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What is Bionics4Education?

The goal of Festo's Bionics4Education is to offer a range of bionics-inspired projects and supporting content that educators can use to create a project-based learning experience for their students that emphasizes creativity, innovation, and problem solving.

Bionics4Education is an innovative learning platform created by the Bionic Learning Network's team of engineers, designers, and bioengineering experts. The team, who successfully develop bionics-inspired projects, realized that the countless prototypes and experimental models developed during the design process could be used as catalysts to inspire and engage learners in the subject of bionics. These prototype designs are the focus of Bionics4Education. They were adapted into a modular training program that features a unique bionics-inspired kit, with which bionics-inspired projects are completed. The Bionics Kit, together with the Bionics4Education learning platform, offers students hands-on experience in the world of bionics, promoting creativity and fun while learning from nature.

Who should experience Bionics4Education?

Bionics4Education is designed for anyone interested in what nature has to teach us. The resources provided by Festo on the Bionics4Education website can be incorporated into any formal or informal learning environment, for all grade levels. Since the projects included in the Bionics Kit require no prior expertise, they can be quickly assembled and unassembled, following the step-by-step instructions provided. Learners can also be challenged with a ‘learn-by-doing’ approach.

Educators – in the classroom

Studying how nature has developed solutions for living organisms can be effective in solving today's engineering problems. Nature has inspired human engineers to mimic many natural designs to solve complex problems and develop incredible technologies.

Bionics4Education resources, including bionics concepts, project instructions, and career exploration, can be used by educators to help guide learners through their bionics experience. Educators should continue to encourage learners to ask the right questions and look to the correct models in our environment to understand how living things meet specific functions. For example, why are fish tails designed like they are? How can we optimize the swimming ability of a fish? How would nature pick up objects? How does an elephant control its trunk?

The resources found on the Bionics4Education website, in conjunction with the Bionics Kit, are used to teach students of all ages. Teacher workshops and training seminars use these education tools to increase educator’s knowledge of pedagogy, engineering, and technology content. This ensures a successful blended learning experience for both the teacher and student when incorporating engineering learning environments.

| K-5 | • Teachers use the student activity worksheets located in Downloads to help incorporate a bionics themed lesson in the classroom.  
• Teachers use the content and videos located in the Nature Knows Best honeycombs to spark motivation and student engagement by exploring how nature has already solved many of the problems we deal with every day.  
• Teachers use the content and videos located in the Biological Background honeycombs to help explain biological role models and natural inspiration for technical applications.  
• Teachers assemble (either before class begins or in front of the class) and demonstrate each bionic robot. During the demonstration, teachers encourage the class to think about what questions the engineers and designers asked prior to designing the bionic prototypes and why certain models in our environment achieve specific functions.  
• Teachers help the class define a real-world problem to work through using a biomimicry design process. |
| Middle/High School | • Teachers use the student activity worksheets located in Downloads to help incorporate a bionics themed lesson in the classroom.  
• Teachers incorporate all or some of the free resources into existing lesson plans for Biology, Math, Science, Engineering, or Technology classes. The Bionics Kit serves as the application of skills and knowledge.  
• Teachers use the Bionics Kit in coding classes and encourage students to create programs for the bionic robots using the Arduino IDE.  
• For career discussions, teachers look to the Career Exploration section to find interviews with some of the Bionic Learning Network’s team members, who explain why they chose their careers. |
| Post-Secondary | • Students dive deeper into the biology, technology, and engineering concepts and redesign the original bionics-inspired projects, so each function has a new purpose. |
| Teacher Empowerment | • The Bionics Kits are also used for teacher training programs to equip educators with the engineering/technology skills and pedagogical knowledge required to successfully teach STEM initiatives. |

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After-school coordinators, youth group leaders, summer camps, school library programs, and home-school classrooms are using the Bionics4Education resources and the Bionics Kit to create ‘hands-on’ learning experiences with a focus on bionic-inspired innovations. Creating a project-based program with an overarching bionics theme is a catalyst for inspiring and engaging learners and helps to build important 21st century skills.

Working with the Bionics Kit and the Bionics4Education resources, students:

- Discover technical innovations inspired by nature
- Create bionic-inspired models
- Explore biomimicry design processes
- Develop communication and collaboration skills
- Understand and apply the Fin Ray Effect®
- Apply problem solving and critical thinking skills
- Engage in a “learning-by-doing” environment

The STEM connection

Bionics4Education helps schools with implementing the correct STEM program. A program which introduces information and skills in the context of problem solving, consists of hands-on activities using equipment that allows for the exploration of many technologies, and provides a turn-key solution. This program allows teachers to spend more time interacting with the class and less time learning new content.

Since bionics serves as a link between biology and technology, the Bionics Kit is a perfect addition to any integrative STEM education program, STEM academy, or early STEM education initiative.

