

FOLLOW-UP CLASSROOM ACTIVITIES, ASSIGNMENTS, AND DISCUSSIONS TO ACCOMPANY THE IDEATION TECHNIQUES VIDEO SERIES

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PI: Kim Bigelow, PhD; kbigelow1@udayton.edu

Co-I: Ken Bloemer, PhD; kbloemer1@udayton.edu

University of Dayton

OVERVIEW

THE IDEATION TECHNIQUES VIDEO SERIES

As part of a KEEN Topical Grant, we produced three videos to cover three different ideation techniques: Painstorming, Bisociation, and Biomimicry. Each video is approximately six minutes long and is meant to be a standalone introduction to the technique, incorporating examples. The videos were designed to be appropriate for any course and any level students. Instructors wishing to incorporate these techniques in their own class should be able to come up to speed quickly by watching the videos and referring to these accompanying suggested activities. The videos are appropriate to have students watch at home (flipped classroom) or in class. These videos are meant to serve as a springboard to additional instructor-led activities, assignments, and discussion where students can begin to practice these techniques. To ensure flexibility, the videos do contain any pre-embedded activities. Rather instructors are encouraged to refer to this packet for ideas of in-class and out-of-class activities that they may wish to try after showing the videos.

Note that when watching the videos, the video on Painstorming is filmed in a more traditional style, showing the presenter in his home kitchen having a conversation with the audience. The videos on Bisociation and Biomimicry are filmed in a more dynamic, engaging way where post-filming editing adds graphics and supporting text. Because of this the Bisociation and Biomimicry videos will appear to “go together” better than Painstorming. While this was due to lessons learned during filming, it is also not necessarily a bad thing, as Painstorming, while incorporated here, is more of an Opportunity Recognition tool – whereas Bisociation and Biomimicry are both presented as two tools to be used during Ideation Sessions. Instructors may wish to present them this way.

SUPPORTING CURRICULUM

To accompany these videos, as part of our topical grant, we have also created this packet to detail each of the three topics and provide extension assignments, activities, and discussions that can be used by instructors.

We tried to choose activities, assignments, and discussion topics that would be easily adoptable to a variety of classes, both within engineering and outside. While we often default to using ideation techniques only during design-related activities, we also tried to incorporate some unique ways of thinking about and applying these ideas.

We thank the many University of Dayton School of Engineering, College of Arts and Sciences, and School of Education faculty members who previewed the videos and shared ways that they would incorporate the videos into their own courses. While we have included some straight forward, perhaps obvious, activities that naturally follow from the videos, we have also been able to incorporate some really unique, creative extensions. At the conclusion of this document we acknowledge the contributors to this work who gave ideas that have been incorporated throughout this document.

The nature of the techniques led the organization and layout of the corresponding activities to be slightly different for each. Painstorming for example is more of an opportunity recognition tool than an ideation tool, and therefore, the activities tended to be stand-alone activities of ways that painstorming could be used in diverse classes. Bisociation, on the other hand, is an ideation method that can be used any time that brainstorming or ideation is occurring for any reason and in whatever class – so that chapter focuses on more general activities to get students to become more comfortable using bisociation. That chapter ends with some examples of specific times within specific courses that instructors may wish to leverage bisociation concepts. Biomimicry is a combination of the two, with both general ideas that can be used in any course and some course-specific ideas also.

We encourage instructors to use the ideas presented as inspiration and share their own best practices with their KEEN Network colleagues. Many of the activities are written to provide envisioned alternative versions or extensions of the proposed activities so that it can be catered to the level of student, the time available, and the course goals. Because of this, specific learning objectives have not been listed with the activities, though instructors are certainly encouraged to do this on their own as they adapt the activities for their own purposes.

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PAINSTORMING

DESCRIPTION OF THE TECHNIQUE

While we have chosen to incorporate Painstorming into this Ideation Techniques Toolkit, Painstorming is better described as an Opportunity Recognition tool used at the very earliest phases of the engineering design and innovation process. The information gained during the Painstorming process then informs and improves the ideation process that follows. As such the Painstorming method can be used as a precursor to, and in conjunction with, all of the other techniques described in this toolkit.

Painstorming is a technique that helps us recognize opportunities for innovation that should be obvious to us, but that we generally miss because we have accepted them as a way of life. In its most basic form painstorming is a systematic way to identify pains, annoyances, and cumbersome ways of doing things that we deal with every day and that if solved could create substantial value. In its most effective form painstorming generally takes the form of having the aspiring innovator – surrounded by others with differing background and perspectives – watch video footage that shows the interactions of one or more individuals and a given product or the interactions of one or more individuals trying to carry out some process in a real-world environment. The focus of the recorded interactions should likely, to at least a degree, match the field of interest of the aspiring innovator. The interactions being observed can be fairly narrowed and targeted - for example an individual turning on a television, or very broad and open to unexpected opportunities - such as a plane full of passengers trying to board and prepare for takeoff. The true value of the technique is best realized in these broader situations where there will be many interactions between individuals and between individuals and their environment, with a high likelihood that some of what we see will surprise us.

According to the painstorming methodology, this video is then reviewed by the aspiring innovator (and ideally others he or she has surrounded themselves with) and the observers take notes of all of the things that could be viewed as annoyances, frustrations, or pains. Optimists may wish to take a more positive spin on the technique, identifying “wishes” and “wouldn’t it be great if” statements. There are likely to be some pains we have all seen or even dealt with ourselves, but we don’t really see their inconvenience until we carefully watch and observe using that mindset. The painstorming process can be even more effective when paired with in-depth instruction on ethnography and best observational approaches. However, even without an in-depth education on video observation, students will quickly begin to form long lists of problems – opportunities – that they are now positioned to solve. It is important to then help students understand that not all problems need to be solved – they likely now have some new ideas that they can move forward with, but for painstorming to be effective, the problem does need to be one where the solution would create value. Instructors may then also wish to deep dive into the idea of value creation, market studies, and the upfront work necessary to know whether a designed-solution would be considered to create value.

PURPOSE OF THE VIDEO

The purpose of this 6.5 minute video is to serve as an introduction to painstorming for students. The video focuses on the pains associated with a conventional coffee maker and then presents the Keurig as a product designed to overcome those pains. The familiar example is meant to make the content accessible to all students, within and outside of engineering. The video also presents several other examples, and more importantly interweaves not only the usefulness of painstorming but the specific methodology that is often used.

The hope of this video is that it can serve as a springboard to more in-depth assignments, activities, discussions, or projects that are more catered to course content. The video is made so that it is short enough to be shown in class, though it can also be shown outside of class.

The material presented in the video seems to most naturally lend itself to engineering design courses, but we feel that the value of painstorming has the potential to impact a wide variety of classes. Because of that we have asked instructors within and outside engineering to stretch their minds and think innovatively about how they might envision using this video in the courses that they teach. Some of these ideas are presented below.

