THE FRANKLIN INSTITUTE

The Science Behind PIXAR

K-12 Educator's Guide

Exhibition Overview

The Science Behind PIXAR

The Science Behind Pixar

On Exhibit March 12, 2016 – September 5, 2016

Recommended for Grades 3 – 12

Learn about the filmmaking process through hands-on activities inspired by some of Pixar's most treasured films, from *Toy Story* to Pixar's newest film *Inside Out*. This exhibition offers an unparalleled view of the production pipeline and concepts used at Pixar every day. Participate in fun hands-on activities, listen to firsthand accounts from members of the studios' production teams, and even come face-to-face with re-creations of your favorite Pixar film characters, including Buzz Lightyear, Dory, Mike and Sulley, Edna Mode, and WALL▪E!

This exhibition was developed by the Museum of Science, Boston in collaboration with Pixar Animation Studios.

Local Sponsor

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TABLE OF CONTENTS

Planning Your Visit 4

Learning Objectives 6

Exhibition Introduction 7

Exhibition Map 8

Exhibition Highlights 9

Activity Sheets 11

Connections to Education Standards 19

Planning Your Visit

The Science Behind PIXAR

Students will have an opportunity to explore a variety of interactives within *The Science Behind Pixar*. Due to the scope of the exhibition, you may want to encourage your students to focus on specific areas or themes. The following pages provide an exhibition overview as well as learning goals and activity sheets to support those goals.

BEFORE YOUR VISIT

- Review this guide to familiarize yourself with the exhibition and determine the learning goals for your students.
- Identify connections between the exhibition and your curriculum.
- Create your own activity sheets or supplement those provided in this guide.
- Facilitate preparation activities for your students before they visit.
- Visit www.fi.edu to review additional related Museum programming.
- Share expectations, plans, and schedules for the field trip with your students and chaperones. Provide copies of activity sheets or other materials to chaperones.
- *The Science Behind Pixar* requires timed entry. Entry times are every ten minutes and large groups may require more than one entry time.

Explore Pixar in a Box, a collaboration between Pixar and Khan Academy that builds on videos from the exhibition and provides in-depth lessons on related topics. For more information: **pixarinabox.org**.

The Museum of Science is committed to making accessible exhibitions.

The Science Behind Pixar incorporates the ADA Standards for Accessible Design. All videos are open captioned for visitors with hearing impairments. Every component has an audio handset that provides recordings of the text label content and descriptions of the images and activities for guests unable to access printed information.

AD Audio Descriptions OC Open Captioning

Planning Your Visit

The Science Behind PIXAR

DURING YOUR VISIT

- Most groups will spend 45 – 60 minutes within the exhibition.
- There are no restrooms in the exhibition and no re-entry. Please have students visit the restrooms before entering. The closest restrooms are in the Bartol Atrium.
- Food and drink are prohibited in the exhibition.
- Backpacks or other large bags are not allowed in the exhibition.
- Photography is permitted in the exhibition.

AFTER YOUR VISIT

- Explore Pixar in a Box, a collaboration between Pixar and Khan Academy that builds on videos from the exhibition and provides in-depth lessons on related topics. For more information: pixarinabox.org

Learning Objectives

During their visit, students will experience how art, technology, science, math, computer science, and creativity are inseparable in the making of Pixar animated films. Students will leave the exhibition with a greater awareness of diverse STEM careers and the collaborative spirit behind animated filmmaking.

EDUCATIONAL GOALS

Knowledge, awareness, and understanding

- Students will demonstrate increased knowledge and understanding of the core STEM content that underlies computer animation.
- Students will demonstrate awareness of the interdependence of art and STEM at Pixar.
- Students will be able to systematically approach complex problems and challenges by breaking them down into manageable parts.

Attitude

- Students will have an increased positive attitude that they can learn about STEM and computer science, and they will gain appreciation for the creativity of careers in those fields.