The Bionics Kit is a STEM teaching tool that emphasizes innovation, problem solving, critical thinking, and creativity. This low-cost tool comes with free online resources. It supports student learning, building the knowledge and skills necessary to apply toward design solutions that solve problems in science, technology, engineering, and math fields.

Bionics Kit Explained

The Bionics Kit contains the material to build three different bionic-inspired robots:

1. Bionic fish
2. Bionic elephant
3. Bionic chameleon

All bionic robots are actuated by servo motors and controlled by a microcontroller. Detailed instructions allow students to create the robots and easily control them by using their smartphones, tablets, or computers.

Because all objects can be disassembled and reassembled, it is possible to create all three models one after another with a single Bionics Kit.
What’s included?

The Bionics Kit contains:

- Transparent corpus (body)
- Electronic board with microcontroller
- 1 tail fin (large)
- 2 tail fins (small)
- 1 waterproof servo motor
- 3 additional servo motors
- Connecting elements
- Sealing rings
- Silicone cap
- Tubing
- Cable ties

The Bionics Kit includes a Materials Pack:

- Balloon
- Foam material for flexible spacers
- Plastic poster board

Additional supplies will be needed. Ensure small weights or screws/nuts/bolts are available for fish balance and that you have scissors, AA batteries (4), and a Phillips head screwdriver on hand. If you want your bionic fish to swim, you’ll need a water basin or fish tank too!

Bionics4Education learning platform

Resources, including bionics concepts, project instructions, and career exploration, are available on the Bionics4Education website. This comprehensive collection of information helps guide learners through their bionics experience. It encourages them to ask the right questions and look to the correct models in our environment to understand how living things meet specific functions.

Everything you need, from directions on assembling the bionic robots to discovering how nature inspires technical innovations, can be found by clicking a honeycomb. Honeycombs can be grouped together to create the desired learning experience within a given time frame.
Bionic Learning Network, the Bionic Learning Network, noticed that they had simple management and lesson implementation. He noticed that they had simple management and lesson implementation. Use the one. Repeat Learn by Doing for each bionic-inspired robot. The robot must be disassembled before assembling a new one.

Use the Learning Path on the following page as a guide. Approximate completion times are identified for classroom management and lesson implementation.
“Introduce”
Technical Innovation Inspired by Nature
Introduce students to bionics and how we can learn from nature. Students learn how nature was the inspiration for Festo engineers!

“Discover”
Biological Background
Discover the biological inspiration for the bionic-inspired fish!

“Learn by Doing”
Getting Started
Follow the instructions to assemble and control the bionic fish.

“Discover”
Biological Background
Discover the biological inspiration for the bionic-inspired elephant!

“Learn by Doing”
Getting Started
Follow the instructions to assemble and control the bionic elephant.

“Discover”
Biological Background
Discover the biological inspiration for the bionic-inspired chameleon!

“Learn by Doing”
Getting Started
Follow the instructions to assemble and control the bionic chameleon.

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Introduce: Ask students if they ever heard of the term biomimicry? What is it? Explain that biomimicry is a way to learn from nature. Biomimicry recognizes that nature has something to teach us. Ask the students if they have ever used Velcro® to close a bag, or tighten their shoes. Then ask them if they knew that Velcro® is an example of biomimicry. Explain to the class that Velcro® was invented after an engineer, who was hiking with his dog in the woods, had to pick burrs off of his clothes and his dog. These burrs interested him so he examined them under a microscope. He noticed that they had simple tiny hooks, which allowed them stick to fur and clothes. After years of research and work, he created what is known today as Velcro®. Velcro® is a combination of the French words “velours” (velvet) and “crochet” (hooklets). It is made up of two strips of fabric, one covered in thousands of tiny hooks and the other with thousands of tiny loops.

From the Nature Knows Best menu, present the information found in each of the honeycombs.

Discover: From the Bionic Learning Network menu, present the information found in each of the honeycombs.

Learn by Doing: From the Bionic Robots menu, students explore the biological background for a specific bionic-inspired robot and then assemble that robot. This is repeated for all bionic robots. The robot must be disassembled before assembling a new one.

There are three Learning Paths on the following pages, one for each bionic-inspired project. Use these Learning Paths as a guide. Approximate completion times are identified for classroom management and lesson implementation.
Introduce students to bionics and how we can learn from nature to solve problems we deal with every day.

Discover what we can learn from animals and how we use what we learn in a technical world.

Introduce students to the biological inspiration for the bionic-inspired fish.
“Introduce”
Introduce students to bionics and how we can learn from nature to solve problems we deal with every day.

“Discover”
What is the Bionic Learning Network? || Bionic Thinking || How We Use the Engineering Design Process
Discover what we can learn from animals and how we use what we learn in a technical world.

“Learn by Doing”
Biological Background
Introduce students to the biological inspiration for the bionic-inspired elephant.

Getting Started
Follow the instructions to assemble and control the bionic elephant.
“Introduce”
Introduce students to bionics and how we can learn from nature to solve problems we deal with every day.