SAMPLE ACTIVITIES & ASSIGNMENTS ACROSS THE CURRICULUM

The Starting Point: Video-Based Observation; Any Class

The most natural extension activity for any course is to follow the painstorming video up by having students videotape a product, service, or environment and use that video to go through the painstorming process. The choice of what to videotape should depend on the content of the course. The instructor could leave this very open-ended or very narrowed, depending on the type of class and the topics being stressed.

Instructions for an open-ended prompt might be:

- “Identify an environment where there are many different types of interactions occurring. Remember that you will be looking for the non-obvious pains, and therefore an environment that is less familiar to you or where a lot of things are going on which may include some unexpected activities work the best. As a bystander, film the environment for 5 – 15 minutes. Make sure to seek appropriate permissions to film first. After filming, complete the activities below to identify the pains that you observe as present.”

Or:

- “Identify any product that you find interesting and/or ready for innovation and change. Perhaps it is even a product that you think is excellent as is. Ask five individuals to interact with the object. Try to keep interactions to about 5 minutes or less. Film each individual. After filming, complete the activities below to identify the pains that you observe as present.”

Specific examples of narrowed prompts that have been catered for specific types of course might include suggesting students film a scenario such as:

- Chemists or biologists carrying out a lab-based experiment
- An individual given a complicated math problem and attempting to solve it
- Current practices of soldering or circuit board manufacturing
- An engineering team given a part and asked to design it in CAD software

Additionally, the open-ended prompts may be narrowed further. For example, in one of my classes students are looking for opportunities for improving the lives of individuals with disabilities. They are asked to therefore concentrate on pains and frustrations that an individual with a disability might encounter when trying to do various tasks in the kitchen.

Prior to analyzing the films, it is helpful if the instructor provides the class with some background into observation techniques, with a possible deep-dive into ethnography methods. The depth of this instruction depends on the purpose of the class and the faculty member's comfort with the material. An easy technique to teach is the AEIOU method of observation, originally proposed by Rick Robinson, Ilya Prokopoff, John Cain, and Julie Pokorny as an ethnography method. Numerous materials are available online, with the following framework from <http://help.ethnohub.com/guide/aeiou-framework> being particularly easy to implement:

AEIOU Framework from <http://help.ethnohub.com/guide/aeiou-framework>

- ***Activities*** are goal-directed sets of actions—paths towards things people want to accomplish. *What are the modes people work in, and the specific activities and processes they go through?*
- ***Environments*** include the entire arena where activities take place. *What is the character and function of the space overall, of each individual's spaces, and of shared spaces?*
- ***Interactions*** are between a person and someone or something else; they are the building blocks of activities. *What is the nature of routine and special interactions between people, between people and objects in their environment, and across distances?*
- ***Objects*** are building blocks of the environment, key elements sometimes put to complex or unintended uses (thus changing their function, meaning and context). *What are the objects and devices people have in their environments and how do they relate to their activities?*
- ***Users*** are the people whose behaviors, preferences, and needs are being observed. *Who is there? What are their roles and relationships? What are their values and prejudices?*

Students should then watch their video carefully, observing. It is helpful for them to focus in on the AEIOU's of the scene and it may be worth them writing down their AEIOU observations and turning these in. Once the student has become very familiar with all that is occurring in their 5+ minutes of video, they should begin to identify all of the pains – but not solutions! – that they observe. They may wish to watch the video several times and should be encouraged to continue to look for those hidden and unexpected opportunities, the pains they didn't expect but noticed the individual(s) in the video really struggling with.

Once their own video assessment is complete, the video should be shared with several other students in the class (or even better other individuals with as diverse of perspectives as possible). The other viewer(s) should complete the same process and then notes should be compared. Students should be reminded the importance and value of getting as many diverse perspectives as possible because each person might see something different when watching the videos based on their own experiences and knowledge.

The original creator of the video should then take all of the pains that have been generated associated with their video topic and identify the pain that they feel would create the most value if solved. Instructors may wish to incorporate some preliminary research and market research at this stage, or for simple assignments may wish to stop here. Some instructors may even wish to use the identified problem and springboard into a full term design project where the identified pain goes on to be solved.

Simplifying the Painstorming Process – The Bug List; Any Class

The Starting Point: Video-Based activity description lays out the most comprehensive and common implementation of painstorming. For instructors who want something simpler or that takes less time, we have found a short in-class activity that still gets at the same points without the need of videotaping and sophisticated observation skills. This activity lends itself especially well to first-year design classes.

In this in-class activity, no video is used. Students are instead told to individually think up at least 5 things that “bug” them. They then share with a partner and make a combined “Bug list”. They then choose one of the things on their combined list that bugs them the most and/or lends itself well to being something that can be solved but that does not have an obvious solution.

Instructors can collect one item from each pair’s Bug List and write it on the board. The instructor can then pick a couple of items from the list that might lend themselves to interesting solutions and let students vote on the one they would like to solve. As a next step, one or more students in the class who have experienced that problem can come up to the front of the room and the rest of the class can practice questioning as a problem definition tool. As the class ask questions, the student “user” can respond with appropriate responses. This can then lead to the development and articulation of associated objectives and constraints. If the instructor wishes to spend additional time on this topic, or is using this to introduce the engineering design process as we often use it for, this can then serve as the problem that kicks off idea generation.

Note that a disadvantage of this simplified activity, that the instructor may wish to discuss with their students, is that it is based only on a student’s very limited personal experiences and observations. Creating the bug list this way, students will likely miss many of the great opportunities that the more thorough video-based method seeks to capture. However, it does serve as a great, easy to implement introduction to painstorming and a good way to break the ice early in the semester.

Also note that we have used follow-up homework assignments related to this. See Deliverables submitted and available to KEEN Network institutions through Kim Bigelow’s 2012-2014 KEEN Topical Grant for other ideas.

Using Painstorming to Identify a Design Topic; Engineering Innovation and Design Classes (And Others)

The Starting Point: Video-Based Observation activity detailed above already alludes to this extension, but since this is one that we believe many instructors will want to consider, we felt it warrants its own activity description.

Design is often embedded throughout the engineering curriculum. However, more often than not students are provided the design challenge by the instructor. Painstorming can be a way for students to take ownership of their design projects, while also having an opportunity to learn the important skills of opportunity recognition (and subsequently evaluation of value creation).

As such, any number of classes that assign a design project might incorporate painstorming so that as the very first step students first define their own problems. This can be more time intensive but students are often more excited to ultimately solve the problem at hand because it is “theirs”.

Taking Your Computer Code to the Next Level through Painstorming; Any Computer Science or other Programming Class

Unlike the activities presented so far, this activity is more catered to a particular class (computer science and programming) and is also a more unique extension than the common ways of incorporating painstorming presented above.