Skills

- Students will demonstrate engagement in STEM and computer science process skills that are used at Pixar.

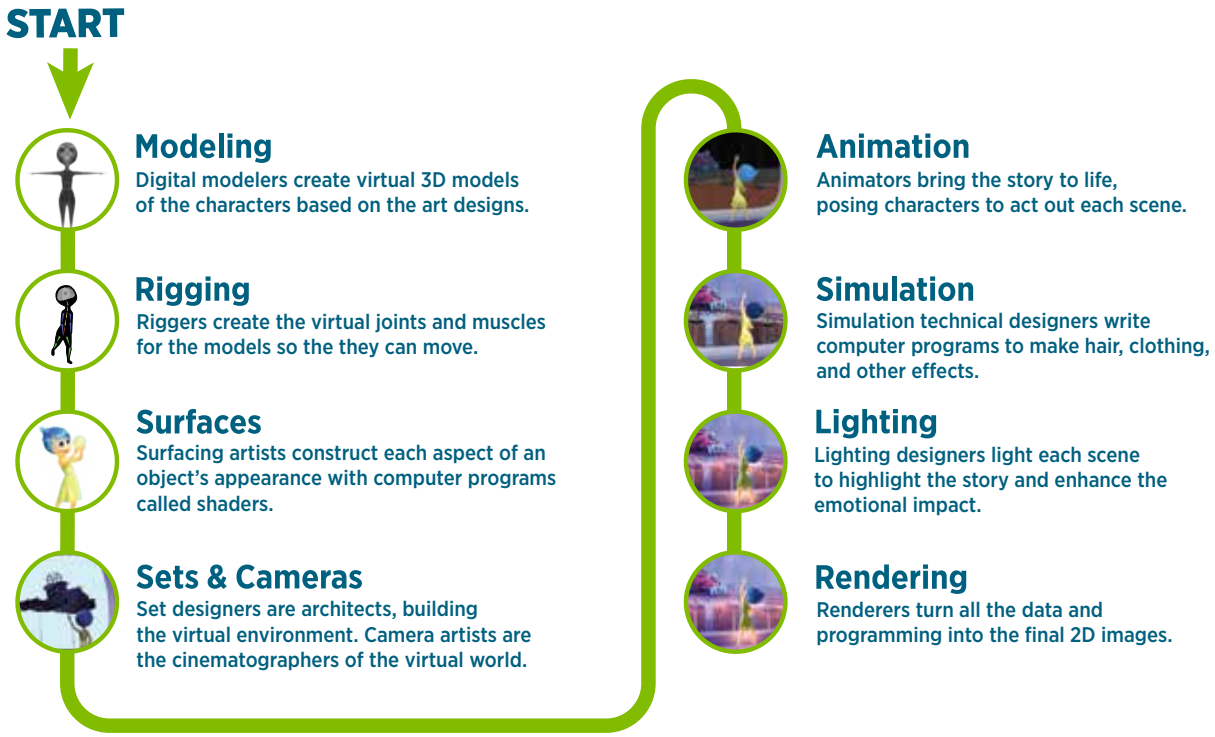
Exhibition Introduction

The Science Behind PIXAR

***The Science Behind Pixar* has been designed to give students a behind-the-scenes immersive look at the process used to create Pixar's groundbreaking films. Below, you will find an introduction to the exhibition content and layout.**

Introductory Theater: Students will begin their exhibition experience with a fun and engaging video on the process that Pixar uses to turn an idea into a film.

Upon leaving the Introductory Theater, students may approach the exhibition in any order they choose. The exhibition is organized around eight steps of the Pixar production pipeline:



EACH AREA INCLUDES:

- **Screen-based activities** that will give students an opportunity to explore real-world challenges faced by the Pixar production team.
- **Physical interactives** that will allow students to gain tactile experiences to help them better understand what happens in the virtual world created by Pixar.
- **Video stories** in which Pixar employees share insight into the complex challenges Pixar has overcome in the development of its ground-breaking films. Additional video interviews highlight the variety of careers at Pixar and will broaden students' views of what it means to work in a STEM field.

