desirable.

Part 3. Share Out and [5 minutes]

- Have each team share some of the things that they had listed, encouraging them to share the most interesting or lesser known applications they had come up with. Wrap-up by sharing (through paper copies) or verbally summarizing some latest research developments in this area, such as:
 - <http://www.pbs.org/wqbnova/next/body/bioinspired-assistive-devices/>
 - <http://www.popsci.com/ultrasonic-helmet-lets-anyone-see-bat>
 - <http://www.natureworldnews.com/articles/2515/20130618/new-echolocation-technique-map-room-snap-finger.htm>

Part 5. (Optional) Wrap Up [5 minutes]

To wrap up this activity, instructors may wish to have students individually or in pairs or teams complete the attached wrap-up assignment.

Name: _____

BIOMIMICRY IN-CLASS ACTIVITY #2

From Nature to Application

WRAP-UP

1. Echolocation was presented in this activity as a natural phenomenon that could be used for nature-inspired, human-made design. What is another example of a natural phenomenon or process that has been applied to a human-created design?

2. Someone wishing to utilize biomimicry must develop a fairly expert level of knowledge about the natural phenomenon. How do you think an engineer wanting to use biomimicry could best develop this knowledge?

3. If in our next class you were told that you were tasked with coming up with a new product, service, or process that would make family car travel more enjoyable:
 - a. How likely would you be to (without receiving any additional instruction or practice) use biomimicry?
 1. Extremely unlikely
 2. Unlikely
 3. Neutral
 4. Likely
 5. Extremely likely
 - b. If you were told you had to use bisociation, how confident would you be that you could do so effectively (without receiving any additional instruction or practice) use biomimicry?
 1. Not at all confident
 2. Not very confident
 3. Somewhat confident

4. Confident
5. Extremely confident

4. If in our next class you were told that you were tasked with coming up with a new product, service, or process that would benefit your local sustainable agricultural farm:

a. How likely would you be to (without receiving any additional instruction or practice) use biomimicry?

1. Extremely unlikely
2. Unlikely
3. Neutral
4. Likely
5. Extremely likely

b. If you were told you had to use bisociation, how confident would you be that you could do so effectively (without receiving any additional instruction or practice) use biomimicry?

1. Not at all confident
2. Not very confident
3. Somewhat confident
4. Confident
5. Extremely confident

BIOMIMICRY IN-CLASS ACTIVITY #3

Animal Inspiration

Instructor Notes on Lesson

Expected Time: 30 minutes

When to Implement: Biomimicry, being an ideation methodology, should be introduced as a way to come up with possible design solutions (after painstorming is covered, if it is). This method lends itself especially well to design challenges that may benefit from a nature-inspired design or relate to environment or sustainability (however, it can be used for design challenges of any topic). The Biomimicry video should be shown first and this would be an appropriate in-class activity to follow. If other prepared activities are being used, this should be follow Biomimicry In-Class Activity #1.

Class Set-Up: Teams of approximately 4.

Materials Needed:

- Scrap paper for students
- White board or chart paper for tracking class ideas
- Students should have access to the internet via computers or phones

Learning Outcomes:

At the completion of this activity, students will be able to:

- Identify features, function, and skills of animals and apply them to complex nature-inspired, human-driven design challenges

Instructor Guide:

After watching the Biomimicry video, put the class in teams of 4 asking students to get out their own note sheet:

INTRODUCTORY DIALOGUE:

Explain to the class that you are going to continue to practice the technique of biomimicry, this time focusing on animals and the features, functions, and skills that they possess, making them well suited for certain tasks. Drawing inspiration from animals is a relatively easy way for individuals wishing to use biomimicry to get started.

Part 1. Become a zoo! [10 minutes]

- Tell each team that they need to assign one person on the team to represent a: Koala bear, Fox, Angel Fish, Giraffe, and/or Hippo.
- Each person should then become an expert on their animal. They should do individual research on their computers or phones to read about and watch videos to learn about how their animal acts and moves, the unique features their animal has, and the characteristics and skills their animal possesses.
- The team should then share together so they all understand the background of all of the animals they represent, so that they can later draw on this. If the instructor wishes, there could also be a class discussion or jigsaw activity so that all of the “koala bears” in the class learn from each other.

Part 2. Design Challenge! [15 minutes]

- Now pose one or more design challenges to the class. These can be quick discussion-based activities where numerous are presented, or one or two that are focused on in-depth.

For example, you might use a more in-depth design challenge that “Your neighbor is a single father of two young boys and he is trying to build a treehouse for them. He recently broke his arm and is having trouble carrying supplies, climbing the tree, and building the house but needs to finish he hopes that the treehouse he is building is spacious, dry, and safe/protected place for the boys to play with. He is hoping that his young boys are able to use the treehouse independently, getting up and down into the treehouse easily, safely, and on their own.

