STEAM NATURALLY RISES

Innovation inspired by biomimicry

Nature's aesthetic designs and engineering feats are elegant models to mimic. STEAM cross-curricular, standards-based projects that are grounded in nature elevate student engagement, challenge learners to solve real-world problems, and naturally tie together science, technology, engineering, art, and math standards.

Empowering Students as Scientists, Engineers, Mathematicians, and Artists

Nature's solutions have been models for and are replicated in medical technology, architecture, interior design, fashion innovations, and ecological restoration. Students who observe nature across the curriculum discover amazing aesthetics and cite science, math, engineering, and technology evidence to support their findings. They form hypotheses about nature's intentions and potential applications using cross-curricular vocabulary and overarching ideas such as patterns, proportions, unity, balance, and emphasis. Natural elements such as color, line, and shape inform their designs. Students see parallels in underlying concepts and how superbly nature is engineered. Later in the project-design process, when they use natural inspiration to construct prototypes, they realize that the creative processes and engineering processes are symbiotic, complementary, and nearly identical.

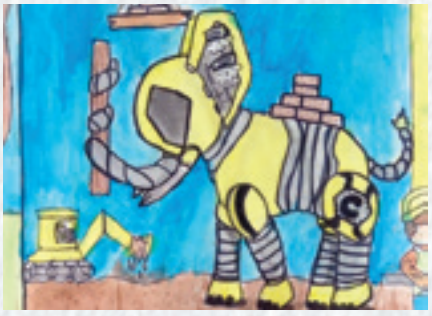
Realizing that the study of innovation must include art and engineering, principal Holly Dalby of Circle Cross Ranch Elementary in San Tan Valley, Arizona, made a firm commitment to infuse art into their STEM program. A student group that serves as the school's chief science officers (participating in a statewide program focused on preparing future innovators) recently became the school's chief creative officers, too. Students compare and contrast how the scientific process parallels the creative process. "They see that both are based on inquiry, observation, citing evidence, designing and creating prototypes, presenting solutions, responding to feedback, and revising for improvements," Dalby explains.

Circle Cross Ranch Elementary students connect the dots between problems and nature's solutions as they design hummingbird robots and code them to tell stories. Their learning journey includes studying habitats and animal behavior patterns. They assess their knowledge with rubrics. "When students self-assess, they quickly realize they are capable of more than they originally thought. Their innovative excellence surprises them," Dalby continues. "I'm thrilled that in our biomimicry projects teachers and students learned it is OK to fail and try a

revised plan. We tell teachers and students, 'Look at it again; come up with new ways to move forward. And have fun.' When educators are open-minded about trying new pedagogy, we model our willingness to take risks and learn from mistakes. Our students need to see that. That is at the core of innovation."

"Learning about the natural world is one thing. Learning from the natural world—that's the profound switch."

—Janine Benyus, co-founder, Biomimicry Institute



Biomimicry to Find Sustainable Solutions

Students can also use biomimicry to identify innovations that may have had beneficial applications but have led to unintended consequences that are detrimental to delicate ecosystems. Some examples to inspire projects include:

- Insecticides, which have increased and sustained crop production, but have harmed birds and bees who ingest the applied chemicals.
- Potable water, one of the most precious and endangered resources on earth, which is often diverted for housing or industry, reducing the flow that sustains life downstream.
- Fertilizers, which increase agricultural production, but have been found to contaminate community drinking water.
- Invasive species of plants or animals, which were introduced accidently or intentionally into environments where they have no natural predators and can devastate natural habitats.

Biomimicry offers solutions such as natural insect deterrents as well as ways to protect the endangered bee population and find alternative crop pollination methods. As students research ways that animals, plants, bacteria, and inanimate objects interact in ecosystems, they discover challenges and new possible solutions that are harmonious with nature.

