Biomimicry Sharing Stories Project

Image: Kevin Krejci/flickr

Biomimicry Integrated Into the Curricula

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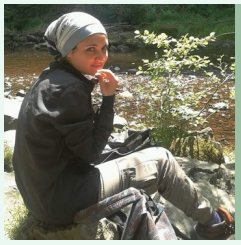

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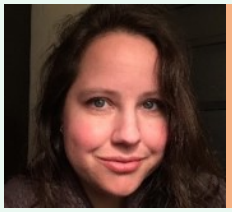

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Biomimicry Sharing Stories Project

Anuj Jain
Singapore
Biomimicry Singapore Network and BioSEA
Curriculum Integration

Image: Kevin Krejci/flickr

Title of Program: Educational Programs in Biomimicry
Ages: 12-18
Group Size: depending on the project ~10-15 (guided walks, school workshops) to 1-3 student(s) (coaching)

About the Program

Anuj Jain is a Biomimicry certified professional and a co-founder of Biomimicry Singapore https://www.biomimicrysingapore.net/.

One of his education programs is about organizing guided nature walks to experience and learn how Nature solves problems. To engage the audience (public or kids' groups), walks are usually organized around one or a few key question(s). For example: How does Nature deal with very little or a lot of water? In this case, Anuj brings attendees to look at strategies found in different places such as in a local rain forest or at a desert exhibit at the local Botanic Garden. Taking time to reflect towards the end of the walk on how the observed nature's strategies could help the attendees in their daily life is important. This could be done through posing questions to attendees such as how could you learn from nature to design a water storage system at your house, resolve a leak on your roof, help save water, etc. These questions help attendees look at Nature in a different way.

Another of Anuj's educational activities is organizing workshops with schools. The goal of one of his workshops was for instance to help students curate an exhibition booth on biomimicry. To do this, they had to learn the basics of biomimicry, what the exhibit storyline should be, and how to make it interactive. Students created a card game exposing different challenges that could be resolved by nature, a poster and even a specific 3D model to explain their ideas about trying to implement biomimicry in the school premises. They asked, "Nature is a place of happiness and play. How can we as kids learn more from it?"

Another workshop was tailored to primary and secondary school teachers so they could brainstorm ways to integrate biomimicry in the school curriculum. The workshop's superstars were the natural specimens that Anuj brought. This was followed by a nature walk on the school's premises. Surrounded by nature, the participants got an opportunity to ask thematic questions that relate to the school curriculum – How does the pomelo fruit build a lightweight and durable shell (materials)? How do elephants stay cool (heat transfer)? How does a pine cone open up in response to fire (chemistry and resins)?

To share his experience in biomimicry, Anuj also offers to mentor school students. One student had to work on a quadcopter project and decided to incorporate biomimicry in it. Anuj coached her to understand which animals to mimic to design a copter and supported her in model design. Building on this experience, he is set to teach a 2-day workshop to students aged 15 – 18 in which they will create a nature-inspired flying or gliding device.

Preparation For Teaching Biomimicry

As an ecologist and trained biomimic, Anuj is the founding partner of the Biomimicry Singapore Network. He leads many projects to bring Biomimicry to communities, enterprises, and education.

Sources of Nature Inspiration

Being exposed to Nature through guided walks and expeditions is certainly a great way to connect and learn from it. At any time, Anuj is able to dig into his personal background in natural sciences that he gained during his Ph.D. in Ecology, his wildlife conservation work, and his professional training in biomimicry. In the classroom he tends to focus on local examples so that students can connect more with their local and very diverse environment.

An online resource such as *AskNature* is another great way to check out the latest strategies and to engage kids in doing their own research. He also makes kids aware of the Global Youth Design Challenge.

Wow Factors

- See participants' eyes lit up when they witness a cool nature strategy during a biomimicry nature walk.
- Teachers and kids engrossed in studying natural specimens during workshops and relating them to the school's lesson plans.
- The biomimicry exhibition booth in school was a success as kids were very proud to share their discovery and exhibit with their parents.

What Were Some Challenges?

In general, Anuj feels that biomimicry brings a lot of excitement at first. However, when it comes to emulating nature's designs in a creative project setting, it is sometimes tricky to have the kids explore a new discipline without them having acquired enough knowledge in biomimicry then be able to link it with other sciences, (e.g. biology, chemistry or physics). That is why Anuj likes using a detailed curriculum like the one named *Biomimicry & Sciences: Applying Nature's Strategies* found in Ecorise (**https://www.ecorise.org/product/biomimicry/**).

In other words, there might be a limitation in what could be done within a short 1 or 2 days workshop for middle and high school students. Being a biomimicry practitioner at a relatively young age is a big learning process, which requires a real investment in learning and research.

The trainers also need to keep the research process sufficiently engaging and fun so students don't lose interest and can get past the discovery stage of the biomimicry methodology. Students usually have great ideas, so ideation and product creation with students can be a lot of fun.

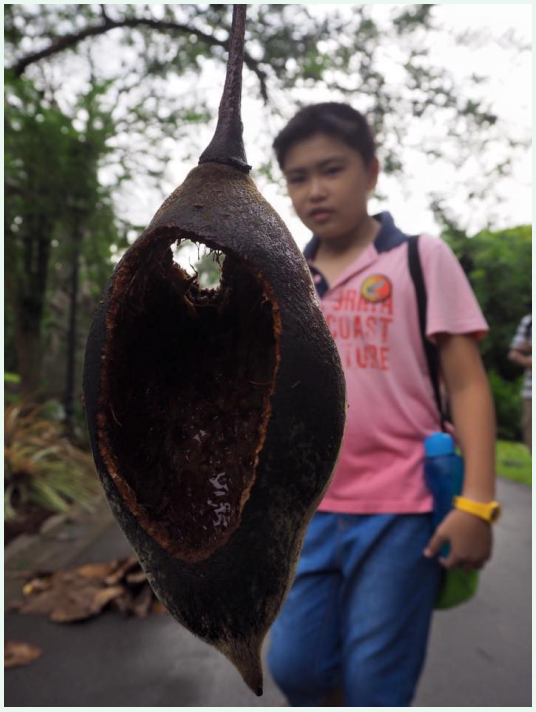
Materials Used

PowerPoint slides, iSite-based biomimicry nature-journaling exercises using natural specimens, paper & coloring materials, magnifying class and microscopes, AskNature's biomimicry taxonomy, B3.8's Life's Principles sheets, B3.8 Biomimicry Brainstorming In-A-Box game, *AskNature*, and the *Ecorise* curriculum.

Any Changes for Next Time?

The Singaporean educational approach is very pragmatic and solution-driven, so it is important to show how biomimicry can solve challenges. Inspiring students is one thing but translating this inspiration to problem-solving for real projects is another. Therefore, the educational resources to be developed have to focus on practical activities and exercises (e.g., making measurements in nature to understand patterns, how mangroves could help better desalinate Singapore's seawater to drinking water).

Anuj is currently involved in running teacher training on biomimicry. He is developing educational support for teachers to help them lead extra-curriculum activities and spread the meme of biomimicry widely in Singapore. He is reflecting on adapting the Ecorise curriculum to the local teaching style and context.



Biomimicry Sharing Stories Project

Arielle Rhodz
Hamilton, MT, USA
Curriculum Integration

Image: Kevin Krejci/flickr

Title of Program: Middle School Spectra Challenge 6 "PONDER"
Ages: 11-14
Contact Hours: 15 contact hours

About the Program

This year Arielle incorporated a Biomimicry Design Challenge to support her curriculum of the Seven Official Thinking Skills and the Engineering Design Process. Students cooperatively designed a model of an invention inspired by nature. She devoted two class periods (50 minutes long) per week per Thinking Skill and used local Biomimicry mentors to support and evaluate their designs. Emphasizing the use of the type of Thinking Skills to support project development, students were ultimately assessed by an Engineer, Nature Lover, and Biomimicry Scientist as authentic audiences.

The Seven Official Thinking Skills she used were: Flexible Thinking (Adapting), Strategic Thinking (Planning), Logical Thinking (Problem-solving), Creative Thinking (Innovating), Analogical Thinking (Comparing), Critical Thinking (Evaluating), and Analytical Thinking (Examining).

The Engineering Design Process came from a video called The Engineering Design Process: A Taco Party, available on YouTube. https://www.youtube.com/watch?v=MAhpfFt_mWM

What Were Some Challenges?

"The concept of function was tricky to get them to understand, so I brought in a bunch of bizarre kitchen tools (pictured to the right) and the students brainstormed each one's purpose, its function." She noticed that the students didn't do the research as much as she had hoped. Gifted students went as far as they wanted, then stopped and made speculations. Some of their designs ended up based on imagination not on fact.

Source Of Nature Inspiration

Arielle's class took two field trips, one to the backyard at their school to look at trees and one to a more natural backyard at a local nonprofit. She also tried a set of matching cards but the students didn't connect to those.

Materials Used

Learning with Nature, AskNature education resources, AskNature.org, some borrowed materials showing biological models and designs that emulated them. She also counted on several local people who were knowledgeable about biomimicry.

Wow Factor

The most powerful exchange Arielle witnessed was students' ITERATING [from the Engineering Design Process] based on mentors' advice: "Gifted students are often reinforced for their advanced ideas, and rarely asked to change or improve. To see them get feedback from informed adults, apply the advice and improve their designs was by far the most meaningful part of the Design Challenge." Arielle brought in some engineers to work with the groups on their designs, then the students had to iterate and fix these. For these gifted and talented students, she strongly believes that *"things should be hard, not easy"*.

Preparation For Teaching Biomimicry

Arielle had taught an enrichment lesson for 4th graders about nature inventions. Then she met a local biomimicry-trained engineer and he increased her interest. In the summer of 2020, she met someone at a conference who knew about biomimicry and that inspired her to teach it to the gifted and talented students.