Exhibition Highlights

MODELING

Digital sculpting creates virtual 3D models

Character design starts with artists who create sketches and clay sculptures called maquettes to get each character just right. Then, a digital modeler creates a virtual 3D model of the character, sometimes digitally scanning the maquette. The final model is a virtual digital wireframe of points and the edges that connect them.

Photo © Michael Malyszko

RIGGING

Digital rigs make movement possible

Riggers create rigs—the virtual bones, joints, and muscles for models. Rigs specify the relationships between body parts so that bending a knee will raise the foot, but not move the hands. A good rig allows the animators to create poses easily and efficiently. Without the right controls, the model won't move the way it should. Too much flexibility makes posing the model too time consuming.

Photo © Michael Malyszko

SURFACES

Appearance is controlled separately from shape

The way something looks tells a story. What is it made of? Is it new or old? Well taken care of or neglected? After a virtual 3D model is created, a surfacing artist constructs its appearance with computer programs called shaders. They determine the way light scatters off the surface so it looks shiny, transparent, and smooth (like glass) or dull and rough (like rust).

Photo © Michael Malyszko

SETS & CAMERAS

Virtual cameras view virtual 3D worlds

Movies need more than just characters. The setting of each scene and the way each image is framed convey the context, story, and emotion. Set designers are architects. They build virtual environments from the ground up. Every pebble, tree, and building helps turn the storyboards into a believable world. Camera artists use virtual cameras to shape what is shown on screen. They choose the composition, camera movement, and lens type to support the story.

Photo © Nicolaus Czarnecki

ANIMATION

Animation is acting

Pixar animators bring a story to life, posing characters to act out each scene. Animators start by creating key frames that mark out important positions in a movement. Then, they use a computer program to describe how the object moves between those key frames so that the resulting animation conveys the desired emotions.

Photo © Nicolaus Czarnecki

SIMULATION

Computer programs create automated motion

While animators focus on acting, simulation programmers create motion that makes scenes feel alive and believable. Some simulations—hair, fur, and clothing—respond to the way a character moves. Other simulations re-create natural phenomena, such as fire or water. Programmers start with the underlying physics, but they balance believability with the artistic needs and the time it takes to run the simulation.

Photo © Nicolaus Czarnecki

LIGHTING

Virtual lights enhance mood and believability

Lighting is an essential part of telling a story. Light shows you where to look and enhances the emotional feel of each scene. Pixar's lighting designers have the additional task of defining virtual lights in the computer. The color, position, and intensity of each light needs to be programmed to achieve the desired artistic effect.

Photo © Michael Malyszko

RENDERING

Rendering turns a virtual 3D scene into a 2D image

The virtual scene is set—the characters are shaded and posed, the lights and camera are in position, and the simulations are ready to run. But no one knows what it looks like until the rendering process turns all that data and programming into an image we can see. Pixar generates low-resolution renders for work in progress and high-resolution renders for the final film.

Photo © Nicolaus Czarnecki

Activity Sheets

The Science Behind PIXAR

These activity sheets have been designed to reinforce the general themes of *The Science Behind Pixar* and help guide your students' experiences within the exhibition. The themes of this exhibition are:

- Art, technology, science, and creativity are inseparable in animation.
- At Pixar, art drives digital technology, and digital technology inspires the art.
- People at Pixar imagine and create compelling movies, using computers as another filmmaking tool.
- Understanding science, math, and computer science are necessary to create believable animated films.
- Filmmaking is a team sport.

