



Bac2Mars Learning Objectives & Standards

Learning Objectives Overview:

Biological engineering and bio-design are burgeoning fields of research that drive advancements in domains ranging from agriculture to space travel. The BactoMars video game was designed to inspire the next generation of innovators by exposing elementary-school children to these emerging areas at the intersection of science and technology. In addition to introducing early elementary aged children to concepts of science and technology, the game was also designed to foster development of basic reading comprehension, mathematics skills, creative problem-solving, collaboration, and more. In order to do this, the Bac2Mars game and all educational support materials were designed to align with state and national standards for education including: Next Generation Science Standards, Common Core Standards, P21's Framework for 21st Century Learning, and more. This document walks you through an overview of each of these standards and how Bac2Mars aims aligns with them. Finally, this document also provides you with a breakdown of each educational Bac2Mars video, as well as the game itself, and how specific Bac2Mars content ties into the learning objectives.

In some cases, our educational content ties in with standards for older children in places where no early childhood standards exist for a given topic. We do this because we believe there is a need to re-envision what children can and should be learning in Kindergarten, in particular in the area of STEM education. For decades early childhood curriculum has focused on literacy and numeracy, with some attention paid to the natural sciences. However, in today's world, science and technology are combined in new and creative ways and thus the range of concepts traditionally explored in school needs to be extended. While understanding the natural world is important, developing children's knowledge of the surrounding human-made world of technology and engineering is also valuable. Biological engineering is an example of an emerging field that integrates life sciences and engineering, the natural world and the human made that children can and should begin to learn about from an early age.



Why Bioengineering in Early Elementary School?

While a significant amount of research focuses on STEM education for the later elementary, middle and high school, and college years, little research is focused on learning abstract scientific concepts in the foundational years. We know, however, both from an economic and a developmental standpoint, that educational interventions that begin in early childhood are associated with lower costs and stronger, more durable effects than interventions that begin later in childhood. Additionally, we know that women and minorities are still underrepresented in many STEM fields. Prior work demonstrates the importance of piquing the interest of girls and minorities during their formative early childhood years before stereotypes regarding these traditionally masculine fields are ingrained in later years. Therefore, it is critical to continue developing engaging STEM-focused tools, games, and materials, such as BactoMars, to begin engaging children from their earliest schooling years.

The Standards:

Our videogame and media content are designed to align with the following standards:

Next Generation Science Standards

The Next Generation Science Standards (NGSS) are K–12 science content standards. Standards set the expectations for what students should know and be able to do. The NGSS were developed by states to improve science education for all students. BactoMars specifically connects to NGSS standards related to Space Systems, Ecosystems, as well as Engineering, Technology, and Applications of Science. While the BactoMars game is targeted to early elementary school students, it addresses some science themes that are typically not introduced until middle or high school. BactoMars attempts to introduce these concepts in a playful and easy to follow way that is developmentally appropriate for elementary school children, but you may notice many of the standards we link to are for older children. Find out more about NGSS standards here: <https://www.nextgenscience.org/>

Common Core Standards

In addition to linking to foundational science standards, the BactoMars video game and educational videos aim to align with Common Core's guidelines for math and literacy development in early elementary school by engaging children with reading, exposure to new words, following the plot of a story, and problem solving. Common Core's learning goals outline what a student should know and be able to do at the end of each grade. The standards were created to ensure that all students graduate from high school with

the skills and knowledge necessary to succeed in college, career, and life, regardless of where they live. Forty-two states, the District of Columbia, four territories, and the Department of Defense Education Activity (DoDEA) have voluntarily adopted and are moving forward with the Common Core. Find out more about Common Core here: <http://www.corestandards.org/>

K-12 Computer Science Education Framework

The K–12 Computer Science Framework illuminates the big ideas of computer science through a lens of concepts (i.e., what students should know) and practices (i.e., what students should do). The core concepts of the framework represent major content areas in the field of computer science. The core practices represent the behaviors that computationally literate students use to fully engage with the core concepts of computer science. Find out more about the framework here: <https://k12cs.org/> While the BactoMars game is not explicitly focused on coding or computer science, it does draw on foundational

P21's Framework for 21st Century Learning

The BactoMars video game engages children in working on tasks independently and collaboratively. It engages children in thinking about solving problems, working together, and engineering solutions creatively. Therefore, it was not only designed to foster specific content learning, but also to foster the development of good citizenship and interpersonal skills. This document demonstrates how BactoMars was designed to align with the P21's Framework for 21st Century Learning. P21's Framework for 21st Century Learning skills were developed with input from teachers, education experts, and business leaders to define and illustrate the skills and knowledge students need to succeed in work, life and citizenship, as well as the support systems necessary for 21st century learning outcomes. It has been used by thousands of educators and hundreds of schools in the U.S. and abroad to put 21st century skills at the center of learning. Find out more here: <http://www.p21.org/our-work/p21-framework>

In the following sections, you will find a specific breakdown of how all of our content aligns with specific frameworks and objectives.