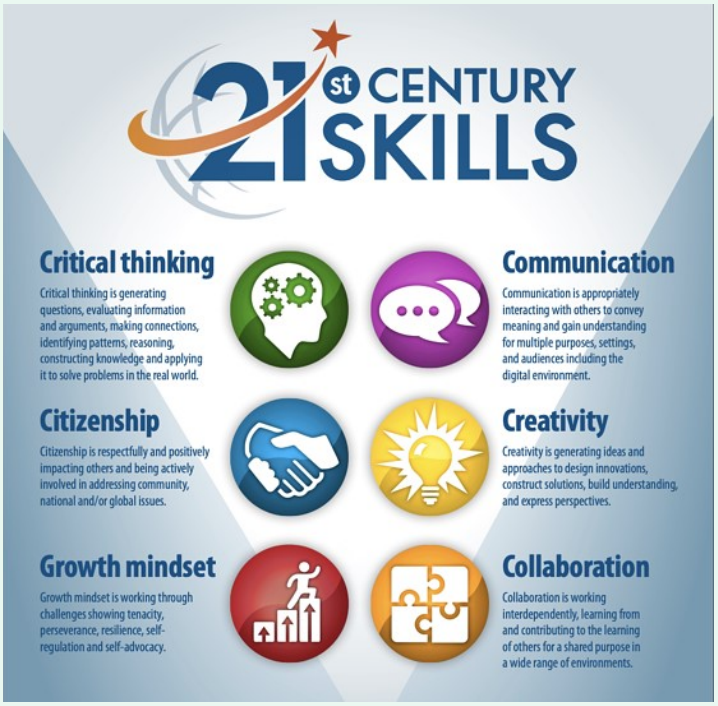
Meeting Teaching Standards

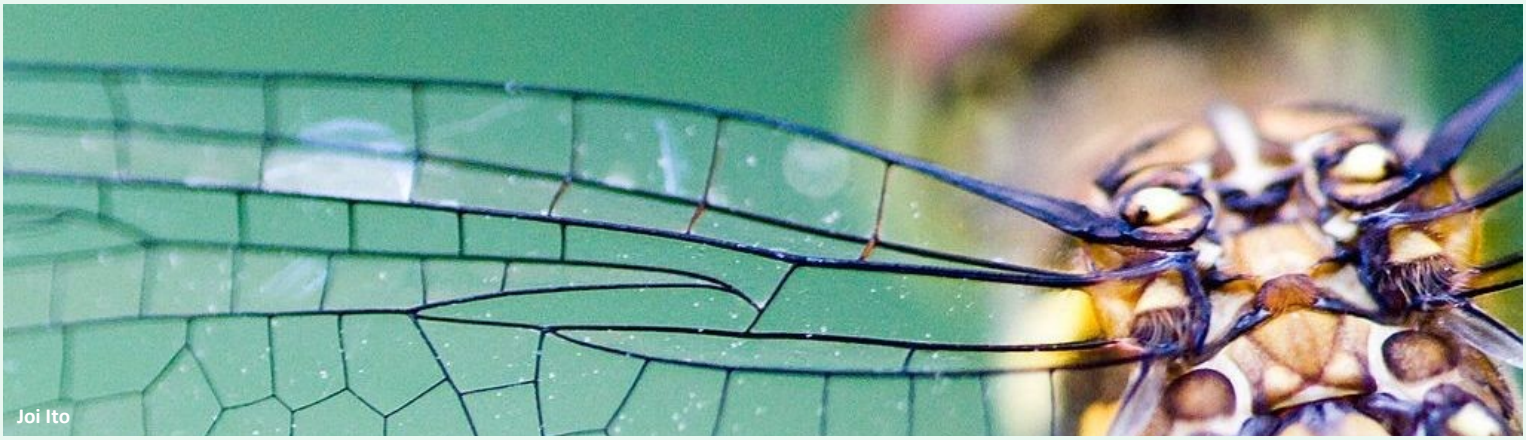
Arielle addressed 21st century skills, thinking skills and Gifted and Talented nationwide standards. She feels pretty privileged in being able to design her own curriculum. Her school district wants more STEM opportunities and this design challenge fit into that well.

Joey Kyber via Upsplash

Any Changes For Next Time?

Arielle would start with the bizarre kitchen tool activity next time, to build a strong connection to function. Then she would take them on the field trips outdoors. She also would have the students use AskNature more for research.





Joi Ito

Biomimicry Sharing Stories Project

Dana Al-Khundakji
Amman, Jordan
King's Academy Boarding School
Curriculum Integration

Image: Kevin Krejci/flickr

Title of Program: Sustainability
Ages: 14-18 depending on courses
Group Size: 11-15 students per class
Contact Hours: 200 hour for her three courses, ~50 hour for her Environment and Sustainability Club

About the Program

Dana is a chemistry and physics teacher. She runs two different courses and one club that focus on Sustainability:

- Conceptual Physics Green Chemistry & Urban Design for Sustainable Design, Environment & Sustainability Club

She runs a sustainability fair by collaborating with teachers to share examples of projects suitable in raising awareness to show care for the planet, care for the people and generate wealth and wellbeing in ethical and sustainable ways.

Her website: is: **https://www.suntainabilityka.com/**

All courses are highly based on biomimicry, which Dana uses to inspire innovative and sustainable designs. Her other approach is considering Transition Design, which is based on looking at the past cultural wisdom of societies that connected with nature and applying that wisdom to the present situation, in order to move communities toward a sustainable future.

The central question in her courses is: "How to create conditions conducive to life?" This offers many opportunities for students to reflect on the need for improving ourselves as a healthy society by using a holistic approach supported by education.

Engin Akyurt via Pixabay

Following are the ways Dana incorporates biomimicry in the courses and clubs she teaches.

Conceptual Physics Course

Dana begins with activities to help students understand sustainability, how science relates and impacts our present and future and that they are ''the creators of hope for a sustainable future''.

She provides examples from the natural world relating to the topic being discussed. Students complete a guided worksheets and are asked to come prepared with research on the organisms they chose. They also participate in an outdoor activity in which they would take pictures or videos and draw.

Biomimicry 1: Owl : Noise Reduction

(Biomimicry in wind turbines)	Nature's example	Human application
Who	Owl	Wind turbine's fin
When	In flight	When the turbine is turning
Where	Edge of wing	Edge of wind turbine fins.
Why	Owls are silent, and don't make much noise while in flight.	Noise of the wind turbine when it is spinning will be decreased.
How	When the owl flaps its wings, air rushes throughout the wing but is split into smaller groups at the edge of the wing, which reduces the noise.	Mimicking the design of the owl will reduce noise. Noise is a huge problem in wind turbines. Mimicking the owl will help reduce that.

Dana often uses videos prepared by VOX and Bloomberg on biomimicry in her classes to show visual examples that can be paused so she can focus on a specific part, such as the geometry, the shapes, forces or the processes.

Using the biomimicry taxonomy, Dana highlights a certain biological function found in nature and in our lives. For example, how does nature manage fluids? Store? Or, distribute water? She refers students to www.asknature.org to research how nature covers specific biological functions to find ways that humans can mimic those whether in physics, chemistry, urban design or even in building communities.

The Life Principles are introduced with examples on flashcards. Dana gives special focus to certain principles such as fit form to function, use multifunctional design, be resource and material-efficient.

For the selected project theme or challenge, they reflect on it from all perspectives (cultural, scientific, ecological, and economic). Students then have to find functions related to this challenge.

Together with her support, students start designing their rubrics by researching answers to the who, when, where, what and how questions related to their own design.

To start working on the design for the project, students study and consider the three levels of biomimetic design:

Three Levels of Biomimicry/Biomimetics:
Translating them into Design Contexts

+ Level 1: Natural Forms (How it looks: 2D)
Forms, Geometry, Patterns & Numbers

+ Level 2: Natural Process (How it is made: 3D)
Structure, Construct, Materiality & Anatomy

+ Level 3: Natural Ecosystems (How it contributes: 4D+)
Social Responsibility, Interior Environmental Quality
& Life Cycle Analysis

Students then write the final draft of the rubric on all the areas they should include in their sustainable, and biomimetic design. They finally begin sketching their nature-inspired design on paper and in design software. The last step is building their design by sketching and then a 3D model, using upcycled materials that are available around them (for example, CDs, bottle cap, hangers, plastic bottle, and glue gun to fix elements together).

In designing, Dana focuses on how design makes us feel, and the impact on people, which is the third level in biomimicry. For example in another unit in which they design their home, they look for life quality, thermal quality, acoustic quality, how they can make their own food nearby and how their design can help them feel calm and relax. All of these things will come together when they see examples in real life and from the natural world [termite mounds, mushrooms, leaves…].

Green Chemistry and Urban Design for Sustainable Design Courses

To introduce these courses, Dana uses the same steps to incorporate biomimicry as she does in her Conceptual Physics course.

Incorporating green chemistry is not easy for all teachers to do. Dana's chemical engineering background gave her the skills to relate applications to theory. As she began to study green chemistry, she was able to make connections and start tweaking her units, while also comparing the harsh chemistry to green chemistry. ''*In chemistry it is easy for a teacher to follow the textbook, and for students, who study regularly to get good grades. However, it is extremely dangerous when they don't realize that these equations and reactions have extremely harmful impacts on humans and the environment*". Dana refers to videos on green chemistry principles that fully meet biomimicry Life's Principles.

Environment & Sustainability Club

This club aims to raise whole-school awareness on sustainability and biomimicry, and makes student-led sustainability recommendations to the school purchasing, operations, and grounds departments. Dana provides learning opportunities through whole school campus activities to learn about permaculture for the Environment and Sustainability Club. She refers to biomimicry as the guideline/lens for addressing sustainability. This is more of an awareness class where students can practice biomimicry as much as possible (essentially with the Life's Principles e.g., Building from the bottom-up). For dorm activities, she brings students out and engages them with the natural world. They do bird watching and permaculture projects on campus (e.g., planting trees that could provide food for birds). The idea is to show the interconnectedness of actions and the meaning behind them. At the end of the year, they do a sustainability fair that includes works produced with other teachers around sustainability.

Sources of Nature Inspiration

Dana relies on natural examples found around the school and close by. Immersion in the natural world is also very important for different observations and reflection.

For online sources, she gives them a lot of reading to find their inspiration by referring them to www.asknature.org for nature inspiration, as well as many other websites, such as The Independent, National Geographic, and the BBC's websites.

Wow Factors

For Dana, "once students start doing hands-on work, there is no limit to the fun they can have. When they apply it many times, they understand it much better".

A few pieces of feedback from students include: "Nature is the best way to innovate, I believe it is heavily underrated. It should always be the main tool when designing anything. As a result of using biomimicry, I start to notice many ways we humans are influenced by it."

Dana added, *"Students from last year were very much involved in their work".* When she asked them this year to come to mentor other kids, they jumped on it, and came to back to provide support.

What Were Some Challenges?

One of Dana's challenges is making students realize that nature offers time-tested sustainable design, and has all the answers to our current challenges. Many students also underestimate biology! For Dana, questioning how a design can become sustainable is the way design should be done. *''What is important is to show them a holistic approach to design things''.* After she conducts her introductory lessons to inspire and grab attention, followed by designing their own projects, students reflect on the value of their work as they develop pride and gain confidence to deal with real-life challenges.

She adds, *"It is a learning moment that takes time. We all have to be patient. And if something doesn't go right, I need to know how to pick myself back up again and discuss it with students. They will come up with solutions. I also learn with them!".*

''Over the past couple of years, I was able to show other teachers my way of practicing biomimicry with students. An art history teacher was doing a project on how indigenous peoples were catching water and designing their homes by using different nature's strategies. Many teachers are now calling me to proudly show me their work. One teacher mimicked the spider web for the tensile strength. Any teacher can find a way to connect with his/her course. You just need to have an open mind."

"To be honest, it takes a lot of creativity, kindness, and generosity to be able to provide a new vision and find connections and examples, which happen at the spur of the moment, provided the context. In order to get other faculty members to understand it, you have to show them that you are connected with the sources themselves."
For Dana, *"teachers have to take risks to try new things. I had no idea how these things were done before. I just had some references. I tried things on my own. "*

Materials Used

From time to time, Dana uses different videos to show the biomimicry approach in action.

For all 3D models, she upcycles all kinds of disposable materials found on campus and presents them to her students, telling them they are going to use these things to help her get to zero waste so nothing is thrown out. So for example, for the wind turbine, they used salad bowls for their fin to mimic the bird flapping.

Teaching biomimicry is about stimulating creativity. Dana believes that youth are the most creative because they are the ones that can take risks. In sustainability, we say that tapping into the power of limits draws creativity. She believes when students are limited with their (upcycled) resources, they actually become more creative for building their 3D models.

Sometimes students want to go for a bigger size in the design. When that happens, she remind them that nature is space-efficient and asked them to consider how they can make it compact. They then look at examples of space-efficiency. She also guides students to be non-wasteful of materials in designing, in the same way nature doesn't waste material.

For chemistry projects, she visits an apothecary and buys natural products that students can use for their design.