ELEMENTARY SCHOOL ACTIVITY SHEETS

- **Pixar 3-2-1:** This activity sheet is designed for students to make observations and ask questions about their experience in *The Science Behind Pixar.*
- **Working Together in Pixar:** This worksheet highlights the collaborative nature of the animation process. Students are asked to identify different examples of when Pixar team members used math, art, science, and creativity to make an animated film.
- **Searching for Shapes!:** Designed for younger students in grades K – 1, this worksheet guides students to identify and draw different shapes within the exhibition. They are then asked to combine different shapes they have found to create an imaginary robot.

MIDDLE & HIGH SCHOOL ACTIVITY SHEETS

- **Pixar Production Pipeline I:** This worksheet asks students to identify two different steps of the Pixar production process and answer questions related to each step.
- **Pixar Production Pipeline II:** This activity sheet encourages students to identify how different steps of the production process contribute to various elements of a Pixar film, such as the development of characters, scenes, and movement.
- **Collaboration in Pixar:** Designed to highlight the importance of collaboration within digital animation, this worksheet asks students to identify ways that Pixar team members have used math, art, science, computer science, technology, and creativity to solve problems.
- **Careers at Pixar:** This activity sheet encourages students to explore different types of STEM careers within the field of digital animation. Students are asked to identify two different careers at Pixar and answer questions related to those careers.

Name: _____

Choose a character from any of the Pixar films you see in the exhibition. Draw or describe your character in the box below:

Describe 3 physical characteristics of your character. What does he/she look like?

1. _____

2. _____

3. _____

Describe 2 personality traits. How does your character act?

1. _____

2. _____

What is one question you have about how the animators created this character?

_____

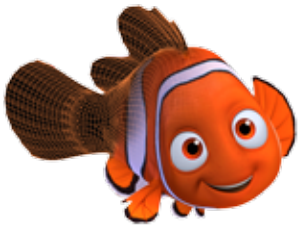
_____

Activity Sheet:

Working Together in Pixar

The Science Behind PIXAR

Name:_____



Art, science, math, and creativity are very important in animation.

Math, art, science, and creativity are all used to make a Pixar film. Explore *The Science Behind Pixar* and write or draw an example of how each of these areas are used by Pixar.

ART	SCIENCE
MATH	**CREATIVITY**

Which of these areas could you help out with on a Pixar film? Why?

Activity Sheet:

Searching for Shapes!

The Science Behind PIXAR

Name:_____

Find examples of different shapes in the exhibition. Name and draw the shape.

_____ **SHAPE:** _____	_____ **SHAPE:** _____
_____ **SHAPE:** _____	_____ **SHAPE:** _____

Draw a character that uses the shapes you found:

Activity Sheet:

Pixar Production Pipeline I

The Science Behind PIXAR

Name:_____

There are eight technical steps in the film production process that contribute to the development of a Pixar film.

MODELING | RIGGING | SURFACES | SETS & CAMERAS

ANIMATION | SIMULATION | LIGHTING | RENDERING

Choose 2 steps of the Pixar Production Pipeline and answer the following questions:

	Step 1	Step 2
Technical Step:		
How does this step contribute to the development of a Pixar film?		
What is one challenge that Pixar members face during this step?		
What skills are necessary to contribute toward this production step?		

Did any of the production steps interest or surprise you? Why?

_____

_____

Pixar Production Pipeline II

Name:_____

There are eight technical steps in the film production process that contribute to the development of a Pixar film.

MODELING | RIGGING | SURFACES | SETS & CAMERAS

ANIMATION | SIMULATION | LIGHTING | RENDERING

Explore the exhibition and identify how different steps of the production process contribute to various elements of a Pixar film.

Identify **two steps** that contribute to the development of a **character's features or persona**. How do these steps affect how the character is perceived?

1. _____: _____

_____

2. _____: _____

_____

Identify **two steps** that contribute to the development of a **scene**. How do these steps make the scene look believable? How do these steps affect the mood or feeling of a scene?

1. _____: _____

_____

2. _____: _____

_____

Identify **two steps** that contribute to the development of **action or movement.** How do these steps affect how characters or objects move in a film?