“Discover”
What is the Bionic Learning Network? || Bionic Thinking || How We Use the Engineering Design Process
Discover what we can learn from animals and how we use what we learn in a technical world.

“Learn by Doing”
Biological Background
Introduce students to the biological inspiration for the bionic-inspired chameleon.

Getting Started
Follow the instructions to assemble and control the bionic chameleon.
21st Century Skills

Students must possess critical thinking, communication, and collaboration skills for 21st century careers. Providing students opportunity and inspiration to optimize solutions for real-world problems, trains them to handle problems that they may face in their professional careers. Together with the Bionics Kit, Bionics4Education provides a learning environment for students to collaborate, communicate, and build critical thinking skills.

Even though students can work through the bionics experience alone, it is encouraged that they work in teams when assembling the bionic-inspired robots. To inspire teambuilding and collaboration, students explore the Bionic Learning Network’s interdisciplinary team approach to completing projects.

Students continue building 21st century skills as they discover how to successfully work on a team by thinking about team goals, the different tasks required to achieve goals, how tasks should be organized, and how a team should work together to accomplish these tasks.

Introduction to Industry 4.0

The real and virtual world are growing increasingly closer together, modern information and communication technologies are merging with industrial processes and are increasingly changing the production landscape.

Industry 4.0 brings together various activities (virtual reality, intelligent components, human-machine interaction, machine-to-machine communication, IoT, big data management) under one term and describes the change that is imposing new requirements on production systems, machines, and people in many areas. Smart factories, which are the heart of Industry 4.0, bring a much higher level of automation and digitization.

The Bionics4Education resources provide an opportunity to introduce students to Industry 4.0. Students view videos of robots working directly with humans in a self-learning workplace for human-robot collaboration with artificial intelligence. They discover how the factory of the future uses control concepts based on speech and image recognition as they explore the technical innovations inspired by nature and designed by the Bionic Learning Network’s interdisciplinary team.

Students examine how the engineers at Festo turn to nature to study the behavior, movement, and communication techniques of mammals, insects, and reptiles to build smart factories with advanced automation and intelligent technology.

Exploring how Festo’s Bionic Learning Network team observes interesting phenomenon in nature and how their interdisciplinary approach to bridging biology and technology translates to new automation applications, students are reminded that curiosity feeds innovation.
Opportunities for career exploration provide students exposure to the working world they will one day enter and help them to make the connection between education and career. By understanding the working world, students can envision their path to career success and begin to set goals.

In the Career Exploration menu, students can view videos of each member of the Bionic Learning Network team as they talk candidly about why they choose a career in bionics.

The Career Guidance interactive activity allows students to learn about other careers related to biotechnology.
**Next Generation Science Standards (NGSS) connection**

The Next Generation Science Standards (NGSS) are a set of K–12 science standards that identify scientific and engineering practices, cross-cutting concepts, and core ideas in science that all K–12 students should master in order to prepare for success in college and 21st-century careers.

The NGSS includes practices and core ideas from engineering and technology. NGSS focuses on the applications of math and science concepts, the emphasis on practices in mathematics, science, and engineering, and the addition of engineering design as a central feature. These standards provide a strong support for the integration of STEM in math and science curriculum and teaching.

Examine how you can use Bionics4Education and the Bionics Kit to align with the standards identified below.

### Elementary

<table>
<thead>
<tr>
<th>K-LS1.1.</th>
<th>Use observations to describe patterns of what plants and animals (including humans) need to survive.</th>
</tr>
</thead>
<tbody>
<tr>
<td>K-ESS2-2.</td>
<td>Construct an argument supported by evidence for how plants and animals (including humans) can change the environment to meet their needs.</td>
</tr>
<tr>
<td>K-2-ETS1-1.</td>
<td>Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.</td>
</tr>
<tr>
<td>K-2-ETS1-2.</td>
<td>Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.</td>
</tr>
<tr>
<td>1-LS1-1.</td>
<td>Use materials to design a device that solves a specific problem or a solution to a specific problem by mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs.</td>
</tr>
<tr>
<td>2-LS4-1.</td>
<td>Make observations of plants and animals to compare the diversity of life in different habitats.</td>
</tr>
<tr>
<td>3-LS4-3.</td>
<td>Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.</td>
</tr>
<tr>
<td>4-LS1-1.</td>
<td>Construct an argument with evidence, data, and/or a model that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.</td>
</tr>
<tr>
<td>4-LS1-2.</td>
<td>Use a model to test interactions concerning the functioning of a natural system animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways.</td>
</tr>
</tbody>
</table>

### Middle school

| MS-ETS1-1. | Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. |
| MS-ETS1-2. | Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. |
| MS-ETS1-3. | Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. |
| MS-ETS1-4. | Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved. |

### High school

| HS-ETS1-1. | Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. |
| HS-ETS1-2. | Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. |
| HS-ETS1-3. | Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts. |
| HS-ETS1-4. | Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem. |