Leland and the Robotic Arm

Lesson Development **GRADES 9-12**

Apollo capsule (Image: NASA)

Earth (Image: NASA)

Leland Melvin (Image: NASA)

INSTRUCTIONAL OBJECTIVES

Students will

- examine how and why Leland Melvin switched from a career in professional football to a career as an astronaut;
- discover how difficult it is to guide a robot through a series of simple tasks;
- use Internet resources to deepen their understanding of the benefits of using robots in space exploration; and
- create a digital collage comparing model "robotic arms" to actual robotic arms.

BACKGROUND

Sometimes, robots are better suited than humans for space exploration. They can travel to worlds too far away or too dangerous for human explorers and extend the work schedule of a crewed space mission. Unlike humans, robots can endure uncomfortable or dangerous physical conditions, perform tasks tirelessly, and do not become bored or distracted. Robots can also operate in airless conditions making them very useful for certain types of work.

The Space Shuttle Remote Manipulator System (RMS) robot arm is one example of a working relationship between humans and robots. First used successfully aboard the STS-7, the RMS is the most common type of robotic arm used in space. The 15-meter-long arm recreates the movements of the human arm, and includes a 360-degree movement at the wrist, something humans are unable to do. It has seven degrees of freedom (DOF), which means that the arm can bend and rotate in seven different directions to accomplish its tasks. The arm also has joints at the shoulder, elbow and wrist and has a gripping component called an end effector.

The RMS has been used for remote assembly operations and for grappling as a positioning and anchoring device for astronauts working in space. It has also been used to grab the Hubble Space Telescope and bring it into the Shuttle's payload bay. On this mission, the RMS helped spacewalking astronauts repair the telescope and replace some of its components. Controlled by an astronaut inside the orbiter, the RMS served as an extension of the operator's arm. (Most recently the crew of STS-122 used the RMS to move the Columbus lab from the payload bay of Space Shuttle Atlantis and attached it to the International Space Station.)

NATIONAL EDUCATION STANDARDS

National Science Education Standards

- **Science as Inquiry**
  - Abilities necessary to do scientific inquiry
  - Understandings about scientific inquiry
- **Science and Technology**
  - Abilities of technological design
  - Understandings about science and technology
- **Science in Personal and Social Perspective**
  - Natural and human induced hazards
  - Science and technology in local, national and global challenges
- **History and Nature of Science**
  - Science as a human endeavor
  - Nature of scientific knowledge
  - Historical perspectives

National Educational Technology Standards

- Creativity and Innovation
- Communication and Collaboration
- Research and Information Fluency
- Critical Thinking, Problem-Solving & Decision Making
- Digital Citizenship
- Technology Operations and Concepts

National Council of Teachers of Mathematics

- Algebra
- Measurement
- Problem Solving
- Communication
- Connections
- Representation

National Institute of Aerospace

Lockheed Martin

AIAA The World's Forum for Aerospace Leadership

Apollo capsule (Image: NASA)

Earth (Image: NASA)

Robotic Arm on International Space Station (Image: NASA)

ENGAGE

Use the Discovery Now radio clip, Leland Melvin, to discuss with your students their understanding of how Leland's career change resulted in teaming with robots in space. Remind students that Leland Melvin first teamed with humans when he played football. The clip can be found at: ***http://www.discoverynow.us/2008/nasa50.html***

These questions can help guide your discussion:

- How did Leland Melvin begin his career as an astronaut?
- What was Leland Melvin's "backup plan" after he was injured?
- How do you think Leland Melvin's football career prepared him for his mission aboard STS-122?
- What was the significance of Leland Melvin's mission aboard STS-122, Space Shuttle Atlantis?

EXPLORE

Today's robots are incorporating multiple sensors that enable them to behave autonomously, making decisions based on the information they receive. They have the potential to change our economy, our health, and the world in which we live. Robots are found in hospitals, in space, under the sea and at home.

An everyday task like tying a shoe is easy once you learn how to do it. However, it is almost impossible for a mechanical robot with limited movement and few sensors.

During this EXPLORE activity; your students will work in teams of three, taking turns to discover how hard it is to accurately guide a robot through a series of simple tasks.

Using a digital camera, students will take digital images of their work and create a digital collage comparing their model robots to actual robotic arms.