Preparation for Teaching Biomimicry

Before becoming a teacher, Dana was a chemical engineer. She discovered biomimicry when she attended the Education for Sustainability course by the Cloud Institute. Over the past two years, she has attended several Continuing Professional Development trainings that helped her incorporating biomimicry and redesigning her curriculum, including:

- The immersion workshop on Biomimicry for Social Innovation from the Biomimicry Institute, which helped her to observe and connect. "There is a lot of physics in biology itself. I am focused on teaching them how to look and observe in real life and also in doing research".
- Biomimicry Intensive Design Course, at the Pratt Institute for Design, NYC, USA that gave her the guided steps to biomimetic practice and design.
- The Permaculture design course at Ecologia de Jenas, Portugal, gave her the hands-on skills to pass on to her students, whether in the classroom, whole school initiatives, or co-curricular activities.
- Renewable Energy Design for International Students, San Sebastian, Spain, which she uses for renewable energy design.
- Project Based Learning, TTC in Rome that was the foundation for designing projects.
- Training of Trainers to build communities, by the Global Ecovillage Network in Europe, which helped her approach the wider school community.
- The Creativity Workshop in Florence, Italy
- AP Seminar Capstone course, CA, USA
- Outstanding Learning and Progress in Science, Leeds, UK

For Dana, teachers have to take advantage of biomimicry as a learning moment to make connections with many aspects of life. "That's my only way to teach now: by making it relevant to real- life".

She also likes to refer to the Holy Quran teachings to show the many references to nature observations that are done in order to guide humans for sustaining life. Dana believes she needs to prepare these kids to take care of our shared place by delivering meaningful education that serves a higher purpose for solving human challenges, whether being emotional, social, ethical, economical or ecological.

Making these connections with real-life also requires a lot of discussions with students to know their culture and background, and understand their learning context.

Any Changes for Next Time?

Dana really would like her students to participate in the Biomimicry Youth Design Challenge. "When I see my student's work over the past two years, I think they have done amazing work. It would be meaningful to them to share their ideas across the globe and within their country, to be the change-makers we hope for''!

Sora Sagano via Upsplash

Biomimicry Sharing Stories Project

Denise Groeneweg
Netherlands
WisMon
Curriculum Integration

Image: Kevin Krejci/flickr

Ages: 11-14
Contact Hours: 3 hours

About the Program

In the science course that I teach we work on a project-base approach. In most of our projects, the students work towards designing a solution for a certain challenge. I try to incorporate as much biomimicry as possible in their design challenge. These challenges range from designing a more sustainable school, to a machine that cleans plastics from the ocean.

Materials Used

AskNature online content - asknature.org. In an international project called Biolearn, we produced lessons that can be found at biolearn.eu.

Wow Factor

Students come up with very different ideas and designs, and are able to look at nature differently after they have practiced biomimicry.

What Were Some Challenges?

Lack of good Dutch resources (AskNature is a nice place to start, but the English level is too difficult for some students).

Kahika via Upsplash

Biomimicry Sharing Stories Project

Kristen Nordstrom
Thousand Oaks, California, USA
Curricula Integration & After-School Program

Image: Kevin Krejci/flickr

Title of Program: Biomimicry

Ages: 5-7 (1st grade) and 8-10 (3rd through 5th grades)

Contact Hours: For the after-school program, she worked with the students two times per week for 1.5 hours each time, lasting 8 weeks.

About the Program

Kristen conducted three programs using biomimicry where students explored local plants and animals and created useful inventions.

After-School 1st Grade Enrichment Biomimicry Course

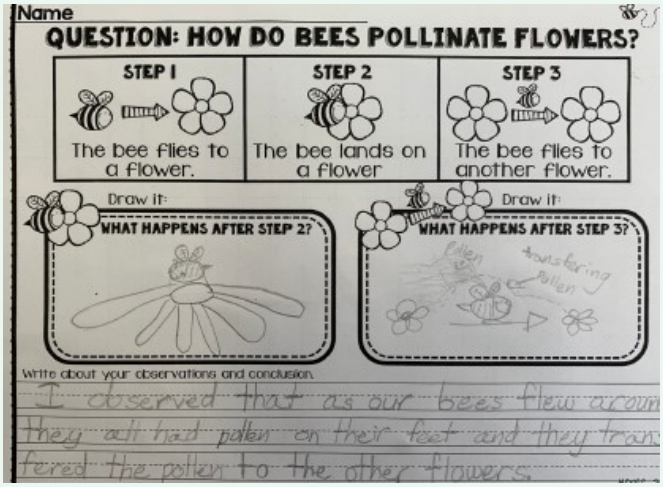
Centered on case studies, Kristen uses videos to show them a phenomenon in nature to start, such as a whale bubble-feeding or a kingfisher diving into the water. The students observed the video then shared their thoughts and questions about this phenomenon. They could then draw a diagram, make a model, or design an investigation. Next, the students researched and read about biomimicry case studies using materials suitable at their level. For example, the students learned about Eiji Nakatsu, the engineer who used biomimicry to redesign high-speed trains in Japan. Next, students applied their understanding of a whale tubercle or a kingfisher beak. They experimented with a paper rotor motor

https://www.nasa.gov/pdf/205711main_Rotor_Motor.pdf
https://www.csuci.edu/news/releases/2017-bullettrain.htm

comparing the flight of straight blades to tubercle-enhanced blades. Finally, students created a biomimicry invention by applying the ideas they discovered such as: tubercle-enhanced frisbees, parachutes, kites, and plane wings.

3rd through 5th Grade After School Biomimicry Class

Kristen teaches this class doing the same general process as for the younger students, but going deeper. The program was an inquiry-based eight-week study that took the students on explorations of their schoolyard habitat. It culminated with student teams creating nature-inspired inventions based on study of local birds with the Audubon Society.



2nd Grade Class This program took place at a science magnet school where they did biomimicry in class. They wove case studies into their curriculum.

If Kristen had to identify three of the most important aspects of her teaching practice that have helped her to bring biomimicry learning to elementary students it would be the following:

1) Use of the 5-E model in all my curriculum design (Engage, Explore, Explain, Elaborate, Evaluate)
2) Use of leveled literacy instruction that supports student learning in biomimicry through reading, writing, listening and speaking
3) Continuous professional training and learning as a teacher through the Biomimicry Institute, National Science Teacher's Association, Buck Institute, and the Lawrence Hall of Science.

Here's a link to the 5E Instructional model: **https://nasaeclips.arc.nasa.gov/teachertoolbox/the5e.**

Meeting The Standards

They used built-in assessments in literacy but also assessed formatively as they went along. They followed performance expectations for the Next Generation Science Standards.

How to Prepare for Teaching Biomimicry

"Read, read, and read"…Janine Benyus' Biomimicry: Innovation Inspired by Nature, Michael Pawlyn's Biomimicry in Architecture, and Jay Harman's The Shark's Paintbrush. Kristen also prepared by creating a detailed map of the ideas they are going to explore and the experiments and investigations we are going to create - pedagogy meets biomimicry. Finally, "*there's a lot of information on the Biomimicry Institute's website that is really helpful when developing background knowledge as a teacher."*

What Were Some Challenges?

"The challenge is always carving out the time within our day at school to devote to biomimicry explorations."

Any Changes for Next Time?

It's always an evolving process, adjusting to different age levels, different settings. She's constantly improving on what she's done before. For the after-school program, she would prefer spending 2 hours each time to allow more time exploring nature.

Materials Used

Biomimicry Youth Design Challenge content, Learning with Nature, and AskNature online content. Kristen also wrote her own curriculum from her own research. These materials align with the NGSS and the Common Core Language Arts Standards. She also developed a PowerPoint with Eiji Nakatsu for the National Science Teacher's Conference.

Wow Factor

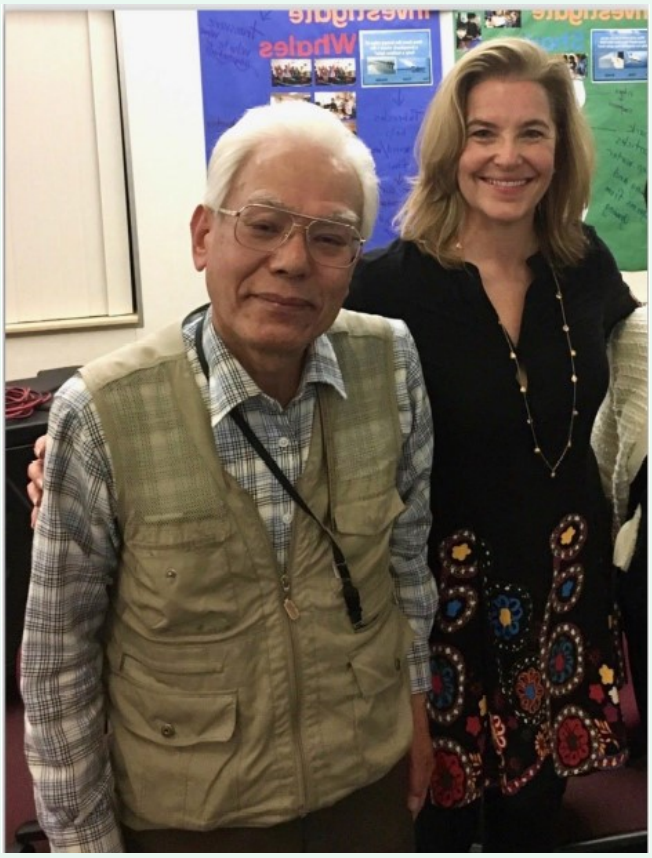
"The wow factor has been sending my first-grade students' questions to Eiji Nakatsu in Japan. He responded and it started a wonderful email dialogue between Eiji and my students that culminated in a memorable lecture by Eiji at our school (funded by the Japanese Foundation)."

See this press release about Eiji Nakatsu's visit to Kristen's school:
https://www.csuci.edu/news/releases/2017-bullettrain.htm

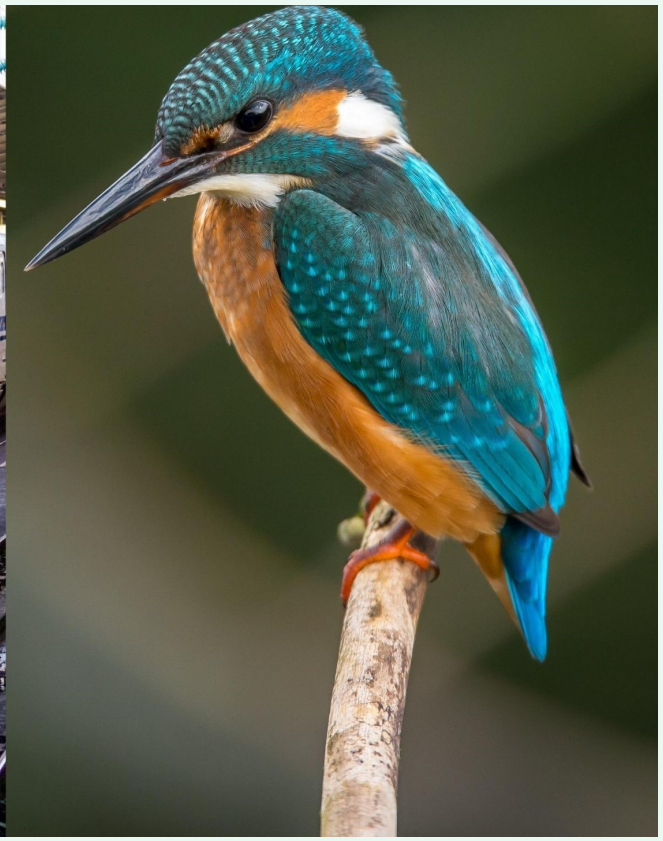
What Else Is Going On?

Kristen has written a picture book entitled, ***Mimic Makers: Inventors Inspired By Nature***
with Paul Boston (Illustrator) and published by Charlesbridge Publishing (release Spring 2021).