The idea with this activity is to use painstorming as a tool to get students to be self-reflective and critically evaluative while they are coding. Many things in coding can amount to a “correct” answer but are done in a cumbersome way and may result in outputs that still need to be manually manipulated (e.g. graphs that need labels added or resizing, data that needs to be transferred into Excel sheets, etc.)

The instructor should first show the painstorming video. The question might be asked “What does a coffee maker have to do with writing my code?!” It may seem like a stretch but by emphasizing the painstorming process and the idea that this process can be applied across a much broader net than just commercial products, then this activity will likely work quite well.

First students should watch the painstorming video, either in class or on their own. The instructors may wish to downplay the specific process that is presented regarding videotaped observation and play up the idea of looking for those annoyances and things that seem cumbersome – as well as the idea that different people may see things differently.

Present all students in the class with a prepared code. This should be in whatever programming language is central to the course. The code should work but should have notable issues. For certain classes it might be helpful if this code is related to loading and analyzing data. Issues that instructor might want to make sure are incorporated into this prepared code might include:

- Poor commenting
- Hard-coded inputs causing the code to have a lack of flexibility
- Plots that do not resize or rescale when it would be helpful to
- Two or more plots that are meant to be compared but do not have the same axes
- Plots that need additional manual “clean up”
- Slow processing because of inefficient coding practices
- No set-up for batch processing of multiple data files
- Outputs generated only on-screen and not saved in a useful reportable way (e.g. analyzed data results saved to an Excel spreadsheet)

Students should independently spend time reviewing and running the code, which they will likely want to do several times. Each time they should keep track, in writing, of the pains and annoyances they encounter. Students should be encouraged to think about if this was a code they needed to use day in and day out at their job, what would become tedious? What could be better? This will likely be an activity where instructors want to emphasize some student accountability (e.g. turning in the list) to ensure that these pains and annoyances actually do get thoughtfully written out.

Once students have their list, the instructors should have the class get into pairs or small groups. While reviewing and running the code the students should compare lists and identify new pains and annoyances that they may have missed individually.

This would then be an appropriate time to have a class discussion. During this discussion the students should propose all of the things they noticed that were annoying and frustrating about the code. The instructor may want to use this discussion as an opportunity to also talk about the benefit of diversity of thought, perspectives, and skill levels, as likely some students noticed things that others weren't. In doing so, the instructor could then also discuss the importance of focus groups and the breadth of the market that software programmers need to design for – and also that what might be annoying or unnecessary for one individual might be critically helpful for another.

Students should then be given a follow up assignment to be done either individually or with a partner to improve the code to fix these annoyances and frustrations. Depending on the course and the intent of the instructor, the instructor may wish to introduce new concepts and the how to's of implementation of certain “fixes”. The instructor may also wish to help students discern the “easy fixes” from those that are beyond the scope of the class, providing resources to those students who do want to go further.

The activity, which might span multiple days, could conclude with a discussion of how the various annoyances were addressed, recognizing they may have been fixed in different ways by different students. The instructor could use this as a teaching moment to talk about best practices. As a related assignment/accompanying notes the instructor may want the students to develop a master guide that lists the generic problems encountered and the fixes. The class should then wrap up with a reflection on the value of doing similar brainstorming exercises as a means of continually improving (and in a way proofreading) all of the codes that the students write, with the potential to advocate/require students to use the notes developed as a checklist for future assignments.

Using Painstorming to Discuss Hazards, Safety, and Efficiency; Research Labs and Lab-based Classes

Similar to the activity *Taking Your Computer Code to the Next Level through Painstorming*, this activity is an extension that seeks to incorporate painstorming in a not just conventional way. It is appropriate for students engaged in research lab activities, and lab-based classes.

This activity is best carried out when students have had significant time to get used to the policies and practices of a lab. It will be most meaningful for students engaged in lab-based research; however students in other lab-based classes may benefit from this. The idea of this activity is to leverage the painstorming video to discuss laboratory practices with regard to safety and hazards, as well as what opportunities exist to make the lab environment and processes more efficient.

Students should first watch the painstorming video. This will be another example where the link between painstorming relative to the coffee maker shown in the video and how painstorming will be used in the lab-based context will require a little bit of a leap – but we do want our students making those connections, so it should work! The instructor may need to emphasize, though, that you want students to pay attention to the methodology of painstorming – and that it can be applied not only to the evaluation and assessment of products but also for environments, processes, and services.

Once painstorming has been discussed, have students individually think about the experiences they and their lab mates have had in the laboratory and list all of those procedures and practices that frustrate them. Alternatively, the instructor could previously film a “busy day” in the lab and show that to the students, following the video-based procedure normally carried out during the painstorming process. Students should then group together and discuss, which could be especially useful if different students have different roles or carry out different types of projects in the lab.

Bring the students together to discuss and compare their lists. As an instructor and/or the research advisor, as students read off their annoyances, record them and/or categorize them on the board. In particular, one of the goals of this activity would be to highlight 1. Those annoyances that are annoyances for a reason --- those things that are put in place to make it harder for us so that we avoid accidents and are – in a way – forced to do things more safely and 2. Those procedures that are not related to safety but are really excellent problems to be solved - that if solved would result in a more productive environment.

The instructor should use the generated student list to frame a discussion about safety and work hazards. It is also possible that some annoyances brought up are things that should not be occurring due to safety policies or other reasons and this would be a good time to address those. For those problems that have been identified and that can be solved, it is up to the instructor whether they want students to spearhead the implementation of the improvement or simply now that the problem has been identified that the instructor wants to specify a policy to follow. Either way, through this activity students have been engaged in making their lab a better place and are more likely to understand and therefore follow the policies and rules regarding safety and hazards.

First-World Problems/Third-World Problems: Painstorming and Engineering Ethics; Engineering Ethics Courses

The activities to this point have been about the application of the painstorming process. This activity is more reflective, questioning the motivation of the use of painstorming and some of the issues that might arise when we use this methodology.

This activity intends to open up a discussion on some of the ethical issues associated with the use of the painstorming method for identifying an issue to be solved. The painstorming technique is normally focused on those annoyances and frustrations encountered in everyday life. As such, more often than not, the issues that will be identified will be quite trivial. Some may therefore question the importance and necessity of solving these problems on a more global scale. Likely, many of the issues that will be identified by the class during the painstorming process will be reminiscent of the “First World Problems” parodies that have emerged as means of poking fun at how ridiculous some of our needs and wants are.

This activity can take many forms. The instructor may want to start by showing the painstorming video and then having the class do some follow-on activity such as those provided above so that students have firsthand experience of generating these potentially trivial “first-world problem” lists.

The instructor may then want to springboard into a discussion of the types of problems and issues that are commonly identified when such a method is used, with the idea that first world problems are those problems that “privileged” individuals face. They may want to have fun with this, incorporating various resources that might resonate well with their students such as Weird Al Yankovic’s song First World Problems, #firstworldproblems, etc. As the discussion or activities evolve, a very powerful video that can be used to transition and deepen this discussion is the Youtube video “First World Problems Read by Third World People” [<https://www.youtube.com/watch?v=5ugM7H4EEKU>].