Videos & Learning Objectives

The following section walks you through each of the BactoMars educational videos and how the video's content and activities are linked to specific learning standards.

Video 1: Going to Mars

Specific Content/Skill	Learning Domains	Links to Standards
Children will learn basic facts about the planet Mars	Natural Science Astronomy	Next Generation Science Standards: <ul style="list-style-type: none"> • MS-ESS1-3 (Space Systems)
An environment is all of the living and non-living things in a place Children will explore the characteristics of Earth's environment Children will explore the characteristics of the environment on Mars	Natural Science Astronomy	Next Generation Science Standards: <ul style="list-style-type: none"> • MS-ESS1-3 (Space Systems) • 5-ESS2-1 (Earth's Systems) • 5-LS2-1 (Ecosystems: Interactions, Energy, and Dynamics)
Characteristics of a biodome	Natural Science Biological Engineering	Next Generation Science Standards: <ul style="list-style-type: none"> • 5-LS2-1 (Ecosystems: Interactions, Energy, and Dynamics)
What a natural resource is (things found in nature that can be used by people) Natural resources found on Earth and Mars	Natural Science Astronomy	Next Generation Science Standards: <ul style="list-style-type: none"> • 5-ESS2-1 (Earth's Systems)

Listening to a story being read aloud while following along with onscreen text and animations	Language Arts/ Literacy	Common Core Literacy: <ul style="list-style-type: none"> • CCSS.ELA-LITERACY.RL.K.3 • CCSS.ELA-LITERACY.RL.K.10 • CCSS.ELA-LITERACY.RL.K.10 • CCSS.ELA-LITERACY.RL.3.4 • CCSS.ELA-LITERACY.RL.3.7
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Video 2: Arriving on Mars

Specific Content/Skill	Learning Domains	Links to Standards
Travel time between Earth and Mars	Astronomy	Next Generation Science Standards: <ul style="list-style-type: none"> • MS-ESS1-3: (Space Systems)
Characteristics of a biodome	Natural Science Biological Engineering	Next Generation Science Standards: <ul style="list-style-type: none"> • 5-LS2-1 (Ecosystems: Interactions, Energy, and Dynamics)
Listening to a story being read aloud while following along with onscreen text and animations	Language Arts/Literacy	Common Core Literacy: <ul style="list-style-type: none"> • CCSS.ELA-LITERACY.RL.K.3 • CCSS.ELA-LITERACY.RL.K.10 • CCSS.ELA-LITERACY.RL.K.10 • CCSS.ELA-LITERACY.RL.3.4 • CCSS.ELA-LITERACY.RL.3.7
Following the plot of a multi-part story about engineers working on Mars	Language Arts/Literacy	Common Core Literacy: <ul style="list-style-type: none"> • CCSS.ELA-LITERACY.RL.3.5 • CCSS.ELA-LITERACY.RL.3.10

Video 3: Bioengineering

Specific Content/Skill	Learning Domains	Links to Standards
<p>Bioengineering is a combination of microbiology and engineering</p> <p>Biology is the study of all living things</p> <p>Engineering is designing and building useful things</p>	<p>Biology</p> <p>Engineering</p> <p>Biological Engineering</p>	<p>Next Generation Science Standards:</p> <ul style="list-style-type: none"> • K-2-ETS1-1 (Engineering Design) • 8.MS-LS1-5 (Molecules to Organisms)
<p>Bacteria are tiny living things sometimes called germs</p> <p>Bacteria can be useful for creating resources that we need</p> <p>A group of bacteria are called a colony</p>	<p>Biology / Life Sciences</p>	<p>Next Generation Science Standards:</p> <ul style="list-style-type: none"> • 8.MS-LS1-5 (Molecules to Organisms)
<p>Cells are tiny units of life</p> <p>Plasmids are an instruction manual for a cell</p> <p>Genes are instructions for building part of a cell</p>	<p>Biology / Life Sciences</p>	<p>Next Generation Science Standards:</p> <ul style="list-style-type: none"> • MS-LS1-1 (Molecules to Organisms: Structures and Processes) • MS-LS3-1 (Heredity: Inheritance & Variation in Traits) • HS-LS1-1 (Molecules to Organisms: Structures and Processes)