Kristen was scheduled to co-present with Eiji Nakatsu this in 2019 at the National Science Teachers Conference in Boston but this was cancelled. Hopefully, she will be able to present an overview of her collaboration and curriculum at the NSTA National Conference in Chicago 2021.



https://www.collegechalo.com/news/biomimicry-2020-iit-m-launches-course/



Biomimicry Sharing Stories Project

Robert Gilson
New York City, New York, USA
Blue School Independent Curriculum Integration

Image: Kevin Krejci/flickr

Type of Program: STEAM
Ages and Contact Hours: Ages 11-14

Materials Used
Biomimicry Youth Design Challenge online content - www.youthchallenge.biomimicry.org, Learning with Nature online content - www.learningwithnature.org, Ask Nature online content - asknature.org

Wow Factor
"The ooohs and aaahs of the students tell me I'm on the right track." Whether looking at the simple sophistication of a spider's silky web, or the structural superiority of the tree curve, students recognize, quite often for the first time, the brilliance of nature. Applying that to an engineering opportunity has been a great extension that fits well into the content of a STEAM curriculum.

What Were Some Challenges?
Being in the city, they don't have opportunities to get outside together. Robert also wrestle with how best to organize his students so that they are each working on a design that inspires them and gives them a team of students to support their ideas. Students sometimes generate an idea that they alone are interested in pursuing, which complicates their ability to fulfill the requirements for submission to the Biomimicry Youth Design Challenge.

"I have had students enter the Biomimicry Institute's Youth Design Challenge in the past and plan to in the future."

Biomimicry Sharing Stories Project

Saju Depalan
Mysore, India
St. Philomena College
Curriculum Integration

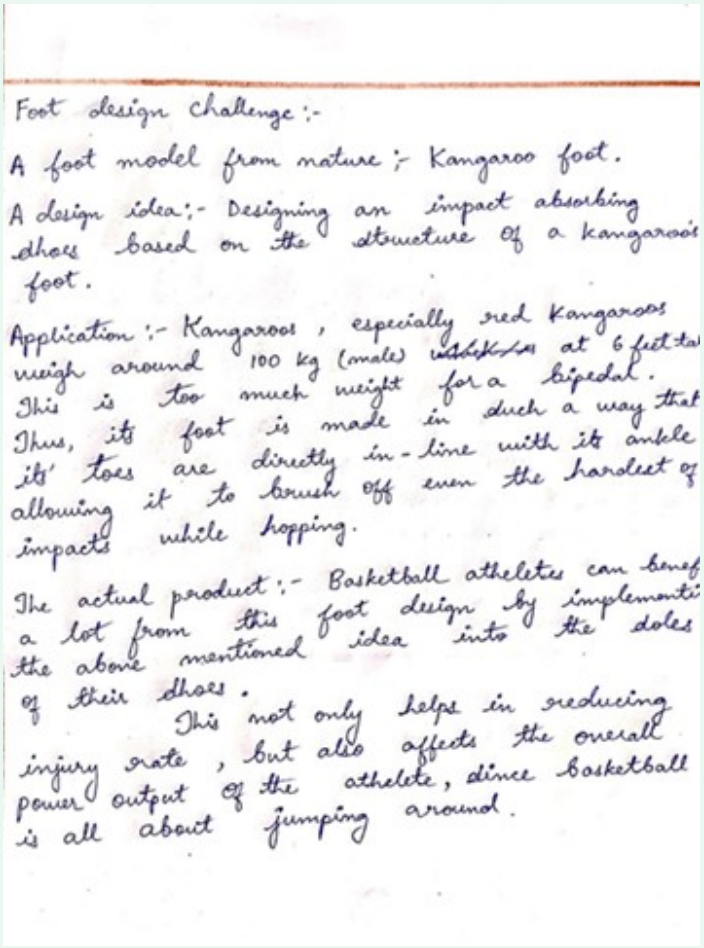
Image: Kevin Krejci/flickr

Ages and Contact Hours: Ages 15-18
Contact Hours: 30-hour

Saju teaches biomimicry as an elective subject to secondary school students in the higher grades level students. It is a 30-hour program, with activity-based assignments See assignment below. He also gives workshops/talks on biomimicry and is also writing a book, “Innovation through Biomimicry". But due to the virus the plans to print it have been abandoned.

What Were Some Challenges?

The word biomimicry gives the impression of mimicry (that is copying movie stars…a common entertainment in India)…so the Educational Authorities whom he approached about developing a seminar were quite dismissive.



Foot design Challenge :-

A foot model from nature :- Kangaroo foot.

A design idea :- Designing an impact absorbing shoes based on the structure of a kangaroo's foot.

Application :- Kangaroos, especially red kangaroos weigh around 100 kg (male) at 6 feet ta This is too much weight for a bipedal. Thus, its foot is made in such a way that its toes are directly in-line with its ankle allowing it to brush off even the hardest of impacts while hopping.

The actual product :- Basketball atheletes can benef a lot from this foot design by implementi the above mentioned idea into the soles of their shoes.

This not only helps in reducing injury rate, but also affects the overall power output of the athelete, since basketball is all about jumping around.

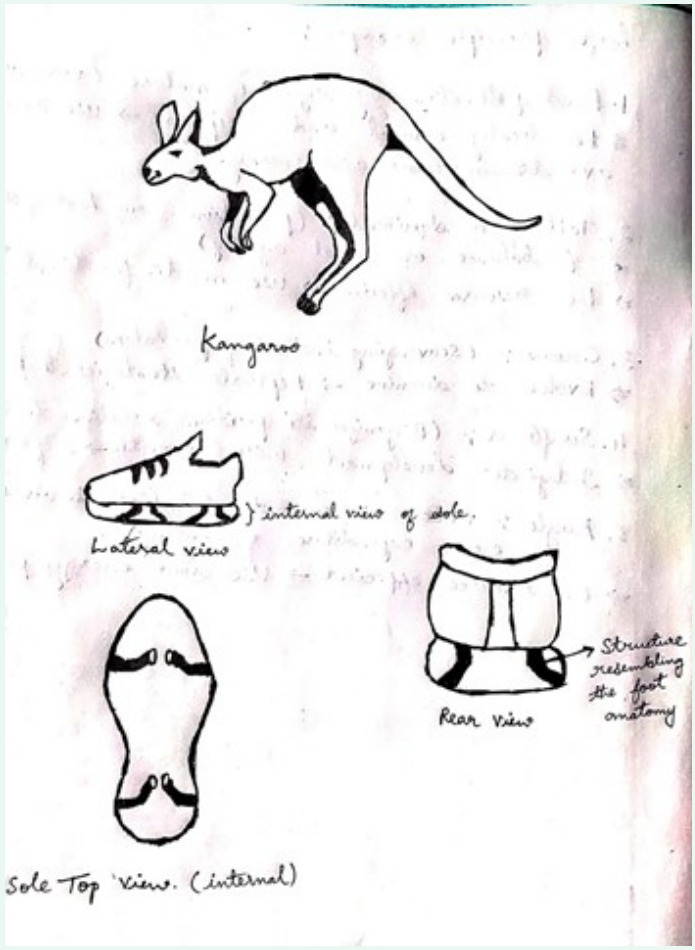



Photo by: Karen Pearson

Biomimicry Sharing Stories Project

Dorna Schroeter

Rhinebeck, New York, USA

Enrichment Programs, Teacher Training & Children's Stories

Image: Kevin Krejci/flickr

Ages: The student programs are designed for middle school, high school and college students, ages 8-21
Dorna's children's story, *The Story of Velcro* is written as a read aloud for ages 4-7. *The Story of Eco-Machines* is written for ages 9-12

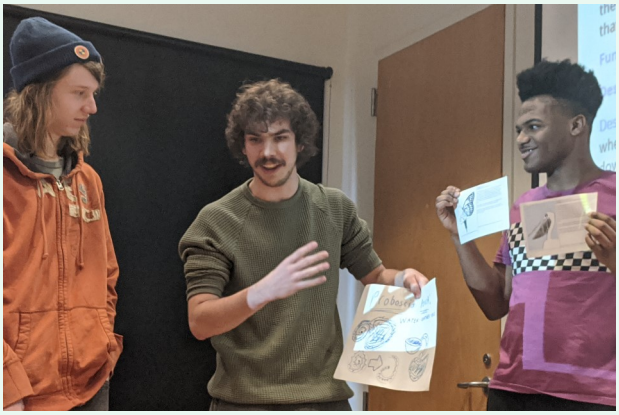
Contact Hours: The student programs ranged from 45 minutes to 2 hours depending on the school's schedule. The teacher trainings ranged from a half-day to a full day.

About the Program

Before retiring, Dorna was Coordinator of the Putnam Northern Westchester BOCES Center for Environmental Education (CEE) (BOCES = Board of Cooperative Education Services). In that role, she designed two biomimicry programs, *Introduction to Biomimicry,* a one-hour program for grades 3- high school and, *Biomimicry Design Challenge,* a 90-minute program for middle and high school students.

> **Description for *Introduction to Biomimicry*:** "What is the connection between a $100 bill and a beetle or a moth eye and a cell phone screen? These are examples of a rapidly growing discipline called Biomimicry which studies nature's best ideas and then imitates these designs and processes to solve human challenges. This program uses a PowerPoint and actual bio-inspired products to help students better understand nature as a source of ideas and the concept of bio-inspired design. Students participate in an exercise that asks them to match organisms with bio-inspired products. This is followed by a discussion of why the organism was used." Dorna received a lot of good feedback from both the students and teachers.

After middle school teachers asked for a follow-up program, Dorna designed a Biomimicry Design Challenge program. In the 90-minute program, students were walked through the design process using a biomimicry design Dorna had done as a model and then presented them with a design challenge around water—too much, too little, or polluted water. To enable students to complete the design challenge in such a short amount of time, Dorna developed a worksheet with a step-by-step process. She also gave them the EcoRise Inspired by Nature cards (https://ecorise.org/school-program/ecorise-curriculum/biomimicry-and-science/) that were used by the Biomimicry Institute for the Youth Design Challenge) along with an additional 4-5 more organisms cards she designed. The students then created their designs. "Although the designs were simple, it took them through the design process, gave them an opportunity to process what they learned, be creative and reached a deeper understanding of biomimicry."



What Else Is Going On?

Although Dorna has retired, she continues to offer these programs and has presented them for local environmental groups libraries and schools. She loves that the audience is made up of young people, their parents and even grandparents. People found the programs inspiring and they still talk with her about it.

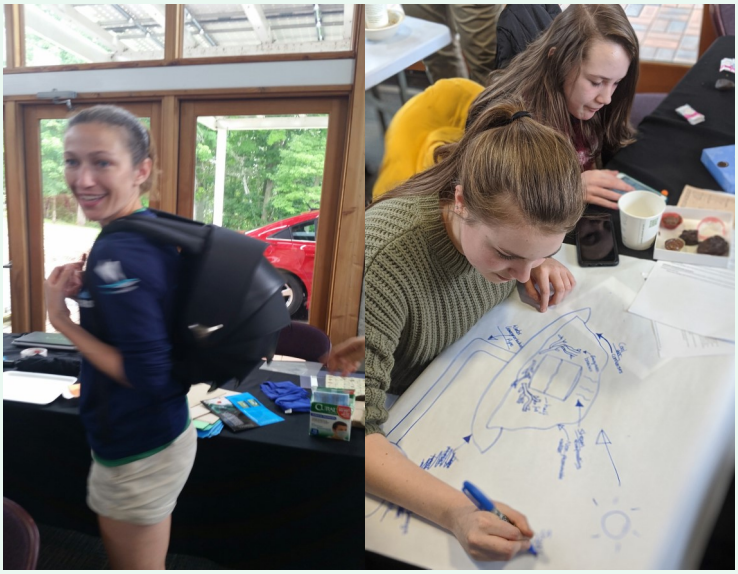
Dorna also does teacher trainings and has done several since she retired, for several other BOCES in New York State and one at the February 2020 YESS! Youth Climate Summit.

