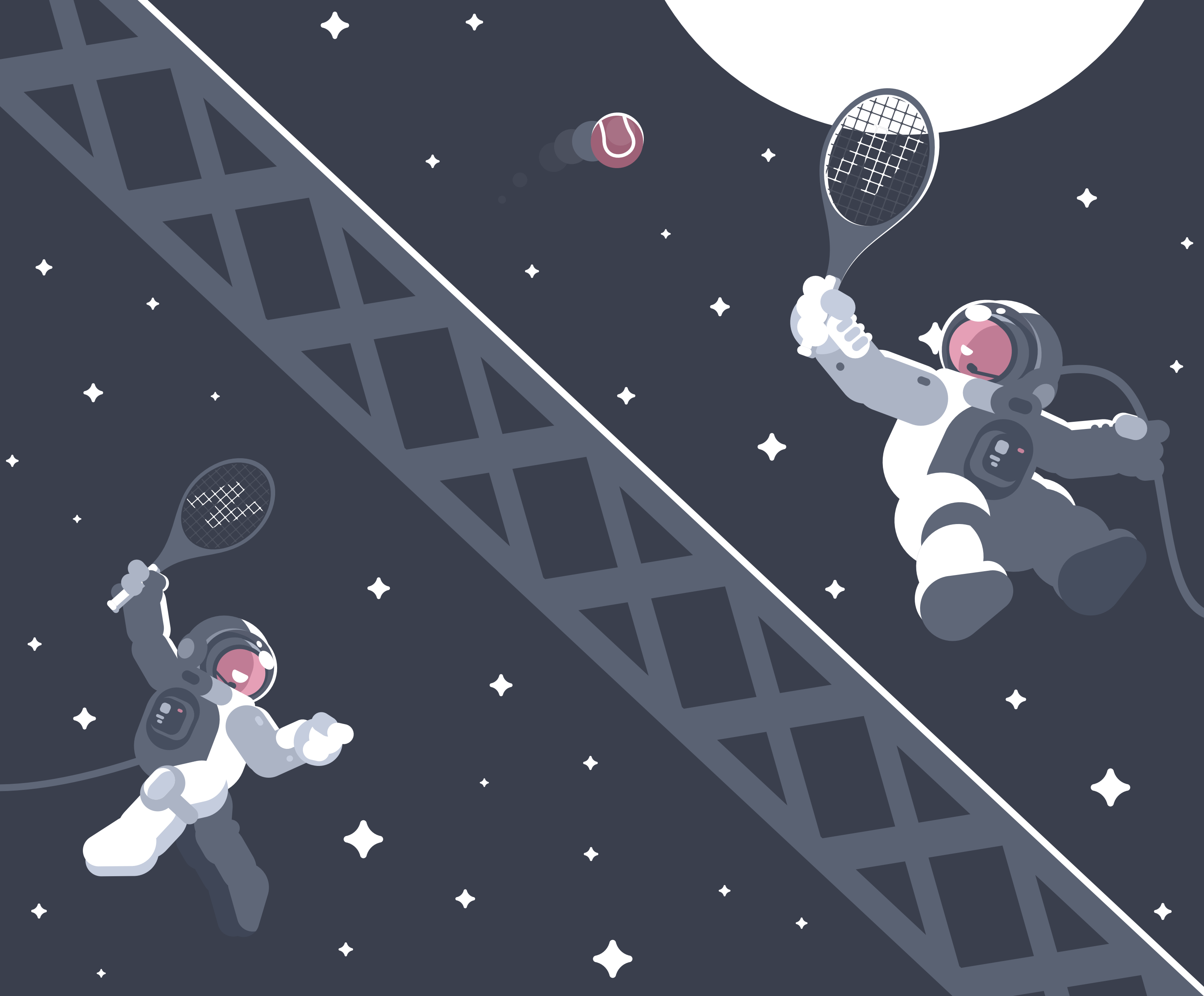

# STAYING FIT IN SPACE

## Exploring Exercise Through Project-Based Learning

BY JENNIFER ALBERT, SARAH IMAM, AND ROBIN JOCIUS

In space, astronauts have to exercise every day to prevent muscle and bone loss (NASA 2015). However, exercising in space is much different from what we're used to on Earth. Astronauts need to use exercise equipment designed for space because objects on Earth are much lighter in space due to *microgravity*, the state in which all objects fall at the same rate and appear to float (NASA 2009).