The discussion and class activities may then switch to thinking about what a problem or need really is and what some of the most significant problems are in our world today. The instructor could go as in depth into this as he/she wants based on the intentions of the course. This could even be used to introduce the Grand Challenges within Engineering.

The conversation should turn back to the pros and cons of painstorming and when it might be an appropriate tool – if ever. While the hope of the activity is not to dismiss painstorming all together, it could serve as a very important backdrop to meaningful conversations. It could also be used to further motivate the importance of talking and being engaged in the community – if we want to address some of these major issues and we are not central to them, how do we know enough? We want to ask the people “in the trenches” what the problems are and not make assumptions.

Some Other Ways the Video Could be Used: Classes and Topics

- Course: Fluid Mechanics
Topic: Non-Dimensional Analysis
Painstorming-related focus: One way to use painstorming is to have students do something in a cumbersome manner and then have them discover, or have the instructor introduce how to do it in a more streamlined way. A specific example within fluid mechanics would be Non-Dimensional Analysis aka Buckingham Pi Theorem for Drag of a Sphere: Drag, D , of a sphere is known to depend on flow velocity, V , viscosity, μ , density, ρ , and sphere diameter, d . So $D=f(V,\rho,\mu,d)$ and setting up a straightforward experiment (vary one parameter at a time while holding the others constant) runs into two problems immediately: 1. It is hard if not impossible to change, e.g. μ and keep ρ constant; 2. Let's say only 10 data points per variable requires $10^4=10,000$ experiments and one has to make 10 different diameter sphere models. After a non-dimensional analysis one obtains $C_D=F(Re)$ where $C_D=D/(\rho*V^2*d^2)$ is the drag coefficient and $Re=\rho*V*d/\mu$ is the Reynolds number. So one has to conduct only 10 experiments and one can get away with building only one sphere model and using one value for ρ and μ since the Reynolds number can simply be varied by changing the velocity.

A similar activity could be done in aerodynamics related to potential flow theory for flow past a Rankine or half-body. Doing this analysis with real numbers is two pages worth of ugly math. Using complex numbers instead reduces the math to a few simple lines.

BISOCIATION

DESCRIPTION OF THE TECHNIQUE

Bisociation is a method, or tool, intended to be used during the process of coming up with ideas (ideation). A common problem in ideating is that individuals get stuck thinking “inside the box” and bisociation helps systematically expand the idea space and “out of box” thinking that occurs. This is achieved by providing a structure that causes the individual trying to come up with ideas to temporarily shift to thinking about something seemingly unrelated, and then ultimately trying to make connections that brings these two concepts together to form a game changing new idea.

Bisociation is most commonly carried out by introducing a “stimulus” to the individuals that are ideating. This stimulus might be a physical object, a photo, a website, or even a new environment. During a single ideation session, multiple stimulus items might be used – one of the activities listed below (*Create a Stimulus Kit*) helps enable this easily in the classroom. These stimulus items might be quite closely related to the ideation topic being focused on, but it works even better when these items are very unrelated to the topic at hand.

The key to maximizing the usefulness of the bisociation method is that the ideation team needs to first study, discuss, and articulate what the properties and characteristics of the stimulus items are. They should also think about and discuss the perceptions that they have of the item, experiences they have had with the item, and other tangential thoughts related to the item. It is important that the team should not be thinking about their ideation topic when they do this. In carrying out the bisociation method and having this conversation about the stimulus item, it is helpful to have many diverse opinions represented within the ideation team. (If the team is not diverse or could benefit from a certain perspective, teams should be encouraged to bring in temporary team members for ideation days.)

For example, if the team is presented with a photo of a pair of dirty gym socks they might list things like: “Smells bad”, “Lost sock”, “Matched Pairs”, “Mismatch”, “Various Sizes”, “Cotton”, “Absorbs and holds moisture”, “Packs of 6”, “Plain white”, “Symmetric”, “Stored in my Gym Bag”, “I wore socks underneath my soccer shin guards”, “Keeps my feet warm”, “I always wear sandals so I don’t need socks”, “Barefoot running”, etc. By having a diverse group, even this simple ideation exercise can quickly grow and this is great!

Once the list is made, the team should think about these features and attributes and now return to thinking about the topic/problem at hand that they are brainstorming about. Often something on the list of attributes can be applied to the topic at hand and an entirely novel idea can come from it. There are many examples of effective products that came about because someone brought two seemingly unrelated ideas together, and these can also be presented by the instructor as desired.

Teams would be encouraged to cycle through stimulus, carrying out this same process for each new stimulus presented.

PURPOSE OF THE VIDEO

The purpose of this 6 minute video is to serve as an engaging introduction to bisociation for students. The video starts out by briefly introducing idea generation and the pitfalls of traditional brainstorming. The video is example-driven showing a comparison between the types of ideas that we might get when using traditional brainstorming, focusing on the existing technology and our own experiences, versus the ideas gathered when a random stimulus becomes momentarily the focus of the ideation session and the attributes of this random stimulus are then related back to the topic at hand to try to make unexpected associations and connections (bisociations). The video presents a very clear and simple three step process on how idea generation using bisociation can be used: Step 1. Choose the stimulus, Step 2. Capture everything we know and think about that stimulus on a white board, and Step 3. Make associations and connections between the original topic/problem to be solved/device to be improved and the stimulus list. The main example presented in the video is related to the redesign of a stethoscope uses the random stimulus of a small cubed speaker stored in a velvet bag. The presentation of this example in the video provides a strong justification for using bisociation as it shows representative student responses generated when traditional brainstorming are compared to the responses and ideas associated when the stimulus was used. We have used this example in a number of workshops and it seems to have wide appeal for all types of students and disciplines since everyone visualizes their own experiences at the doctor. The video ends with a “mission” to conduct a bisociation session of “your own”, which does lend itself nicely to an in-class tie-in, though it is also presented in a way that it is not a commanding next step.

Note that the video does not talk in depth about the best ways to go through the ideation process of making the associations and connections and turning them into new ideas. This part of the process may lend itself to the implementation of other ideation tools for a more structured process (for example we pair bisociation with a structured post-it note style round robin where ideas are iteratively built upon). Also note that as with almost all ideation methods, bisociation will work best when a diverse team that differs in their experiences and perceptions is present. The video does not emphasize this and it may be very valuable for an instructor to delve into this deeper and/or include activities related to this.

The hope of this video is that it can serve as a springboard to more in-depth assignments, activities, discussions, or projects that are deeper and more catered to course content. The video is made so that it is short enough to be shown in class, though it can also be shown outside of class.

The material presented in the video seems to most naturally lend itself to engineering design courses, but we feel that the value of bisociation has the potential to impact a wide variety of classes. Whereas our painstorming chapter included examples of deep-dives into course-specific areas where painstorming could be incorporated, because of the wide applicability of bisociation, we first start with activities and extensions that would be appropriate for any class. We then conclude this chapter with some specific discipline-specific ideas.