- Instruct the students to first break down all of the sub-problems contained within the design challenge problem statement (e.g. carrying large, heavy objects with one hand; lifting materials into the tree; ensuring a dry space, getting children up in the air safely, etc.). They should do this as a team, recording their responses on their scrap paper.
- Then, working in their teams, instruct each person to contribute at least one solution to at least one sub-problem that is directly inspired by something their animal is capable of

doing. As this is done the teams should discuss how to practically design some solution that is comparable to that inspired by the animal.

Part 3. Share Out and [5 minutes]

- As a class, have each team share their solutions and what animals these solutions were inspired by. Look for commonalities and differences across the class groups. If differences in approaches arise, the instructor may want to initiate a class discussion on which the “better” solution between two or three proposed might be. The instructor may also need to emphasize practicality and how easy/difficult it might be to mimic certain animal feature/functions.

Part 4. (Optional) Wrap Up [5 minutes]

To wrap up this activity, instructors may wish to have students individually or in pairs or teams complete the attached wrap-up assignment.

Name: _____

BIOMIMICRY IN-CLASS ACTIVITY #3

Animal Inspiration

WRAP-UP

1. Which animals were easiest to draw inspiration from? Which were most difficult? What made a particular animal more or less suited to serving as inspiration? How much did this have to do with the specific task proposed?

2. How easy was it to imagine how to practically mimic (build) the feature, function, or skill that your animal utilized? How could you make this process easier?

3. If in our next class you were told that you were tasked with coming up with a new product, service, or process that would make family car travel more enjoyable:

a. How likely would you be to (without receiving any additional instruction or practice) use biomimicry?

1. Extremely unlikely
2. Unlikely
3. Neutral
4. Likely
5. Extremely likely

b. If you were told you had to use bisociation, how confident would you be that you could do so effectively (without receiving any additional instruction or practice) use biomimicry?

1. Not at all confident
2. Not very confident

3. Somewhat confident
4. Confident
5. Extremely confident

4. If in our next class you were told that you were tasked with coming up with a new product, service, or process that would benefit your local sustainable agricultural farm:

a. How likely would you be to (without receiving any additional instruction or practice) use biomimicry?

1. Extremely unlikely
2. Unlikely
3. Neutral
4. Likely
5. Extremely likely

b. If you were told you had to use bisociation, how confident would you be that you could do so effectively (without receiving any additional instruction or practice) use biomimicry?

1. Not at all confident
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3. Somewhat confident
4. Confident
5. Extremely confident

BIOMIMICRY HOMEWORK ASSIGNMENT #1

An Extension of In-Class Activity #1

Grand Challenges in Engineering

Task 1. Review the 14 Grand Challenges for Engineering in the 21st century, available here:

<http://www.engineeringchallenges.org/challenges.aspx>. Identify the one that you want to focus on for the rest of this assignment.

Note that you will be utilizing biomimicry and some of the Grand Challenges may be better aligned with biomimicry techniques than others.

Task 2. In a Word document that you will turn in as part of this assignment, summarize, in your own words, the Grand Challenge that you will be tackling. This should be at least two paragraphs. You should include what the problem is, how prevalent it is, and why it is a problem. If appropriate, use bullet points after your written paragraphs and break the Grand Challenge down into smaller problems to be solved.

Task 3. Browse the internet and try to find out if anyone has ever solved some or all of the challenge you are focusing on (or the related smaller problems) before. This could be a commercial product/service, or an emerging research development (you might want to search publications in Google Scholar). You do not have to do an exhaustive search, but after looking for a while (~15 minutes) move on to Task 4, regardless.

Task 4. If you find that there are existing products or emerging research that aligns with your challenge, then create in your Word document a company (or research) overview about their solution and how it works. After you write about the company, also include a short written evaluation about how likely it was that the solution that you found was inspired by nature in some way. Also identify and briefly discuss the closest natural phenomenon you can think of that their solution reminds you of.

If you do not find an existing product or emerging research, instead type a compelling letter to the National Academies of Engineering (NAE) about where specifically there is an opportunity for research and development. Be explicit, identifying a process/phenomenon from nature that you believe can be adopted in a solution of this Grand Challenge and provide evidence for why.

DELIVERABLES

Submit the completed Word document on Isidore

Grading for these deliverables is out of a total of 50 points and will be based on completion of the tasks and overall quality and thoughtfulness of your deliverable. Individuals earning the highest grades on this assignment will have demonstrated an outstanding effort and thoughtfulness on this assignment, which will include in-depth and thorough written responses and reflections that are relevant to the assignment's focus. Highest scoring papers will look and read professionally, being nicely organized and well edited.

BIOMIMICRY HOMEWORK ASSIGNMENT #2

An Extension of In-Class Activity #3

Animal Contributions

Task 1. Identify an animal that you are going to use for inspiration throughout this activity. Find a photo of this animal and copy the image into a Word document. Note that you can NOT use a koala bear, fox, angel fish, giraffe, hippo or shark since these have likely been used by you or your classmates in other related activities.