It may be helpful for your students to review this Nortel LearniT video tutorial for help in creating their digital collages. The tutorial can be found at ***http://.nortellearnit.org/technology/Imaging /***

A. Guide the Robot

1. Prepare for the Lesson:
   - Organize students into teams of three.
   - Create a course for the robot to maneuver by setting up six chairs or desks in alternating (zig-zag) positions.
   - Place a shoe, with untied laces on the last chair.
2. Gather these materials for each team of students:
   - Digital camera
   - Blindfold
   - Masking tape
   - Tongue depressors or popsicle sticks
   - Basket with handle (for holding items)
   - Marble
   - Tennis ball
   - Pencil
   - Pair of shoes with shoelaces

Apollo capsule (Image: NASA)

Earth (Image: NASA)

Making Use of the Shuttle's Remote Manipulator System During STS-82 (Image: NASA)

3. Assign one student to the robot's role, another student the role of the controller and the third student the role of recorder using the digital camera. Remind the student to remain silent while in the robot role.
4. Loosely tape the tongue depressors to the robot's fingers with the masking tape. Remind students to make sure that the robot's fingers are not taped too tightly.
5. Blindfold the robot once the tongue depressors are secured.
6. Hand the robot the basket.
7. Following verbal instructions from the controller, the robot will move along a prescribed course, stopping on cue to pick up the marble, tennis ball, and pencil, placing each item in the basket.
8. Direct the robot to a chair and instruct the robot to:
   a. place the basket on the floor
   b. pick up the shoe
   c. sit in the chair
9. Instruct the robot to tie the shoelaces.
10. Ask students to switch roles and repeat steps 4-9.

EXPLAIN

A. Use these general questions to help lead a discussion following the EXPLORE experience:
- When you were the robot, how difficult was it to complete your tasks?
- Which task was the most difficult to accomplish?
- As the robot, did you find that being unable to speak made the tasks more difficult?
- What sensory devices could you add to the robot to make controlling it more precise?

ELABORATE

A. Share these resources with your students to deepen their understanding about the use of robots in space and how they enhanced Leland Melvin's tasks aboard STS-122.
1. Leland Melvin
   - Leland Melvin is Taking His Vision Into Space
     http://www.nasa.gov/mission_pages/shuttle/behindscenes/profile_lelandmelvin.html
   - Leland Melvin: Astronaut By Chemistry
     http://www.nasa.gov/astronauts/l_melvin_profile.html
   - Leland Melvin: NASA Biography
     http://www.jsc.nasa.gov/Bios/htmlbios/melvin.html
   - NASA Astronaut Leland Melvin's Football Story
     http://www.space.com/missionlaunches/nfl_series_day4_of_5.html
2. NASA and Robots
   - Types of Robots
     http://prime.jsc.nasa.gov/ROV/types.html
   - The Remote Manipulator System
     http://prime.jsc.nasa.gov/ROV/rms.html
   - NASA Robot Web Links
     http://prime.jsc.nasa.gov/ROV/nlinks.html
   - Mobility and Robotic Systems
     http://www-robotics.jpl.nasa.gov/

Apollo capsule (Image: NASA)

Earth (Image: NASA)

"Black Eye Galaxy" M64 (Image: NASA)

B. Challenge your students to compare the digital images of their "robotic" hands created in the EXPLORE experience to the robotic arms used in space. Encourage them to create a digital collage to illustrate their comparisons.

Encourage your students to put a descriptive title screen, credits and references at the end of the project. Please remind students to use only images that they have permission to include. Review copyright and copywrongs by watching the Nortel LearniT video tutorial at: ***http://nortellearnit/org/technology/Digital_Ethics/***

EVALUATE

Through discussion and the results of the EXPLORE experience, determine if your students have an accurate and deeper understanding of the benefits of using robotics in space exploration.

To evaluate Digital Collages, use this rubric found at the Nortel LearniT site:

- Digital Imaging Rubric
  http://nortellearnit.org/resources/Handouts/

EXTEND

These activities may be used to extend or continue your students' exploration.

A. Encourage your students to listen to these Discovery Now audio clips from previous Discovery Now seasons:
   - DEPTHX ***http://www.discoverynow.us/2007/science.html***
   - Raven the Robot ***http://www.discoverynow.us/2007/science.html***
   - Gripping Mechanism ***http://www.discoverynow.us/2007/science.html***
   - SAM ***http://www.discoverynow.us/2007/exploration.html***
   - Robonaut-Robotic Astronauts ***http://www.discoverynow.us/2007/exploration.html***

Once they've listened to the clips, challenge them to write and record their own Discovery Now radio spots. They might imagine they are reporters interviewing scientists who have invented a robot to perform a specific task. Possible interview questions include:

- What sparked your interest in robots and robotics?
- What kind of training is required to create robots or robotic devices?
- Why did you create your robot? How does the structure of your robot allow it to perform certain functions?
- What advice can you give young men and women who wish to pursue a career in science and robotics?