SAMPLE ACTIVITIES & ASSIGNMENTS

Get Ready to Bisociate! Create a Stimulus Kit

The key to the bisociation process is that anything can serve as stimulus to inspire during ideation. The most game-changing ideas often come from the most unusual connections and associations, therefore requiring that students start with objects, pictures, etc. that are totally unrelated to the topic at hand. This means that multiple stimulus items need to be readily available to students who plan to use bisociation techniques, regardless of the type of class that they are in. Because ideation is often a team activity and therefore there is a higher likelihood that this will occur when the team is together in a classroom, where “odds and ends” may not be readily available --- the creation of stimulus kits can be very valuable.

This simple activity could, at its core, be carried out being called “junk in a box”. Basically you want each team to have access to an assortment of stuff. This could be instructor provided --- we have instructors who have pre-packaged boxes of “stuff” that they keep in their offices and bring to class to present each team with a box on the days where ideation will be occurring. The content in the box doesn’t have to change, though it certain can. What constitutes stimulus? Anything! While care and thought in selecting items will potentially add some value to the exercise, the end goal is to have a bunch of stuff that leaves that students asking “How will this ever be related to my problem?” We have had faculty clean out their houses and garages – bringing in broken items that were going to go in the trash, or children’s toys that their kids have outgrown. The dollar store is also a great place to get “stuff” --- especially in the case where you want all of your kits to be identical (depends on the purpose of your activity). Remember that the process requires thinking and listing the characteristics and attributes of the stimulus object, so having objects that represent a diverse range of colors, materials, sizes, etc. will be beneficial. Photos, pages from websites, etc. will work too. We have found that the crazier the stimulus, the better the results --- a Skymall.com website ad showing a life-size statue of Bigfoot, pictured walking through the snowy served as quite the stimulus piece in my first-year design class.

While instructors can provide the kits, we have found it is more meaningful to have student teams create their own stimulus kit together as a team, once bisociation has been introduced. Instructors should ask each student member of the team to bring in 3 items that they feel are very different from each other. Instructors may wish to elaborate upon this, making it a team building activity by requiring that these 3 items represent the individual’s interests, hometown, culture, etc. and then having the students present each item and its background to the team before putting it in the kit/box/crate.

Another extension of this would be trying to get students to stretch their efforts and creativity by making it a bit of a scavenger hunt ---- find the oldest thing that you can, find the smallest thing that you can, find the funniest photo on the internet that you can, etc. This likely would not add significant value but may make it more interesting or competitive to the students to help with buy in.

Note that this tends to work best as an early-in-the-semester, easy-to-implement, very quick activity that sets the teams up to have the materials they need for successful ideation sessions throughout the

semester. Throughout the semester, if used frequently, the boxes may need to be “freshened up” with new stimulus.

Also note, that physical stimulus is not the only way to do this. During our ideation sessions where bisociation will be used, students are allowed to have their computers out and encouraged to use web-based resources such as the website StumbleUpon.com which brings users to a website at random; Google Images – can type “random”; or Skymall.com magazine (whatever is on page 8, top right!).

Finally note that while random stimulus is most appropriate for building the students’ stimulus kits, it may be helpful for the instructor to bring their own “stimulus kit” of related – but not too related – items that are specific to the topic at hand. For example, for the stethoscope example shown in the video, that might include: Other medical tools, a stethoscope from a child’s play set, Photos of the clinical environment, and ear buds. Students might start with this to get the more convention ideas out first, before moving on to the even more “out there” ideas created through the use of random stimulus.

Demonstrating the Power of Diversity When Ideating Using Bisociation

Bisociation, like most ideation methods, works best when the ideation team is very diverse. While most students think of “diversity” in a fairly narrowed view (potentially including race, ethnicity, gender, religion, disability and sexual preference), for purposes of ideation the value will come from diversity of experiences and perceptions. While these tend to be influenced by these commonly thought of types of diversity, they can go well beyond that to include all of the various life experiences an individual has had.

This can be a fun activity, reminiscent of various game shows. Students are put into groups of 5 – 8 students and all students have a stack of index cards or scrap paper. The instructor then presents a series of stimulus one at a time and asks the students to secretly write down the first thing that they think of when they see the item. This gets more interesting, and probably more useful as an overall activity, if the instructor purposefully stacks the team so that at least one team is not very diverse and one team is very diverse (we have used the results of the Meyer’s Briggs test and other personality surveys to form teams ahead of time for this type of activity).

This activity will not always work, so be prepared to interject and have examples readily available of what is “normally” seen. So for example, we’ve used an example of using a red rose as a stimulus. Following the thought that “A rose is a rose is a rose” we might see a less diverse team all write down “Rose” or maybe “Red”. A team with a lot of diversity of thought might include descriptions like “Tango”, “Grown in the Garden”, “Used to Make Tea”, etc.

Let students see and experience for themselves the power of diversity of thought as they see how similar – or different – their responses are to their teammates. This of course, takes a good level of class comfort with each other. This activity could be expanded to make sure some of the stimulus items are objects that are a little “odd” or “unclear” as this will also likely emphasize the benefit of using unrelated stimulus combined with a diverse team to generate valuable, unique ideas.

The instructor should follow up the activity with a discussion to debrief and reflect on the importance of making sure a diverse team is present when ideating using any method – but especially bisociation where building on each other’s ideas and trying to bring very diverse ideas together is critical.

If this activity is done early in the semester this could lead into a conversation or activity related to forming teams for the remainder of the course based on diverse characteristics. This could also be a time when you tell your students that they are welcome to invite other people to class on any ideation team to help represent any perspectives their team is missing and would like represented.

A+B = C: Identifying Practical Examples of Bisociation

One of the best activities to show the benefit and create student buy-in to the bisociation method is to go through the range of novel products and services that have been created through combining two things that we wouldn’t have thought would go together into something new and novel. This can be done through a PowerPoint-based in-class activity. Instructors could carry this out in a fun, interactive way by using a THIS + THIS resulted in ? format where the images are put up for the class to see and guess at. Each answer could be revealed immediately or suspense could be allowed to build by going through all of the “questions” before the answers are revealed (IF*AT cards could also be a fun way to carry out this activity.)

KEEN Network members Jonathan Weaver and Darrell Kleinke at the University of Detroit Mercy have led a similar activity and have a number of examples that resonate well with students. They chose to start their activity with “well of course” connections: A old-fashioned auction + the internet = Ebay! And then move on to harder to guess connection results --- who would have known that rubber + a waffle iron served as an inspiration for the rubber grid soles of Nike running shoes!

This activity could be entirely instructor driven where the examples are already prepared and the students are just having fun guessing and seeing the variety of connections that have been made. If so, then the activity would probably be best completed in a single session of less than 30 or so minutes. Otherwise, the instructor could also get the students actively involved, by having them identify the “bisociation stories” behind common products.