She's also working on a children's story series entitled, *How an Idea from Nature Changed Our World*. The first book, *The Story of Velcro* was written as literary support for the new science standards, which include a Performance Expectation about biomimicry for grades 1 & 2. The second book, *The Story of EcoMachines* is written for middle school. It follows real-life scientist, John Todd and is a real-life illustration of the application of the NGSS's Science and Engineering Practices, Disciplinary Core Ideas and Cross Cutting-Concepts. **www.anideafromnature.com**

During the pandemic, Dorna did a number of virtual book readings. She has a number of other topics in mind for future stories.

Source Of Nature Inspiration

The programs are short and indoors, so the inspiration mainly came from the pictures in the PowerPoint, any natural artifacts she brought in, along with her extensive collection of bioinspired products.



Wow Factor

"After teaching my one-hour Intro to Biomimicry to a 5th-grade class, a student came up and handed me a drawing she had done based on what she learned. Her grandfather has Alzheimer's and was always walking away from home and getting lost. My program inspired her to design "slug slippers". Like a slug, the slippers would leave a trail that her grandfather could use to find his way home."

Just before retiring, Dorna was asked by a group of parents in her community to help their children compete in the Biomimicry Youth Design Challenge. They met on Sunday nights. Using some of the material she designed, along with some of the Biomimicry Youth Design Challenge online content and AskNature, the group submitted a design for a permeable surface to address flooding and took first place in the middle school division. The prize money was used to create a traveling biomimicry exhibit for the local library system. After it has been on display at their library, the plan is to let other libraries borrow it.

Any Changes For Next Time?

"I teach it differently every time!" Dorna always adds new information and bioinspired products when she learns about them. She does need to figure out how to do all that she wants to do in 1-2 hours.

Preparation For Teaching Biomimicry

For the Youth Design Challenge, both Dorna and the parents realized that the parents couldn't have done it by themselves. She feels people need some introductory background, such as one of The Biomimicry Institute's online course, using the Youth Design Challenge materials, or taking teacher workshops.

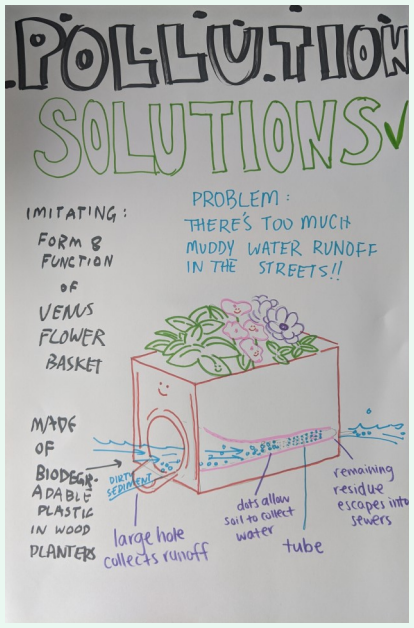
Dorna learned about Biomimicry on her own. She was fascinated when she heard Janine Benyus speak at a conference and she started reading. She organized a summer camp and brought in Tom McKeag to teach it, which gave her a chance to learn from him. She has also taken a number of workshops put on by the Biomimicry Institute and the Biomimicry Networks. She has also attended a number of Biomimicry summits. And, she is still learning.

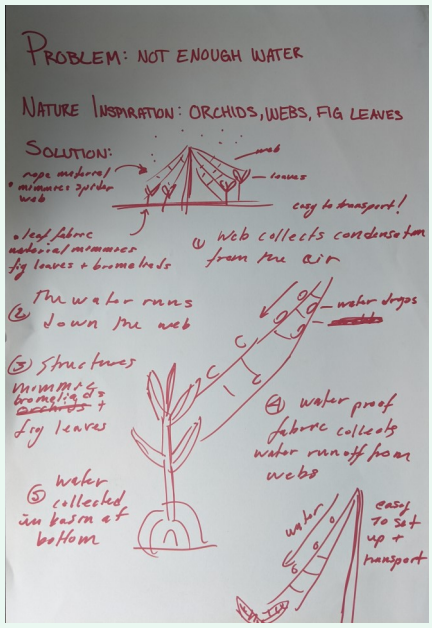
Materials Used

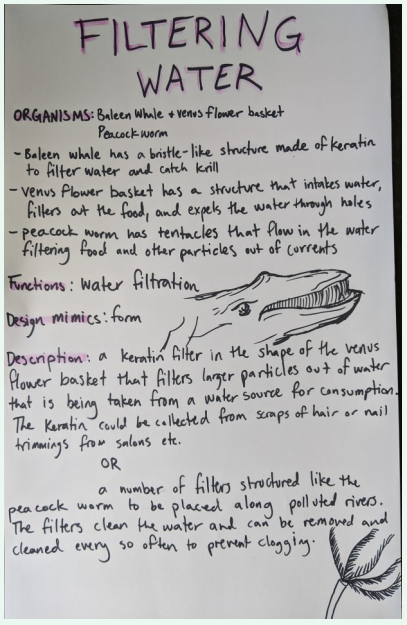
The strongest part of Dorna's programs involves the actual bioinspired products (and some images) that she has gathered. "*I was way out ahead in terms of getting products. I got funding to build a biomimicry kit for teachers in our to region borrow. Although I had to buy some, like the Pangolin backpack, most companies were very willing to share their product with me".* These days, companies aren't giving out as many samples; most have to be purchased, although they are happy to provide fliers and color images. Other materials she has used were from the Youth Design Challenge and Learning from Nature.

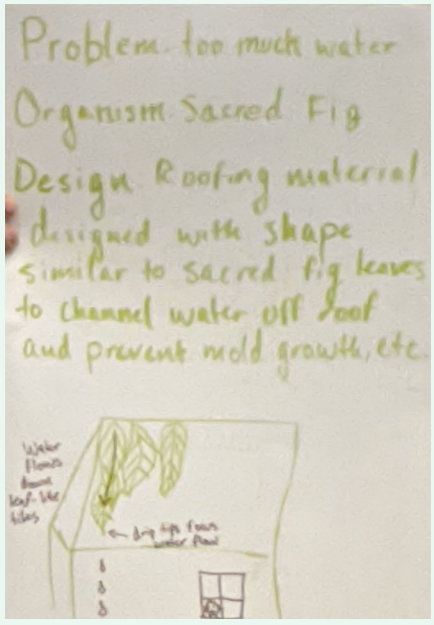
Meeting The Standards

At the time Dorna was at CEE, the programs didn't need to meet standards. However, now that there are Performance Expectations for biomimicry in the U.S. Next Generation Science Standards, the staff at her former program have developed new biomimicry programs to align with and support the new science standards.










Clay Banks via Upsplash

Biomimicry Sharing Stories Project

Jasmine Smith-Gillen
Providence, Rhode Island, USA
Roger Williams Park Zoo
After-School Program and Summer Camp

Image: Kevin Krejci/flickr

Ages: 11 - 18

About the Program

Both a Brown University summer program for middle and high school students, and an Advanced Course Network afterschool program series.

Materials Used

Ask Nature online content - asknature.org, 2016 EcoRise Youth Innovations & Biomimicry Institute

Wow Factor

The most inspiring moment is witnessing the students innovate on their own. I have appreciated their perseverance in the process of working out the design constraints, both in theory and in physically creating the model. They have communicated that this has opened up a career pathway for them and given them hope.

What Were Some Challenges?

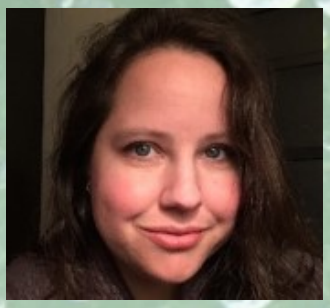
The leap from the design question function to how nature performs that same task is a challenge for these students. Most students struggle with the abstract nature of multiple correct possibilities, being so accustomed to one right answer. Guiding them outside their comfort zone to allow space for open-ended inquiry and critical thinking is the biggest stretch. Also, encouraging brainstorming of multiple solutions, as some students come in with an idea of what they want to design already, without considering the purpose of their solution.

Other Related Programs

Also offered in the summer is two weeks of day-long programming and a twelve-week afterschool program that meets two days a week for two-hours. In both cases, the program aims to develop critical thinking skills, communication, teamwork, and perseverance. They culminate in a showcase presentation to peers and adults, of the process and the final model solution.

https://www.the413mom.com/the413mom/2015/10/road-trip-worthy-roger-williams-park-zoo-providence-ri.html

Roger Williams Park Zoo/Facebook



Biomimicry Sharing Stories Project

Jennifer Breslin
Rhinebeck, New York, USA
Special Program

Image: Kevin Krejci/flickr

Title of Program: Youth Design Challenge: The Futuristas

Ages: Five youth ages 8-11 in 5th & 6th grades

Contact Hours: The group met on Sunday evenings beginning in early November for a total of 18 hours.

About the Program

This was a private group formed by a group of parents and students that were very interested in biomimicry and the Biomimicry Youth Design Challenge. The group met at the local public library on Sunday evenings. This was done in an informal setting so no pre- or post-assessments were done. However, the increased understanding of biomimicry and design was evident in two post-presentations done by the students. A biomimicry educator lives in the community agreed to help with the program which benefited us greatly.

After a particularly heavy winter which was rain instead of snow, due to climate change, they kids and their parents were asked to walk around our village to observe the impact of the heavy rain. The kids (and their parents) noted the heavy flooding and as a result chose flooding as the problem they wanted to address.

Our program included:

- Learning about biomimicry and participating in a mini design challenge
- Learning about Climate Change through a local environmental educator
- Determining what problem we wanted to address
- Looking for a local example of our problem by walking around our village
- Researching and contacting experts to meet or talk with
- Determining what biological functions we should research
- Learning how to turn a biological strategy into a design strategy
- Going on a field trip to Bard College to meet with the Sustainability Director and to learn about and tour their permeable parking lot.
- Participating in solution design brainstorms and drawing sessions

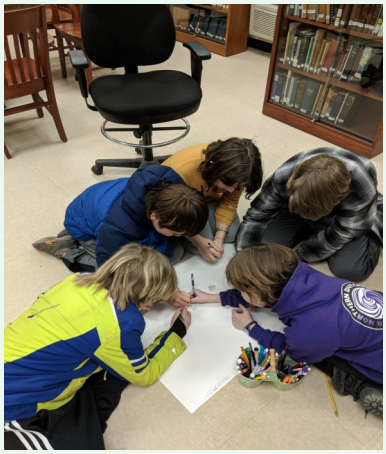
Students built and tested two different prototypes using different placement of the substitute materials for cork, sponge, and mat. They looked at variables like flow of water, quality of water, storage of water and the integrity of surface. The kids loved this exercise!

Materials Used

The biomimicry educator introduced the group to biomimicry through her program material and introduced the participants to the design challenge concept through a mini design challenge she had created for her programs. This was extremely useful in having a preview of the process and helped the kids move forward more effectively. Some of the Biomimicry Youth Design Challenge online content was used, but because this was not a school program and they only met once a week for 1.5 hours, they used only selected material.

The interactive sessions such as when they did the mini design challenge and the building of the prototype were the most successful.