1. _____: _____

_____

2. _____: _____

_____

Activity Sheet:

Collaboration in Pixar

The Science Behind PIXAR

Name:_____

Art, technology, science, math, computer science, and creativity are inseparable in animation.

Look for examples of how each of the following areas are used in the production of a Pixar film. In the spaces below, explain how each area has been used to simplify or solve a problem faced by the Pixar team.

ART

_____

_____

_____

_____

MATH

_____

_____

_____

_____

TECHNOLOGY

_____

_____

_____

_____

COMPUTER SCIENCE

_____

_____

_____

_____

SCIENCE

_____

_____

_____

_____

CREATIVITY

_____

_____

_____

_____

Which of these areas could you contribute to on a Pixar film? How?

_____

_____

_____

Activity Sheet:

Careers in Pixar

The Science Behind PIXAR

Name:_____

The making of Pixar films involves the collaboration of many different people with unique roles. Check out each exhibition area and look for a video describing someone's job at Pixar.

Research Scientist	Technical Director	Director of Photography	Character Modeler	Character Animator	Software Developer	Rendering Supervisor

Choose 2 careers represented in the Pixar exhibition and answer the following questions:

	Career 1	Career 2
Job Title:	_____	_____
What does this person do in his or her job making Pixar films?	_____	_____
What skills are required for this person to do his or her job at Pixar?	_____	_____
Do you think you would like this job? Why or why not?	_____	_____

Which jobs interest or surprise you? Why?

_____

_____

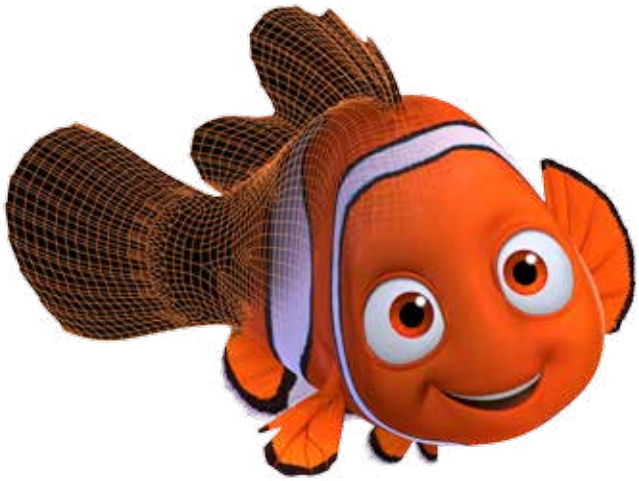
National Standards Connections

Pixar production team members use art, technology, science, math, and computer science to create realistic virtual worlds. In *The Science Behind Pixar* exhibition, students will begin to understand the academic and creative concepts that are vital to the production of their films. Making these connections will give students a new context for learning. The exhibition also introduces students to STEM focused careers. Below is a selection of the National curriculum standards that students will be exposed to while visiting this exhibition.

National Standards		Grade
Computer Science	CPP.L1:3-5 Identify jobs that use computing and technology.	K – 3
Computer Science	CPP.L1:6-9 Identify a wide range of jobs that require knowledge of or use of computing.	3 – 6
Computer Science	CT.L1:6-3 Identify ways that teamwork and collaboration can support problem solving and innovation.	3 – 6
Computer Science	CT.L1:6-4 Describe how a simulation can be used to solve a problem.	3 – 6
Computer Science	CT.L1:6-6 Understand the connections between computer science and other fields.	3 – 6
Computer Science	CT.L2-6 Describe and analyze a sequence of instructions being followed (e.g., describe a character's behavior in a video game as driven by rules and algorithms)	6 – 9
Computer Science	CPP.L2-7 Identify interdisciplinary careers that are enhanced by computer science.	6 – 9
Computer Science	CT.L2-10 Evaluate what kinds of problems can be solved using modeling and simulation.	6 – 9
Computer Science	CT.L2-12 Use abstraction to decompose a problem into sub-problems.	6 – 9
Computer Science	CT.L2-14 Examine connections between elements of mathematics and computer science, including binary numbers, logic, sets, and functions.	6 – 9
Computer Science	CT.L2-15 Provide examples of interdisciplinary applications of computational thinking.	6 – 9
Computer Science	CT.L2-9 Interact with content-specific models and simulations to support learning.	6 – 9
Computer Science	CPP.L3A-10 Explore a variety of careers to which computing is central.	9 – 12
Computer Science	CT.L3A-12 Describe how computation shares features with art and music by translating human intention into an artifact.	9 – 12
Computer Science	CT.L3A-8 Use modeling and simulation to represent and understand natural phenomena.	9 – 12