Yes, Bisociation is Better than Traditional Brainstorming

Often I find that after I teach these great ideation techniques, students use them for the activities that require them, but then quickly fall back to traditional brainstorming the next time they go to ideate. Demonstrating to students the power that bisociation can have can help with buy-in and sustained use.

To do this instructors should come up with some prompt they want students to brainstorm about. It can be whatever makes most sense related to purposes of the class. One example that I used in a first-year engineering design class was: **“You are a member of an engineering design team. You have been**

approached by a company that designs kitchen gadgets and accessories. They are looking to your team to provide a new, unique kitchen gadget that helps make preparing and/or serving food better.”

Before showing the Bisociation video, provide students this prompt and ask them to brainstorm their ideas. This can be as formally or informally done as the instructor desires, and related to other skills they might be trying to work into the class. We did this very early in the semester when first-year students still often weren't comfortable sharing their ideas. So we did this in a very formalized way that also attempted to show students the benefits of ideating in a team. We gave students approximately 3 minutes to list all of the ideas that came to their mind on their own individual piece of paper. (Good documentation will be critical for this activity to work). Students then got into teams of approximately 5 and were asked to together make one master list of all of the ideas they could come up with in the next 10 minutes. This generally included most of the individual ideas from each person as well as new ideas that the teams thought of as they discussed. At the conclusion of the time period, students were asked to count the number of ideas and circle this at the top of the page. Then, as a team, they went through and identified the three best ideas that their team had (instructors can provide a discussion on what "best" means, reviewing value creation principles, etc. depending on the scope of the class and desires of the instructor). For each of these three ideas, the team filled out one "Idea Card". The idea cards, the template of which is included in the appendix of this packet, requires the students write down a name for the design/product, a target audience, the benefits, and how it (functionally) works. The lists of ideas and the completed idea cards should then be saved – it is possible that this activity would need to span two (or more) class periods.

The bisociation video should then be shown, along with any additional instruction/activities that instructor wishes to incorporate about this methodology. After bisociation has been introduced sufficiently, the students will repeat the same activity but do so using the principles of bisociation. It is up to the instructor how in-depth and how much time they would like this process to take. It can get tedious, but is important to do so instructors should decide whether they want to incorporate both related and unrelated stimuli and/or use multiple items of each. In my class when I did the activity, we chose only a single unrelated stimuli which was a life-sized statue featured in a Skymall magazine.

Once the stimulus has been introduced, help students systematically walk through the bisociation process properly. They should begin by listing all of the characteristics, attributes, and personal perceptions about the item. Again, this could be done first independently and then as a group (which we find works very well in building comfort at the first year level). Once this is done students should be shown the original prompt again and asked to think about their attribute list and come up with as many ideas as possible. Make sure to keep the structure and time the exact same as you had done for the traditional brainstorming method. We again do independent ideation using bisociation for 3 minutes, team bisociation ideation for 10 minutes, count up all of the ideas, choose the 3 best, and do an idea card for each. We make sure that the students mark a big "B" on all of their papers to denote which ideas came from the bisociation round.

The instructor should then facilitate a discussion comparing the quantity and quality of ideas that have been generated using each of the methods. It is often beneficial to have the teams share their best ideas out loud so everyone in the class can hear what other teams came up with. Interestingly, when I did the activity, the students perceived that their ideas were better before the stimulus was used and felt that it had been busy work that created "silly" ideas. In reviewing the ideas, though, I saw a lot of in-depth

concepts and thinking that was reflected in the stimulus rounds and not the traditional brainstorming rounds. As an instructor, be ready to acknowledge and debrief on these feelings – and hopefully you will find that the stimulus round provided more ideas as well as more game changing ideas than traditional brainstorming. Wrap up the discussion to encourage students to see the value of the ideas they created in the bisociation round of ideation and to continue to use these methodologies throughout the course and curriculum.

Note that we have explored using a rating rubric to try to get at the quality of ideas presented on the idea cards, and feel that this whole activity lends itself to scholarly research a faculty member may want to embark upon.

Extensions: Some Other Times to Incorporate Ideation - Bisociation

First, realize that while bisociation seems to lend itself best or most easily for ideating product ideas, that it is a tool that can be used *for any reason brainstorming or idea generation is occurring*. Like painstorming, you could even incorporate brainstorming/idea generation into opportunity recognition -- - by identifying possible problems to be solved, topics to write an essay about, research questions worth investigating, etc. Here are some less conventional situations you might want to use idea generation (incorporating bisociation or other techniques) in class:

- Coming up with an interesting, novel research question that will serve as a starting point for a term research project
- Identifying topics for essays or research reports
- Designing education outreach activities
- Rethinking layout or organization of a workspace, classroom, or lab
- Planning activities of professional development activities for a student organization
- Activities where you want your students to practice being more descriptive, observational, or perceptive

BIOMIMICRY

DESCRIPTION OF THE TECHNIQUE

Biomimicry is a technique that can assist individuals when ideating. This is a technique where we look to nature for inspiration in coming up with solutions for human problems. Because the over 30 million plants and animals of earth have been evolving for billions of years, it is generally believed that they have reached the most efficient, elegant – and generally – sustainable solutions to many functions that we seek to replicate in our products and services. By trying to generate solutions that imitate life we often can come up with ideas that are functionally better than we could otherwise do. Biomimicry is a growing field and deep dives into the history, background, and context can be found in a number of TedX talks, books, and other resources – especially those by Janine Benyus.

Biomimicry can be most useful when the ideation team has already narrowed their discussion to identify some kind of functional need that they are trying to figure out how to accomplish. For example, the team might be trying to figure out how to: get this train to go fast but not create sonic booms; to get water in a village from here to up there; to make this product have a profile that helps it move most quickly through this fluid; to make this out of a material that is conformable but strong; etc. The idea with biomimicry is that when faced with these types of problems there is probably something – or many things - in nature that has already solved this problem --- and perfected it over millions or billions of years. A website called AskNature.com helps provide a concise summary of some of the many ways nature carries out whatever the need is, providing the design team with many new (but proven!) ideas that can then be leveraged into their own solution.