The resources on AskNature were a good starting point for biological function, but then to really understand it, they researched further using on-line resources. Unfortunately, they struggled to find additional information that was at a level they could understand. Most of the material was too advanced academically for this group. For instance, they were interested in how plants filtered for toxins but couldn't really find accessible research for this and had to change course. Perhaps this could be addressed through new content on AskNature, links to age appropriate external learning resources on biology, ecology, etc, through facilitated access to experts (who would volunteer their time to answer student questions), or through engaging with local teachers or experts.



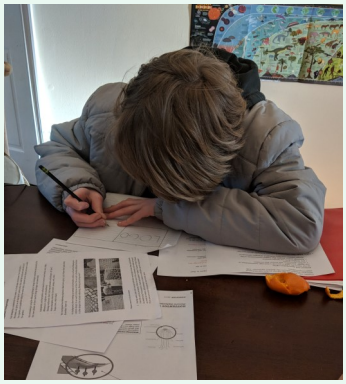
What Were Some Challenges?

One challenge they had was fitting everything into the small amount of time we had. They had to give homework to the team, but because this was not a school-related program, it didn't always get done so it would have been better to do most of the work in the sessions.

"We were fortunate to have a biomimicry expert with us and it would have been more challenging without her knowledge and support."

Source Of Nature Inspiration

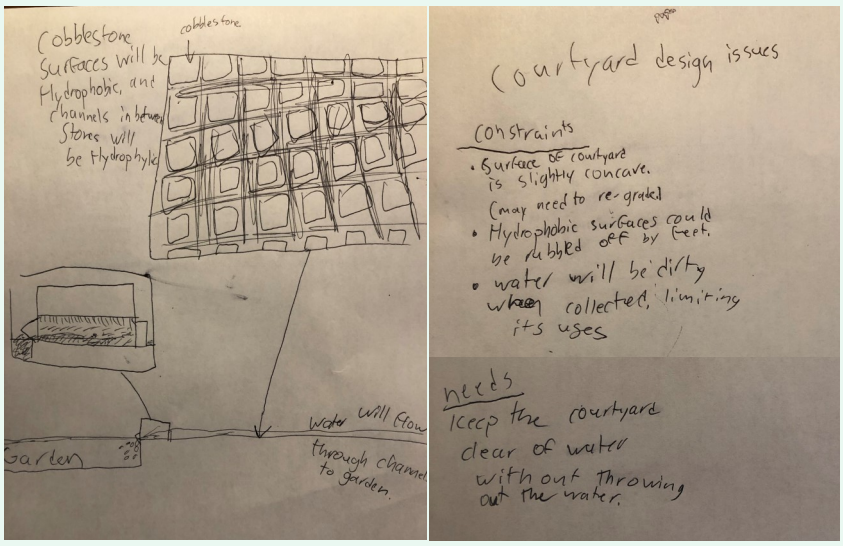
After brainstorming (which involved good lateral thinking) and determining what functions were need for our design, they researched online organisms that exhibited those functions. They began with AskNature, but used other sites as well.



Wow Factor

Our team won the middle school division for the 2018-2019 year. This was incredibly exciting and received some great local publicity. Some of the kids also participated in a green expo in our town and in Drawdown Learn conference at the Omega Institute with our local biomimicry expert. At each they talked about their work and the value of biomimicry. This gave them a further sense of pride and helped them reinforce their knowledge by continuing to explain it to others.

The kids had an incredible experience and got a good sense of how biomimicry works and its potential. They were hoping to really "solidify" this, with some reinforcing follow-up experiences to keep them engaged, such as a biomimicry club/YDC at the library but that has not happened due to the virus. However, once people are able to come together our library received a grant to run an inter-generational biomimicry mini challenge. We hope to engage more young people through these when they go forward.



Lessons Learned

For this age group, the scope of the challenge was a bit much in terms of conveying so many concepts and background learning, as well as attempting to go quite deep on the science and technical side. The organizers had hoped to get this into the school through demonstration but it seems to be too intensive a challenge to integrate into the curricula in a public school that lacks real project/place-based learning. However, in follow up presentations on biomimicry to young audiences, there was a lot of interest. The ability to deliver varied biomimicry experiences to younger age middle school students in environments beyond the classroom would be valuable and worth developing.

Biomimicry Sharing Stories Project

Kumar Neeraj
Bihar, India
Durdih Village, Khetee Organization
Community Program

Image: Kevin Krejci/flickr

Title of Program: Biomimicry in Total Immersion: Nature Re-connection Guaranteed!
Neeraj Kumar, Khetee organization, Durdih village, Bihar, India
The non-governmental organization, Khetee has a collaboration with reNature, an organization that supports Agroforestry programs over the world for regenerative agriculture. Learn more about Khetee (https://www.facebook.com/khetee.org/)

Ages: 10-15, typically after school programs

Group Size: Community group of 20 to 30 kids

About the Program

Khetee works with community youth and farmers on the awareness, training, and implementation of agroforestry models. Located in Durdih Village, Northern India, the organization is transforming the prevailing unprofitable agricultural system from monoculture farming to regenerative agroforestry.

For Kumar, agroforestry is a direct application of Biomimicry to agrosystem challenges. By coming to Khetee, community members learn the best farming and regenerative practices inspired by ecosystem functioning (with all interactions within the soil and among plants and animals).

Source of Nature Inspiration

By being outdoors, kids learn to stay connected with nature. They observe and reflect for example on how:

- A rich soil can restore groundwater supply or can keep the soil in place.
- A 6-foot hedge can support local fauna (insects, birds, butterflies) and help in many other ecosystem services.
- A tree's shadow can provide air conditioning in the hot summer season.
- Flowers' scents can attract bees or repel pests.
- Plant biodiversity can be pictured through all shapes of leaves.

Wow Factor

"Doing is learning for kids. Children feed their curiosity by taking time with Nature, spotting biodiversity around them (especially insects and birds) and practicing their care for the land. Some of the birds were not seen for many years and now that our land has been partly restored, they are coming back which is such an excitement for kids to witness."

By developing this strong sense of connection with Nature, children were eager to participate to the Global Youth Strike against Climate Crisis initiated by Greta Thunberg on March 15, 2020. Kumar helped them for a whole month in preparing slogans, making posters and practicing local songs for this event. Videos of the strike were shared with the BBC (https://www.facebook.com/470911516262605/posts/2361185260568545/), which combined a lot of them from all over the world. This was a unique moment for the village, which couldn't have happened without this sense of nature connection promoted by the organization.

Preparation For Teaching Biomimicry

Kumar came across Biomimicry by reading Jeanine Benyus's book. Since then, he has been using AskNature to look for more examples and to share them with kids.

Materials Used

Few materials are needed, as outdoor activities are favored. Videos are used to explain science behind solutions offered by nature. Children also have access to a library with Nature books.

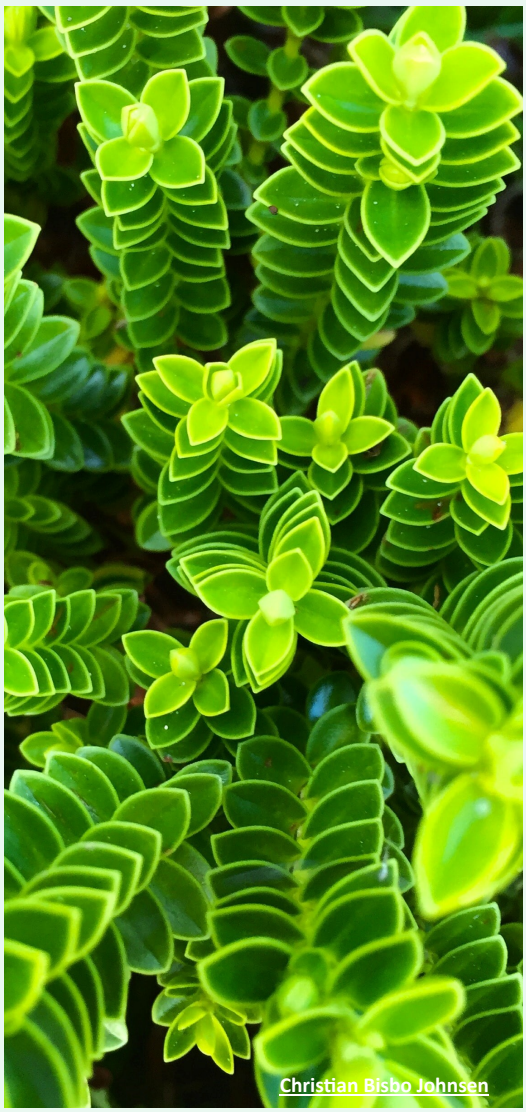
What Were Some Challenges?

"In rural communities, people do not take things like nature education seriously. For them, education means books, school, classes, coaching and homeworks Even teachers in the schools are accustomed to daily school curriculum and textbooks. So they don't give much credit to such activities at first. No youth wants to do farming and even when one goes to agricultural college, he ends up becoming a salesman for big agrochemical company. Children think that farmers are illiterate and that they don't know anything. But so many basic principles of Nature are not there in our conventional education and society."

Kumar wants to make farming fashionable to kids so that they value farmer's skills and knowledge to build the only possible future for agriculture regeneration and climate change mitigation (silvopasture **https://drawdown.org/solutions/silvopasture** and regenerative agriculture **https://drawdown.org/solutions/regenerative-annual-cropping** are #9 and #11 respectively in Project Drawdown's list of *Drawdown: The Most Comprehensive Plan Ever Proposed to Reverse Global Warning*. **https://drawdown.org/** Penguin Books Paperback – Illustrated Edition, April 18, 2017")

Any Changes for Next Time?

In accordance with local government and school, Kumar is developing a curriculum that put in parallel mainstream education and ecosystem learning such as chemistry and plant communication, mathematics, and land management. It is about studying patterns found in the natural world together with a scientific approach. Engaging more schoolteachers is something that Kumar tries to encourage so that Nature Education becomes more recognized as a basic and essential need in our society.


Christian Bisbo Johnsen

Biomimicry Sharing Stories Project

Dr. Miranda Wilson & Jen Marie Wentzel
Atlanta, GA
The Westminster Schools, K-12 Independent School
Special Program - High School January Term Program

Image: Kevin Krejci/flickr

Title of Program: Biomimicry

Ages: This class is open to freshmen and sophomores.

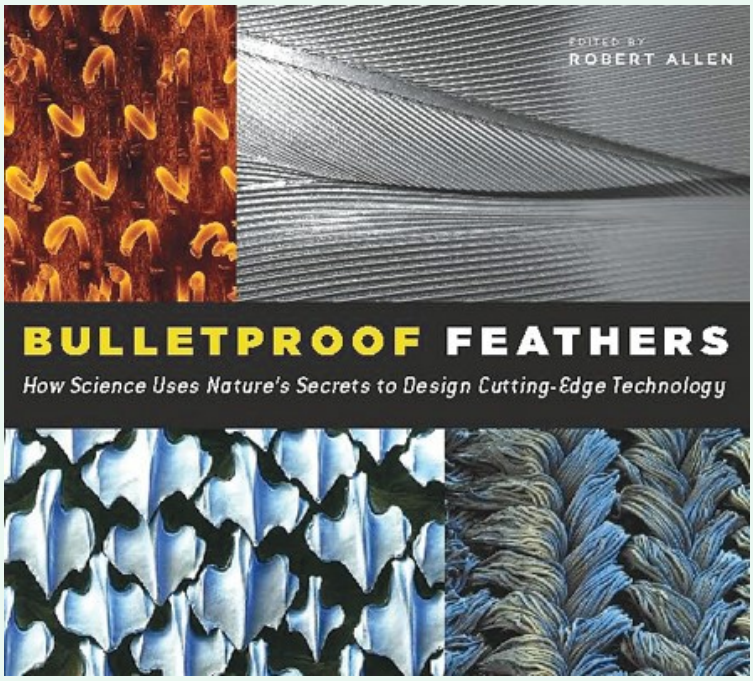
Contact Hours: It was a 3-week program, meeting Monday – Friday. There were approximately 60-70 contact hours.