Connections to Education Standards
(continued)

National Standards		Grade
Mathematics	CCSS.MATH.PRACTICE.MP1 Make sense of problems and persevere in solving them.	K - 12
Mathematics	CCSS.Math.Practice.MP2 Reason abstractly and quantitatively.	K - 12
Mathematics	CCSS.Math.Practice.MP4 Model with mathematics.	K - 12
Mathematics	CCSS.Math.Practice.MP5 Use appropriate tools strategically.	K - 12
Mathematics	CCSS.Math.Practice.MP6 Attend to precision.	K - 12
Mathematics	Common Core 5.G.A.1 Use a pair of perpendicular number lines called axes to define a coordinate system, with the intersection of the lines (the origin) arranged to coincide with the 0 on each line and a given point in the plane located by using an ordered pair of numbers, called its coordinates. Understand that the first number indicates how far to travel from the origin in the direction of one axis, and the second number indicates how far to travel in the direction of the second axis, with the convention that the names of the two axes and the coordinates correspond (e.g., x-axis and x-coordinate, y-axis and y-coordinate).	3 – 5
Mathematics	Common Core 6.G.A.4 Represent three-dimensional figures using nets made up of rectangles and triangles, and use the nets to find the surface area of these figures. Apply these techniques in the context of solving real-world and mathematical problems.	6 - 8
Mathematics	Common Core HSG.GMD.B.4 Identify the shapes of two-dimensional cross-sections of three-dimensional objects generated by rotations of two-dimensional objects.	9 - 12
Mathematics	Common Core HSG.MG.A.1 Use geometic shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).	9 - 12
Media Arts	MA:Cr.1.1.7 Produce a variety of ideas and solutions for media artworks through application of chosen inventive processes, such as concept modeling and prototyping.	7
Science	AAAS 1B/E1 Scientific investigations may take many forms including observing what things are like or what is happening somewhere, collecting specimens for analysis, and doing experiments.	3 – 5
Science	NGSS Practice 2 Use models to describe or predict phenomena.	3 – 12
Science	NGSS Practice 5 Apply mathematical concepts and/ or processes (e.g., ratio, percent, basic operations, simple algebra) to scientific and engineering questions and problems.	6 - 8
Science	NGSS Practice 5 Use digital tools and/or mathematical concepts and arguments to test and compare proposed solutions to an engineering design problem.	6 - 8
Visual Arts	VA:Cr2.1.4a Explore and invent art-making techniques and approaches.	4
Visual Arts	VA:Pr4.1.7a Compare and contrast how technologies have changed the way artwork is preserved, presented, and experienced.	7



The Science Behind PIXAR

MARCH 12 – SEPTEMBER 5

Locally Presented by: TE connectivity

IN THE MANDELL CENTER

AND THE NICHOLAS AND ATHENA KARABOTS PAVILION

This exhibition was developed by the Museum of Science, Boston in collaboration with Pixar Animation Studios.

Funding provided by:

Google Institute of Museum and Library Sciences National Science Foundation Science Museum Exhibit Collaborative

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Connect with the Museum community!

#ScienceOfPixar

Museum of Science 1 Science Park Boston, MA 02114-1099 **mos.org**

MR-15-6950