Biomimicry can become more tangible when students see examples of how this has been done to result in successful design solutions. One example that we have found to resonate well with students was the troubleshooting that occurred when the high speed Bullet train was first introduced in Asia. As the Bullet train sped through tunnels it created frequent sonic booms that irritated and annoyed nearby inhabitants. To solve the problem, the design team first tried to articulate what the problem was: that a very fast moving object had to be able to speed through the air within the tunnel and emerge without disturbances that caused the sonic boom sound. The design team thought about other objects in nature that move very fast and must pierce through still air/water. They identified the kingfisher bird as doing just that --- and determined that the reason it is able to move and fish the way that it can, piercing through water with very minimal disturbance, is due to the shape of its head and beak, which have assumedly been optimized over billions of years to meet their fishing needs. Likely there were other animals and natural phenomenon that the design team could have continued to look into and consider as likely options --- perhaps many would have resulted in the same type of takeaway that the profile and shape of the object is critical – but it is also possible that other design attributes would have emerged. Regardless, ultimately the Bullet Train was redesigned, with the new shape of the front of the train (which solved the problem) looking very similar to the familiar shape of the kingfisher. For more on this story check out one of many resources: a short podcast available at <http://earthsky.org/earth/sunni-robertson-on-how-a-kingfisher-inspired-a-bullet-train>

Biomimicry can therefore be used with other ideation techniques, and can actually fit quite well with bisociation, where biomimicry can serve as stimulus for generating ideas of how to mimic the natural phenomenon --- for example; knowing this is how the kingfisher accomplishes this task, what are ways we as humans could do something similar (but within the constraints that we can't really be the perfected bird!)?

It should be noted that biomimicry can be best capitalized on when there is a deeper understanding of biology and/or physiology than many of our engineering students will have. This also serves as a motivation for cross-training and the importance of making connections across knowledge and curriculum.

PURPOSE OF THE VIDEO

The purpose of this 6 minute video is to serve as an exciting introduction to biomimicry for students. While it is intended to be a standalone video it does make reference to bisociation, so would make sense to be introduced after bisociation in courses implementing the full video sequence. The video starts out by briefly introducing the concept of biomimicry. The video then focuses on two examples where products were developed by making connections between natural phenomenon and various problems that humans face. The process of biomimicry is not elaborated on at this point, but the stage is set to then move into this briefly later in the video. One of the examples is shark skin and the unique properties that make it resistant to growth and adherence, which as a byproduct also enables a smoother and more efficient glide in the water. The example focuses on how these properties were able to be studied and replicated to form a product that is now being used to: coat commonly used medical tools to assist with sterilization and reduce the spread of superbugs; embed in wound dressing to help wounds heal faster; and coat the hulls of ships to prevent the growth of algae and barnacles which would slow the ship down. While not explicitly articulated in the video, this lends itself nice to further instructor-driven discussion of various KEEN-related principles such as opportunity recognition and value creation. The other focused example is on sea coral and its carbon dioxide sequestration process. The example focuses on another researcher who made a connection between the way that sea coral does this and the work he was doing in cement to create a much better, more eco-friendly cement sequestration process that mimics the process that coral uses. These examples help set the stage for what can be done using biomimicry. Note that these two examples also make reference to the usefulness of bisociation, highlighting the fact that the products being discussed were because the individual made the connections between a natural phenomenon and the various problems they were aware of. This is slightly different than determining whether and when to use biomimicry when starting off with a new problem to be solved.

With the stage set, the video turns to a very brief discussion of when and how to use biomimicry. It is presented as a tool that can be used in conjunction with bisociation, serving as the stimulus or also a tool all its own when looking for a particular design solution that is efficient, environmentally friendly, etc. where nature may be able to provide us examples that we can build upon. AskNature.com is presented as a place where this can be done.

It should be noted that when showing this video to faculty, many of them identified that they would likely focus only on a part of the video, show that to the class, and then build their activities onto that.

For example, as described below, multiple applications related to the aerospace curriculum were proposed but because of the relation to the shark skin example, that instructor would focus on using only that portion of the video to springboard into the activity, rather than the full 6 minute video. The video is made to be adaptable so that you can certainly do this, though it should also be short enough and appropriate enough to show in its entirety.

SAMPLE ACTIVITIES & ASSIGNMENTS

Finding and Researching Biomimicry Examples Specific to the Course Focus

This activity is one of the more straightforward extensions to follow the video, and can be adapted to a variety of classes. With this activity or assignment students would be instructed to do their own web search to identify a design that serves as example of a biomimicry application. The specific biomimicry-related functions would be related to the content of the course.

For example:

- A Fluid Dynamics class might have students find examples of nature-inspired designs for controlling turbulent flow
- A Thermodynamics class might have students find examples of nature-inspired designs focused on energy efficiency or regulation of temperature
- A Design of Machinery class might have students find example of nature-inspired designs focused on mechanical advantage
- A Materials class might have students find example of nature-inspired designs of a whole variety of material properties and structure (e.g. a deformable but incredible strong material; a material that is resistant to antimicrobial growth, etc.)

Students should research the topic and be encouraged to find several examples before narrowing in on the one they find most interesting or unique. They should be prepared to explain this at an appropriate depth. Instructors may want to provide prompts to ensure students go deep enough to meet their instructional goals.

Students could submit via written homework, share in a whole group discussion, etc. It might be beneficial for the instructor to have a short prepared wrap-up that draws on some of the examples that they had hoped some or all students had found and relates all of these examples to the broader class goals and/or another upcoming assignment/activity that will make continued use of these examples.

So What All Does My Animal Do? Biomimicry Functions

This is another fairly straightforward example that easily stems from the video and could be used in nearly any course just to further illustrate the concepts of biomimicry and set the stage for further applications of the technique in other areas of the course.

In this activity, students or student teams are each presented a different animal. Student teams must then use their pre-existing knowledge and/or research that animal to be able to list all of the different attributes that that animal has that may be useful in a design or product.

A follow-up discussion or activity could have students start proposing how or why that attribute would be useful in a design or product, and/or how it might be able to be mimicked into something that could be physically implemented in a human-driven design.

An alternative activity would be for the instructor to call out design needs and let the class debate over who has the animal that should be the starting point for generating ideas for solutions from. Choosing design needs that are not clear cut may be useful --- for example while a shark and a bird are clearly different they both have attributes that could make them very useful in solving various fluid dynamics problems. The instructor could then also use this into a lead-in about how we might be able to get even better solutions by combining (similar to bisociation) these various related but different animals/attributes.

A different follow-up would be to then have the students take everything they have been doing and relate it back to the course content. For example, “Which of these attributes might be able to help us in solving problems that are thermodynamics-based/materials-based/machine design-based?” The instructor may want to have some examples ready of an animal who has attributes that are very much related to this course focus and describe how.

Analyzing Human Engineers versus the “Natural” Engineers (More Analysis-Centric than Design)

Whereas we tend to think about ideation in terms of design, this activity takes the biomimicry video and builds upon it focused on analysis, and potentially experimentation.

This activity/assignment/lab would take more effort and more set-up than some of the other more straightforward activities presented. The idea is for the instructor to think about their own course content and come up with an example that can be framed in a “who does it better?” set-up: Human Engineers, or “Natural” Engineers (the animal, plant, or natural environment that naturally replicates this same activity). Students would then need to do research and/or experimentation to attempt to get data that can help them justify their decision.

While this will be quite class-specific, one example would be: Which converts solar energy more efficiently: Photovoltaic cells (human engineered) or Photosynthesis (naturally “engineered”)?