About the Program

This January term program was co-designed and co-taught by Dr. Miranda Wilson, a science teacher, and Jen Marie Wentzel, an art teacher. One of the school's criteria for a January term class is that it be completely interdisciplinary. Each fall the faculty propose classes that need to be approved. The school hosts a January term class fair to enable students to learn about that year's offerings. There were 15 students in the class.

Credit

Students receive a full semester worth of credit, but couldn't miss any days of class. The grade didn't go into their core grades or GPA but it gets put on the student's collages transcripts.



Materials Used

Textbook: Bullet Proof Feathers edited by Robert Allen was used as a textbook because it was perfect for that grade level with lots of diagrams and pictures and examples.

On-Line Databases: The school has a great library and research librarian who helped students learn how to access peer-reviewed journal articles. They brought the librarian into the classroom to teach the students how to use databases effectively. Time was spent teaching students how to find articles using AskNature as a starting point. The teachers both agreed that freshman and sophomores are not quite ready for this type of in-depth research but did well with help and experience. The biology teacher, Dr. Wilson has a research background and she felt her research experience was very helpful.

Labs: They also did some labs to help with some of the concepts. For example, a self-assembling molecule lab using bubbles and a lab building Tensegrity structures with popsicle sticks.

Biomimicry Institute Material: The biomimicry design spiral was used as a framework for designing the course. The program included some of the Youth Design Challenge lessons like the abstract design strategies, biologizing the question and function, and context activities. AskNature was used as a starting point for research.

The videos available on the Biomimicry Institute's Design Challenge website of previous design challenge submissions were very helpful to give students an idea of what their videos and final products were expected to look like.

Other: They also supplemented with activities from the Center for Biological Design (CBD) at Georgia Tech, particularly when they went on their field trip to the Atlanta Zoo because CBD had some good materials that correspond to the zoo's exhibits.

Program

Introduction: The program started with a deep dive into climate change. From that, the students pick what problem they were most interested in trying to solve.

Grouping: The students were able to choose their own groups because the teachers felt that because they were going to be working closely together for 3 weeks, they should be able to pick people they wanted to work with. But they didn't let them pick their groups until the 4th day after they had spent time doing an exploration of personal qualities and skills, asking questions such as:

- If you think you are a science person or an art person go to one side of the room or the other.
- Do you think you are more creative or more fact-based?

When choosing their groups, students were told to think about their own skills and weakness so that they chose people of different strengths and weaknesses. They also suggested that they chose people who were creative, but could also get work done.

In the end, the group that did well had a good mix of qualities in their group. The group that didn't do so well had all very similar types of students.

Field Trips: They did multiple field trips, to the Atlanta Zoo, Georgia Aquarium, Atlanta Museum of Design, Center for Biological Design at Georgia Tech and the Chattahoochee Nature Center. (FMI see Appendix)

At the zoo and aquarium, they looked at animal adaptations to help generate design ideas. The nature center had a biomimicry class (see below) in which they went into nature to look at adaptations. Back inside they gave each student parts of animals such as beaks, feet, fur, etc. and did a mini design challenge. They also did a drawing class to help students with their drawing and design skills. This gave the students a preview of what they were going to be doing.

At the Museum of Design, they looked at sustainable buildings to see if some of the ideas they had been thinking about could be used in the design of sustainable buildings. The museum was working on a new exhibit about biomimicry so the curators came to the students final design presentation at the end of the term. They were so impressed that they asked to incorporate some of the students material into their exhibit.

At the Georgia Tech Center for Biologically Inspired Design, they went to the labs where they are doing research in biological design and biomimicry. They were able to see robots, virtual reality and their chemistry labs where they were working on the design of new materials.

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Teacher Reflections

Co-teaching this class with an art teacher and science teacher was very helpful because they each brought a different set of skills, the science teacher not being familiar with design and the art teacher was not familiar with the science so it was really nice to be able to tag-team when the students were struggling with either component. This created an environment of exploration and learning together. Working collaboratively as they did and, telling the students that this was the first time they were teaching this, created a "we are all learning this together classroom environment rather than, I am the expert and was very helpful when issues came up."

It might be hard if someone doesn't have a biology background because they may not understand the science behind some of the biological examples. But depending on the grade being taught, a technological understanding of a lot of the science behind it may not be necessary.

Final Project: The student's final project was a mini design challenge. That included a video about their design, a model of their design, a scientific explanation of the animal adaptation as well as how their animal adaptation was like their design and a presentation to the full class who provided critiques to each group.

Assessment

Two rubrics were used for grading, an art rubric used by the art teacher in her classes and a science rubric. These rubrics assessed how much students understood as well as how much effort they put in.

What Were Some Challenges?

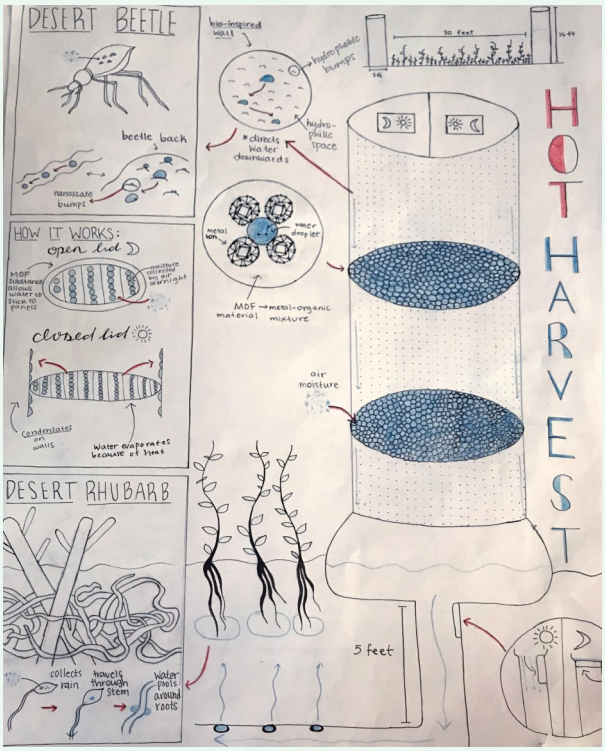
One challenge was the students ability to come up with ideas. To help them move through their creative blocks, a lot of class time was spent on brainstorming. They had the students put ideas on post-its and post them around the room. Other groups were asked to provide feedback. At times the students seemed to really enjoy giving and receiving feedback and ideas of what might or might not work, although it was also hard for them as they didn't always like hearing the critiques. The teachers felt this was a good life lesson that will help them receive feedback in the future. Homework assignments focused on coming up with ideas were also given.

Wow Factor

This is the first time the class has been taught and the students seemed to really enjoy it. During their trip to the Atlanta Museum of Design, the students got to interact with the curators of their new biomimicry exhibit. The class invited the staff to see the final presentations and one of them told the instructors, "I was so inspired by your students and can't wait to see their final presentations!"

Creating prototypes enabled the students to learn life skills. One female student even learned how to use a drill and a jigsaw during the production of her design.

Pawel Czerwinski via Upsplash



Hot Harvest Design

Hot Harvest Prototype

Going through the process helped students understand that it is hard. The teachers set the stage for this by telling them that being creative is really hard and that even adults struggle with it. The teachers hope that this is a life lesson they will remember when they are asked to extend themselves in the future and hope that the process will be a bit easier.

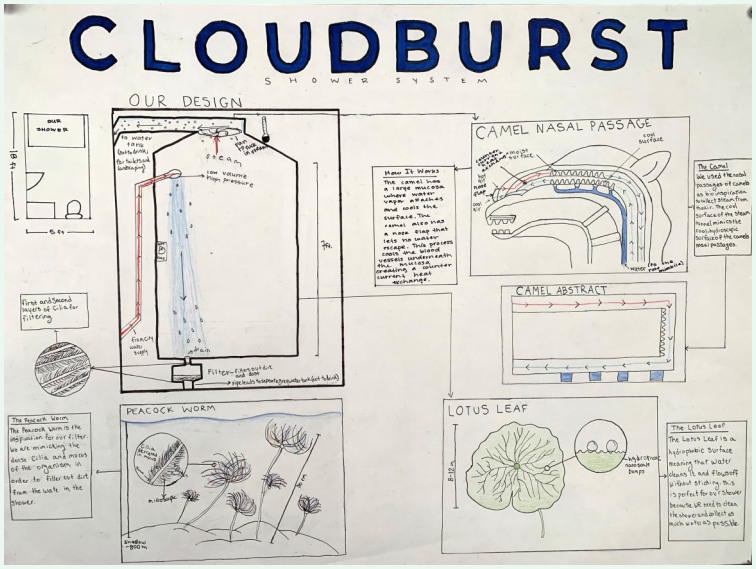
One of the lessons that the teachers are going to carry back to their regular curriculum was helping students understand that failing is OK, that lessons are always learned from something that didn't work and that there are always lots of other ideas to come back to.

Lessons Learned

- Feedback from the students indicated that they really just wanted to dive into a project and have more time to explore. So, they will change the timing and organization by starting the class with an introduction to biomimicry and some basics behind it and then go on some field trips to explore. They are going to relook at when to schedule the field trips because some turned out to be better at the beginning and some at the end.
- One of the hardest parts was coming up with ideas. The teachers wondered if their juniors and seniors who had already had biology would have been able to get into the process much more easily, although they didn't know if they would have come up with better designs.
- They will also work more closely with their research librarian to help students better access data information sites.
- Although the teachers are not in charge of what grade level this course will be offered to, they plan to recommend to the January-term coordinator that the course be offered to juniors and seniors where there is a higher level of interest rather than freshman and sophomores. The teachers speculate that the lack of interest on the part of the freshman and sophomores is because they hadn't been exposed to biology since 7th grade.
- Based on feedback and conversation with the students enrolled in the course, the teachers think that the students were more interested in the design rather than the biological.
- There is some value in having a working knowledge of biology and biomimicry. If one doesn't, it might be hard to understand the science behind some of the biological component.

Recommended Resources

Nanonews is geared toward middle school and lots of cool stories about nano products and biologically inspired design in relation to nanoscale.