		<ul style="list-style-type: none"> • HS-LS1-2 (Molecules to Organisms: Structures and Processes)
<p>A product is a substance made from something else</p> <p>A resource is something in nature that we can use</p>	Life Sciences	<p>Next Generation Science Standards:</p> <ul style="list-style-type: none"> • MS-LS2-1 (Molecules to Organisms: Structures and Processes)
Listening to a story being read aloud while following along with onscreen text and animations	Literacy/ Language Arts	<p>Common Core Literacy:</p> <ul style="list-style-type: none"> • CCSS.ELA-LITERACY.RL.K.3 • CCSS.ELA-LITERACY.RL.K.10 • CCSS.ELA-LITERACY.RL.K.10 • CCSS.ELA-LITERACY.RL.3.4 • CCSS.ELA-LITERACY.RL.3.7
Following the plot of the multi-part story about engineers and Mars	Literacy/ Language Arts	<p>Common Core Literacy:</p> <ul style="list-style-type: none"> • CCSS.ELA-LITERACY.RL.3.5 • CCSS.ELA-LITERACY.RL.3.1

BacToMars Video Game

The following section walks you through the BactoMars educational video game and how the game's content and activities are linked to specific learning standards. To play the game, please visit: <http://cs.wellesley.edu/~aloparev/BacPackTablet/public/>

Specific Content/Skill	Learning Domains	Links to Standards
Reading basic words and sentences	Language Arts/Literacy	<p>Common Core Literacy:</p> <ul style="list-style-type: none"> • CCSS.ELA-LITERACY.RL.1.10 • CCSS.ELA-LITERACY.RL.2.10 • CCSS.ELA-LITERACY.RL.3.10 • CCSS.ELA-LITERACY.RL.3.4
Working independently to complete a task		<p>21st Century Skills:</p> <p>Life & Career Skills including:</p>

		<ul style="list-style-type: none"> • Initiative and Self-Direction • Leadership and Responsibility
Working collaboratively to complete a task	Social and Interpersonal Skills	<p>21st Century Skills: Life & Career Skills including:</p> <ul style="list-style-type: none"> • Flexibility & Adaptability • Interact Effectively with Others • Work Effectively in Diverse Teams
<p>Exposure to working on a computer using a mouse or trackpad</p> <p>Exposure to working with other children on a task online</p>	Computer Literacy	<p>K-12 Computer Science Framework</p> <ul style="list-style-type: none"> • Grade 2- Devices • Grade 2- Network Communication and Organization
Children will engineer a bacterium by picking out genes and placing them into plasmids before inserting the plasmids into the bacterium. They will iteratively test their solutions	<p>Engineering</p> <p>Biology</p> <p>Biological Engineering</p>	<p>Next Generation Science Standards:</p> <ul style="list-style-type: none"> • K-2-ETS1-3 (Engineering design) • 3-5-ETS1-2 (Engineering design) • MS-LS1-1 (Molecules to Organisms: Structures and Processes) <p>21st Century Skills:</p> <ul style="list-style-type: none"> • Creativity and Innovation
<p>Understanding sequencing, inputs, and outputs when making combinations of genes</p> <p>Using problem solving when making gene combinations</p>	Computational thinking/ Computer Science	<p>K-12 Computer Science Framework:</p> <ul style="list-style-type: none"> • Grade 2- Algorithms and Control <p>Common Core Math:</p> <ul style="list-style-type: none"> • CCSS.MATH.PRACTICE.MP2

<p>Children will explore the difference between a resource and a product when designing bacterium</p>	<p>Problem Solving</p>	<p>21st Century Skills:</p> <ul style="list-style-type: none"> • Creativity and Innovation <p>Next Generation Science Standards:</p> <ul style="list-style-type: none"> • MS-LS2-1 (Molecules to Organisms: Structures and Processes)
<p>Children will be exposed to content about Mars and the environment on Mars</p>	<p>Astronomy Natural Science</p>	<p>Next Generation Science Standards:</p> <ul style="list-style-type: none"> • MS-ESS1-3 (Space Systems) • 5-LS2-1 (Ecosystems: Interactions, Energy, and Dynamics)