Task 2. Spend 5 – 10 minutes researching your animal. Focus on learning what unique features, functions, and skills your animal has. You might specifically study how your animal eats, moves, cares for its young, protects itself, etc. Summarize what you find into a long, bulleted list in the Word document, underneath the photo of your animal.

Task 3. Next, in your Word document, make a table with two columns and six rows. Label the first column “Animal Features”. Choose at least 5 of the features, functions, and skills that your animal possesses (from the bullets you created in Task 2) and list these in column 1, one per table cell. Label the second row “Similar Human Design”. Then for each animal feature/function/skill in column 1, list something that is man-made that is functionally similar. For example, if an elephant is able to pick up large objects on the ground with its trunk and lift it high into the air; you might list for similar human design “A pulley system; Pneumatics; Magnetic arm; etc.” You only have to list one man-made object per animal feature, but you are welcome to list more than one (which might be helpful later in the assignment).

Task 4. Now work backward. Thinking about everything you have written, and what you have to work with, generate a real-world problem definition (design challenge) that has nothing to do with animals but that will require the solution to use at least two of the animal features/related manmade “tools” you have listed. Be creative and have fun with this. See previous design challenge prompts we have used in class if you need examples. Write out the problem definition in the Word document, under the work you have already done.

As an example thinking about the elephant trunk and pulley system in a more simplified case that uses only one feature/tool and not two.....you might write *“My neighbor bought a brand new van for her family vacation. She bought a roof-top carrier to place on top of the van to carry additional luggage. She packed it while it was on the ground and is now not tall enough or strong enough to lift it onto the van’s rooftop. She doesn’t have the help of any other adults but she does have a garage full of odds and ends. How can she safely get the packed carrier on to the top of the van?”*

Task 5. Finally, in your Word document, summarize using a few sentences one possible solution you have in mind to the problem definition/design challenge you wrote out during Part 4. Add a few additional sentences to compare the effectiveness of your solution and the animal-related one that you originally started with. (If you had an elephant's trunk, for example, would that have been the hands down best approach? Why or why not?).

DELIVERABLES

Submit the completed Word document on Isidore

Grading for these deliverables is out of a total of 50 points and will be based on completion of the tasks and overall quality and thoughtfulness of your deliverable. Individuals earning the highest grades on this assignment will have demonstrated an outstanding effort and thoughtfulness on this assignment, which will include in-depth and thorough written responses and reflections that are relevant to the assignment's focus. Highest scoring papers will look and read professionally, being nicely organized and well edited.

COURSE DESIGN PROMPTS THAT CENTER ON THE USE OF BIOMIMICRY

The following prompts are those that an instructor wishing to have students utilize biomimicry as a central focus of a course design project may wish to use. While biomimicry is well suited for use as an ideation tool for the majority of design project that requires ideation, the projects presented here try to truly play up the role of biomimicry in a more substantial way. You can also utilize any of the prompts presented in painstorming that were envisioned as semester projects that began with painstorming but ideally moved on through the remainder of the design process (where biomimicry could be included nicely during ideation).

1. You are a packaging engineer and have recently been hired by Amazon.com to design new packaging that is strong, durable, protective, and economical. The packaging should be resistant to damage upon being dropped or left in bad weather. Ideally the package will be appropriate for a wide variety of sized objects, without unnecessary waste or environmental impact. Your boss suggests to you that you should look to nature to see how plants, animals, and the environment packages, holds, protects, and/or carries goods. Use the biomimicry technique to ultimately research nature-inspired design solutions that you will then use as inspiration to create human-designed mock-ups or functional prototypes (depending on instructor preferences).

2. You started volunteering at the zoo in your hometown on the weekend. You just love the animals. You have been assigned to help at the giraffe enclosure, but on your breaks you spend every free moment you have with your favorite animal: the manatee. In school that week, your engineering instructor gives you an assignment to practice using biomimicry. You are told to pick an animal, study it, and then think about how that animal's natural processes, skills, and features can be adapted and utilized in a human-centered design. Naturally, you decide to focus on either, or both, giraffes and manatees. The instructor has left the assignment quite open-ended....the natural processes, skills, and feature you focus on can be used for ANY human need or product (though the instructor did mention he will give (not real) extra credit if the design helps with his latest home project, installing attic insulation.)

3. You became involved with the sustainability club at your university and want to take action to help our environment. First, go on a "photo walk" taking photos of sustainability-related concerns that you encounter. Review these photos and decide on one of these issues that you will solve during this course. You should first seek to fully understand the problem. Once you have identified and defined this problem, you remember that you learned that biomimicry often inspires environmentally-friendly solutions. You therefore decide to use biomimicry to generate possible solutions to the issue you have identified. Decide which objects in nature have avoided these issues, or solved them in some natural way in the past and start with these as your inspiration. Utilize the "Ask Nature.com" website for additional ideas, and do your own research. You will ultimately create a human-designed, nature-inspired mock-up or functional prototype (depending on instructor preferences) of your solution.