This could also be used as a way to teach particular experimental concepts and testing methodologies.

The instructor could then facilitate a wrap-up of the debate. They may want to have their own research prepared as to what the “data” really shows, as well as any other trade-offs that might need to be considered. If the human engineered designs “did worse” than the instructor could facilitate a discussion of what lessons could be learned from evolution to improve the human design process and its outputs. This would ideally lead in to application of this information and mindset into future activities.

Bringing the Zoo Together: Design Activity

This activity is similar to the *So What All Does My Animal Do?* activity above, but at a much more involved level. This activity could serve as a small design process activity or motivate a whole semester-long/year-long design project, depending on desires of the instructor as to “how far” they wish to take it. One of our faculty learned this activity at a workshop he attended, though we unfortunately do not have the name of the original source.

Students are placed on teams of 4 – 6. Each person in the group is presented a different animal for them to research. They are to learn and be ready to articulate some of their various attributes relative to biomimicry-related processes.

As a group, the students then need to incorporate some aspects of their animals into a design to solve either a given task (provided by the instructor), or alternatively identify their own task to be solved (this more open ended option provides a chance to work on the important skill of opportunity recognition).

Not all animals need to be used, not every attribute or behavior of each animal. However, students should work to make connections between how most of the animals’ attributes could work together to create a complete design that takes the best parts of each.

Biomimicry-Inspired Design Projects

The *Bringing the Zoo Together* activity alluded to the idea that the activity could be used to launch a whole semester-long or even year-long design project. This straightforward design-related activity is here to capture this obvious extension from the video.

Many instructors now do project-based learning and especially in engineering, design-oriented projects tend to be incorporated in numerous classes across the curriculum. This activity description is here to encourage instructors to be creative in their choice of topics and how they present and facilitate them. Biomimicry, as well as other topics, can be easily worked in.

In a Heat Transfer course, for example, though the design project could focus on any of a number of problems, one instructor strategically picked two topics that will lend themselves to having students explore biomimicry. Students are requested to develop new inventions for: 1. Clothing that maintains human thermal comfort and 2. Building walls that convert waste heat (from thermal storage of solar energy) to electricity and with an ability to sense thermal dynamics within the walls in order to optimize demand response (for energy).

After being introduced to Biomimicry via the examples shown in the video, students would then be instructed to research if there are organisms in nature that display the functioning they are trying to create and to then envision ideas that could inform their designs. Note that as this instructor points out these ideation techniques do not have to work in isolation, in going through the ideation process, students will also be learning and using bisociation techniques being given a “bag of improbable materials” to serve as stimulus (see Stimulus Kit).

Similarly, in an Aerospace Course the focus could be on exploring the effect of the sharkskin dermal denticles on the boundary layer. Similar to the activity *Analyzing Human Engineers versus the “Natural” Engineers* a term project could have students experimentally explore the effect of surfaces with different skin friction coefficient on the boundary layer. Materials could even potentially be purchased from Sharklet Technologies and experimented upon.

Some Other Ways the Video Could be Used: Classes and Topics

- Course: Mathematical Programming Class
Topic: Complex, Non-linear Mathematical Programs
Biomimicry-related focus: Evolutionary algorithms are very useful in solving complex, non-linear mathematical programs. These algorithms are inspired by biological processes such as reproduction, mutation, recombination, and selection. The video could set the stage to talk about evolutionary algorithms and their development and use (and usefulness) within programming.
- Course: General Microbiology or Biology of Infectious Disease
Topic: Host-Pathogen Relationships
Biomimicry-related focus: In these classes, biomimicry can be best demonstrated by pathogens that have surface markers that make them look like human cells to avoid degradation by the immune system. By pointing out the concept of biomimicry, the instructor can ask the student to examine different host-pathogen relationships to gather and share more examples of biomimicry as a demonstration of the importance of distinguishing self from non-self in host-pathogen interactions.
- Course: Intro to Flight, Aero Design, AeroDynamics
Topic: Boundary Layer Effects
Biomimicry-related focus: This activity would be related to the sharkskin portion of the Biomimicry video. Students would be asked to watch it before coming to class. Then in class the instructor would initiate a discussion around boundary layer effects. The instructor should ask students to think about the [mostly flying or swimming] animal kingdom and extremes. Think about really fast animals, or about animals that can almost hover around their prey. The instructor should be ready to prompt with questions like “What are their primary unique external features? What purposes do they serve?” The instructor might bring up the fact, for example, that sharks don’t look like fish and that sharks noses are shaped differently, as are their tails. The instructor

should be ready to jump to “What about the flying world?” or get more diversity in thinking about the underwater world “What other fast sea creatures look different?” Students could have time in class to Google some of these things and come up with answers that would inform and sustain the discussion. The hope would be that they’d look at dolphins or raptors, or at soaring birds. Doing a quick Google search on any of these things will reveal numerous areas where birds and seas creatures have things to teach us and to inform the way we think about and design airplanes.

For Aero Design classes which have more advanced students in them, instructors may want to extend their discussion to include configuration and layout type decisions. For example asking questions “Why do airplanes look the way they do?”, “Do we see inherent differences between fast and slow planes?”, “Do we see similarities in natural flyers?” The instructor should be ready to provide a few examples. This would probably not be a long discussion, maybe as short as 3 minutes, but it would be good for breaking up lecture.

- Course: Materials
Topic: Ceramics
Biomimicry-related focus: This activity would focus on the coral example provided in the video. Students would be asked to watch the video focused on this part, perhaps supported by additional instruction by the instructor focusing more in-depth on other naturally occurring ceramics such as sea shells (especially abalone shells). Students would then be instructed to do research on how we can make the man made ceramics like chalk and wine glasses stronger (even in tension) and less brittle like the abalone shells.
- Course: Physiology
Topic: General
Biomimicry-related focus: The instructor could lead the students in a discussion asking questions such as “What other biomimicry examples in biomedicine can you think of?”, “What benefits do these have?”, “Can you think of any of the physiological processes discussed in this course that potentially could lead to a biomimicry product?”, and “Which of the themes of physiology are replicated in the examples of biomimicry presented in the video?”
- Course: Research Methods
Topic: Technical Communication
Biomimicry-related focus: Students would be instructed to visit AskNature.com and find an inspiring example from nature that has biomimicry implications. Students would then need to find a corresponding peer-reviewed journal article on the same topic. As an assignment students would evaluate the summary on AskNature.com and its ability to communicate these ideas accurately but to a lay audience, comparing and contrasting the two types of communications.

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CONTRIBUTORS

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APPENDIX

IDEA CARD TEMPLATE

Idea Card

Introducing the _____ *<name>* _____
_____,
the first & only _____
for _____ *<target audience>* _____
that _____
_____ *<benefits>* _____

It works by _____

Idea by: _____

Idea Card

Introducing the _____
_____ ,

the first & only _____

for _____

that _____

It works by _____

Idea by: _____