Cloudburst Design

Cloudburst Prototype

Appendix

Chattahoochee Nature Center
Program Title: Engineered from Nature
How can nature help us solve human Education Program problems? Engineers use the adaptations of plants and animals to design products that improve people's lives. Students will be introduced to biomimicry and after meeting one of CNC's non-releasable raptors, will apply the adaptations of raptors to engineer solutions to real-life issues. **www.chattnaturecenter.org/education/schools/high-school/**

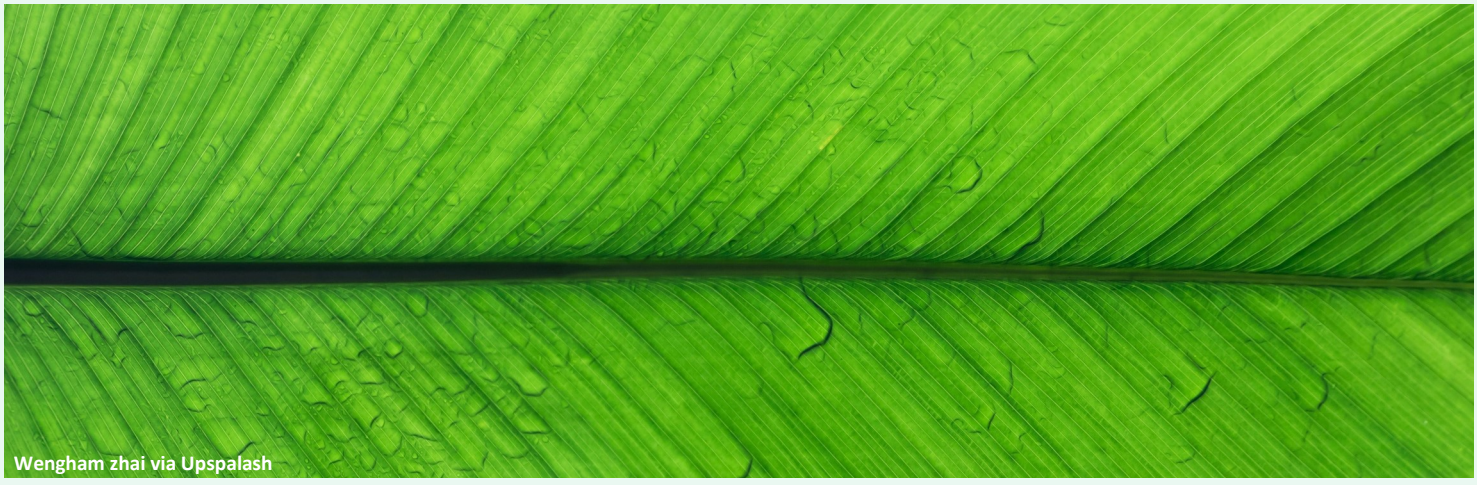
Learning from Nature Exhibit: The Future of Design
Demonstrated how designers are finding sustainable solutions to human challenges by emulating nature's time-tested patterns and strategies. The exhibition will invite visitors to get involved in learning about biomimicry and designing based on ideas drawn from nature. Learning from Nature exhibit: **www.museumofdesign.org/learning-from-nature**

This exhibition was curated by Veronica Klucik and Malaysia Marshall in collaboration with The Biomimicry Institute and with the help of Exhibition Advisor, Jeannette Yen, Director of the Center for Biologically Inspired Design at Georgia Tech. Exhibition design by Susan Sanders.

Atlanta Museum of Design **www.museumofdesign.org**

Georgia Aquarium **www.georgiaaquarium.org**

Center for Biologically Inspired Design
Georgia Tech Center for Biologically Inspired Design works with Emory and Georgia State and received a grant from NSF to help design curriculum training for high school teachers and offer a summer program to teach them how to teach biologically inspired design in their engineering classes. **www.cbid.gatech.edu**


Wengham zhai via Upspalash

Biomimicry Sharing Stories Project

Mouna Chamariq
New Rochelle, New York, USA
Murray Avenue School
After-School Program

Image: Kevin Krejci/flickr

Ages and Contact Hours: Ages 6-14; 1 hour per week for a semester
Group Size: 10 kids with two educators

About the Program (ran from 2006 - 2009)

The after School Program is named *"Eco-Programs - Opening New Horizons for Children*". It covers important aspects of sustainable living to stimulate children to think out of the box and to give them the tools to be active members in the community. They presented four programs to children to help them understand the inspiration of nature in different areas:

- Nature & Architecture: how nature inspires architecture around the world. Eco and sustainable architecture, local materials, local plants, local workers
- Eco Design: how waste is dealt with in nature and nature inspired packaging.
- Reading labels: The ingredients of consumable products and their impact on the planet and our health, using and learning how to read them.
- Sustainable living and multiculturalism: how to build environmentally responsible housing and how to live sustainably with examples of traditional communities from around the world.

A Biomimicry theme, which is a design from Nature that could be emulated, was studied for three to four classes. Ex: colors, nest, architecture or shelter in the wood. The first class was used to introduce the subject; the second one, to observe resources from Nature and discuss about them in terms of Biomimicry (how Nature designs things?). Third and fourth classes were used for the kids to build their models.

What Were Some Challenges?

"For some kids who were more in their head, doing models was more difficult, so we helped them. For others who were more creative, it was kind of natural."

Source of Nature Inspiration

Personal resources from Nature (from countryside, forest, beach) as well as others found by the kids prior coming to class (this was their homework) were used as inspiration. Some kids brought a lot of different small things; others tend to get only few bigger things, depending on their curiosity and connectivity with the Natural world.

Wow Factor

"All kids really loved the hands-on. It was super-important for them. They could loose attention when you presented something, but as soon as you gave them a sample from nature to look at or asked them to build a model they concentrated better and loved it. Designing and building models boost children creativity as well as social interactions. They loved sharing their ideas with their peers. The multidisciplinary aspect of Biomimicry helps open their mind and welcomes creativity." Models were exhibited at school and presented to the parents. All kids were very proud and happy to speak about their model.

Some feedbacks they got from the parents included "after the after-school classes, my son feels a passion about being an architect and protecting nature" and, *my daughter likes to spend more time outside to gather materials and observe nature before coming to your class". "

Preparation For Teaching Biomimicry

Mouna is a LEED certified interior designer and designer. Architecture brought her to Biomimicry and most specifically a book on Architecture inspired by Nature. When Mouna thought of setting up this after-school program, she contacted the Biomimicry Education Network via phone calls and emails, to be as close as possible to the experience of Biomimicry. She found for example, support on how to address the Biomimicry theme with key questions to ask (How Nature design things? What is the function of this design?).

"Nature is generous and it was very supportive to find people [from the BEN] eager to help with similar generosity". AskNature.org was also essential for her preparation.

Materials Used

Resources from the Natural world were observed with sometimes magnifying glasses. For the construction of the model, *"as we were also working on a project for recycling in our town, the kids were bringing from home reusable (non recyclable) elements to do their architectural model for each Biomimicry theme."*

What Will You Do Differently?

This afterschool program was conducted for three consecutive years about 10 years ago. Mouna is now a yoga teacher and she is actively (and generously!) sharing a yoga philosophy among different communities. As she reflects on her story, she knows that she would probably do things differently if she had to. Architecture would maybe not be the driver for approaching sustainability and our needs for inspiration from the Natural world.

"Educators with a passion or a special interest will bring their enthusiasm with them and will find their way to relate it to Biomimicry as there are many entrance doors. Same for kids: some registered to the program because they loved Nature, others came because of architecture. It was for everyone. And then they discovered the beauty of Nature. So you don't bring them only with Nature. To mix Nature and a subject is very attractive."

Biomimicry Sharing Stories Project

Sherry Ritter
Montana, USA
Summer Camp

Image: Kevin Krejci/flickr

Title of Program: Biomimicry: Design Like a Shark

Ages: 9-14

Contact Hours: This was a one-week camp, Monday – Friday from 9-2:30. Friday was the day each group presented their design in a short presentation for parents and another of the camp groups.

About the Program

This camp was a partnership between a non-profit called Stevensville Coding for Kids and the local school district. It was originally designed for the middle school level, but a 16-year-old really wanted to attend so he was admitted. Although the age range could have created challenges, he loved plants and asked to be included despite his age, so it worked. Last year there were eight participants and that was a nice number to begin with. They did well working independently perhaps because half of them were home-schooled. The camp could have taken up to 12 students.

The program went through the biology to design process, including daily trips with our journals to a nearby garden and a 1-day field trip to a forest. At the end, the eight participants worked in teams of two to come up with a biomimetic design. During the garden field trips, a favorite activity to get them understanding the meaning of "function" was to have them brainstorm the functions of a roof, then of their hands, then of a maple seed.

The first activity they did on the all-day field trip was a journaling activity. Then they did the Genius of Place, looked for patterns in nature, and talked about some of Nature's Unifying Patterns.

Martin Oslic via Upsplash

For the Genius of Place activity, the kids had to find an organism that they were willing to just sit and watch for 15 minutes. Sherry warned them ahead of time that just sitting and watching something for 15 minutes was going to be hard. Real learning only begins after 10 minutes because that's when they have gotten over the obvious and have to go deeper. Although she had been told that kids that age wouldn't last 10 minutes, not one of them had any trouble with the 15 minutes .

They weren't allowed to draw or take photos during that time, just observe. They were told when the 15 minutes were up and then they had to fill in the information on the worksheet they were given and draw their organism. When they were done, they placed a flag by the organism so it could be found later. The questions asked on the worksheet were:

- What do you think your organism is? If you don't know just briefly describe it and sketch it.
- Briefly describe its natural history, what you observed about the organism, and how it interacts with its environment.
- Think about some of the strategies or adaptations you noticed.
- What is the challenge the organism needs to solve using those strategies?

In preparation on the first day of camp, Sherry had gone over some keywords such as strategies, adaptations, organisms, etc.

After the group came back together, they did a tour of every organism, talked about who might be interested in emulating this strategy and if they could think of a possible design based on this strategy. This is where Sherry's feedback came in to guide them to this idea of learning from nature and applying it to a design. The day in the field was important and this activity was valuable because they had not been given a biomimicry lecture.

Materials Used

"On AskNature, I used AskNature Nuggets, the VOX video from AskNature Resources, and the students were shown how to navigate through the AskNature site." For print and other materials, Sherry modified materials she used with adult workshops: Function Junction activity, Genius of Place activity, and she created a matching game.

The **Function Junction activity** can be found online at: **https://asknature.org/resource/function-junction/**. It is a simple, hands-on activity that gives students practice in identifying function in the biological world and relating it to human design challenges.

Genius of Place activity came from a workshop Sherry taught in Costa Rica. For this group, She scheduled at least 1.5 hours to complete it. Sherry emphasizes to adults when doing an adult workshop that if they can't schedule 2 hours, don't do it!

In the **Matching Game**, there were 10 sets of 4 cards. Each card showed an organism, an adaptation, habitat, or design. The students worked in small groups to match sets of cards.

The matching game cards, the AskNature cards, AskNature Nuggets, and various Nature's Technology Summaries are resources that Sherry has gathered over the years and were used as inspiration for their designs.

Wow Factor

The students were very engaged. *"I was most impressed with how children from the ages of 9 to 16 could sit still and just observe one organism for 15 minutes."* A friend told Sherry that her granddaughter came back every day excited over what they had done.

What Were Some Challenges?

One of the things that Sherry noticed was that students had a hard time adapting to the creative processes instead of just learning facts. They had a really hard time abstracting animal adaptations as a first step to the design process.

The room they were assigned to use during the day was a computer lab and it was hard to keep the students focused on what they were supposed to research without straying off into watching videos. Another challenge was the distance to natural habitat; the garden they visited was fine but so many plants were not native and they evolved in very different environments.

Any Changes for Next Time?

Sherry would prefer to not be placed in the computer lab during future camps. It wasn't really good for exploring natural artifacts and kids were just too focused on the computer.

The director of the camp program, who is not a biologist, questioned the need for a field trip when planning the next summer camp because it creates some liability problems for her nonprofit. However, Sherry convinced her that the field trip is so important that they need to find a way to do it.

*"I was reluctant to have the students make models because I am not good with them myself, but I found a great resource on AskNature Resources: Biomimicry Design Challenges by Technovation Families (**https://asknature.org/resource/biomimicry-design-challenges/**). Participants make models of, for example, a root system or a pine cone. A materials list is provided for each model. I'd like to have them make models of their projects rather than PowerPoints. That's another way to keep them off the computers except for research."*

Biomimicry Institute's Youth Design Challenge

"We did not submit anything last year but I might have the groups do the design challenge and then submit their designs the following spring."