Getting Started With IDEA

To introduce the multidisciplinary STEAM approach, or to include biomimicry in cross-curricular projects, consider using the **IDEA** design thinking approach, outlined by the National Art Education Foundation:

1. **Identify** community members, parents, and faculty with content expertise to help teachers develop rigorous project plans. Is there a local university or business working in biomimicry? Could collections from a library or museum provide illustrative examples? Communicate with online locations and peruse long-distance resources. Authentic integration means the projects' objectives address each discipline's standards, so draw upon expertise from many fields.
2. **Define** how this work will be done. Provide collaborative planning time and STEAM-related professional development to embed this approach schoolwide. Establish ways for teachers to share ideas and learn from each other's experiences. Align your plans with the purpose of embracing STEAM and biomimicry.
3. **Explore** new ways to support these teaching practices. Remove barriers. Find resources. Apply for grants. Document progress. Serve as an advocate and spokesperson so the district and school board members know about and support your STEAM projects. Highlight students' work. Trust them to be school spokespersons who publicly represent your learning community.
4. **Assess** and review the process and projects. Do formative assessment

throughout the initiative. Help teachers use STEAM artifacts in authentic assessment. Include students in building evaluation tools and conducting self-assessments. Celebrate student growth, and help them stretch their capabilities as they use a continuous improvement process along the journey.

Cross-Cutting Concepts

The Next Generation Science Standards identify "cross-cutting concepts" that transform previously siloed notions of science into a holistic view of how scientific disciplines intersect. Engineering is intentionally included as both a physics-based discipline and, equally importantly, an innovation process. As STEAM takes hold, teachers see how the arts contribute iterative creative processes that parallel iterative engineering processes in structure and flow. The integration of these fields leads to strong pedagogical practices.

Wanda Carroll-Williams, principal of Joseph Pye Elementary in Ladson, South Carolina, explains, "STEAM is not the curriculum. It is a philosophy of teaching that brings interconnecting subjects together. In STEAM projects, each discipline's standards are addressed. Some question the role of the arts in science lessons. I quote Mae Jemison, doctor, dancer, and astronaut, who said, 'Science and the arts are manifestations of the same thing. The arts and sciences are avatars of human creativity.'" STEAM projects help students internalize the concept that scientists, artists, and engineers are creative. Each of these professions involves creating, presenting, responding, and connecting—four pillars in the National Arts Standards framework.

Biomimicry comes alive at Joseph Pye Elementary. Art teacher Heather Hill engages students in a series of projects on how birds inspire innovation. Characteristics such as color concealment and wing structure were incorporated into their *Aircraft of the Future* exhibit, presented at Boeing Corporation's local grand opening. Hill explains, "American painter Abbott Thayer created the concept of military camouflage based on coloration concealment he observed while painting birds. Students used this as well as other bird adaptations to inform their aircraft designs." Boeing leaders were impressed with students' prototypes that drew upon several biomimicry areas. Students also studied how natural rhythms and a musical metronome inspired Earl Bakken's original pacemaker. They studied Venus flytrap plants and dolphins and tested ideas about nature-inspired medical stents and air-bag designs through origami.

"When students see how the disciplines align and are integral to the design process, they stretch even further. I love that when I walk into a classroom I can't tell if it is a math or science or art lesson, the concepts are so seamlessly blended," Carrol-Williams explains. To enable diving deeply into projects, Joseph Pye Elementary is also using a different scheduling system. The arts teachers (dance, media arts, music, and two visual art instructors) each have a group of students every day for five-day rotations, enabling them to avoid "the classic 'wait until next week when we meet again' interruption, which disturbs continuity of thought in a project," Hill explains.

Seeking New Insights and New Partners

Bringing an artistic lens to biomimicry is an important part of the process. Nature combines form, function, and aesthetics in ways that can be applied to many possible solutions. Art-making enables students to represent their ideas visually. Art builds observation skills, an appreciation of natural beauty, and new ways to communicate ideas that go beyond what words alone can articulate. The visual language observed in nature and represented in art can help connect disparate ideas, or real components, within complex systems. Because seeking new ideas is integral to the biomimicry process, the SEEK™ protocol can easily be applied.

SEEK™

- **See:** What do you see? Observation is critical to this process.
- **Evidence:** Why do you say that? Cite evidence from your observations.
- **Explain:** What are the possible intentions, purposes, and applications of what you see?
- **Know:** What do you know and want to know? Inquiry keeps the discovery going.

While other schools' projects may inspire you, it is your students' natural curiosity about nature that will drive your school's STEAM biomimicry explorations. When teachers ask "what if …" questions and give students agency to dive deeply into the intersections of science, technology, engineering, art, and math, students will exceed expectations. As they seek new solutions and marvel at where their observations, evidence, explanations, and inquiry take them, students, like STEAM, will naturally rise to the challenge.

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