This article describes the design and implementation of an interdisciplinary unit in which students research the effects of exercise on heart rate, create hypotheses about the differences of exercise in space, and design activity trackers for astronauts on the International Space Station (ISS). During the unit, students learn about science and engineering practices, forces and motion, space science, data analysis, and statistics. The unit culminated with students generating a list of questions to ask astronaut Randy Bresnick about his time on the ISS and his research on the effects of space on exercise and health during a LiveLink discussion. The unit aligns with the *Next Generation Science Standards* (see *NGSS* connections box, p. 69).

## Engage

To engage students' prior knowledge about life in space, we start the lesson by showing them a video clip (see Resources) about the ISS, a research laboratory staffed with national and international scientists that continually orbits Earth at 402 km (250 mi.) above Earth's surface. In a discussion following the video clip, students mentioned that "being in space is a lot more than just being hundreds of miles above the Earth's surface." This comment led to a discussion on how basic activities on Earth are very difficult to carry out in space. As a class, we list activities (e.g., walking, eating) that would be difficult to do on the ISS and activities (e.g., flying) that would be easier on the ISS. We then ask students to brainstorm what made some activities easier and others harder.

When several students begin to hone in on the topic of gravity, we use an example of a baseball to help students understand the concept of microgravity. We tell our students, "If we were to drop a baseball inside the International Space Station, it would appear to float due to a lack of difference in speed and gravity. The baseball and everything aboard the International Space Station and the International Space Station itself are actually being pulled toward the Earth equally so the overall effect is that everything inside the ISS 'floats.'"

To connect to the central focus and goals of the learning segment, we ask students to brainstorm about how microgravity affects the human body and why it might be necessary but difficult to exercise in space. We suggest asking students to think of moments when they may have experienced weightlessness (e.g., jumping on a trampoline or riding a roller coaster). We then ask students to think about how we can measure the effects of exercise on the body. Most students have heard of an exercise tracker such as a FitBit. We suggest asking, "What does the exercise tracker monitor?"

After discussing and debating the difficulty of exercising in space, we ask students to think about how to monitor and measure the impact of

**CONTENT AREA**

**Earth science**

**GRADE LEVEL**

**6–8**

**BIG IDEA/UNIT**

**Space science and the human body**

**ESSENTIAL PRE-EXISTING KNOWLEDGE**

**None**

**TIME REQUIRED**

**One to two hours**

**COST**

**Minimal (<$20)**

**SAFETY**

**Teachers should watch for signs of overexertion.**

**FIGURE 1:** Data table

| Position | Student's name | Student's name | Mean, median, mode |
|---|---|---|---|
| Lying flat heart rate (beats/min) | | | |
| Sitting heart rate (beats/min) | | | |
| Standing heart rate (beats/min) | | | |
| Heart rate after 1 minute of exercise (beats/min) | | | |

exercise across different environments. During all discussions within this lesson, we formatively assess students' contributions to the class discussion using a checklist to monitor their understanding of new content and to make adjustments to activities and materials. To prepare students for the lab, they create a research question pertaining to heart rate, body position, and exercise. Sample research questions include: "Is my heart rate faster when I am walking or running?" and "Is my heart rate faster when I do jumping jacks or when I am running?" Questions must be approved by the instructor to ensure they are feasible to investigate before students move to the lab.

## Explore

Next, students engage in an interactive lab where they measure and research heart rates of different positions: lying, sitting, standing, and after brief exercise of their choice. In our classroom, students use heart rate monitors (e.g., exercise tracker, sensor, or Fitbit-type watches that record heart rate). If these tools are not available, teachers could show students how to use a stopwatch to find and record a pulse at their wrist or throat by counting the beats per minute or in a 10-second period. Then teachers would tell students to multiply that number by six to find the heart rate. We recommend pairing students, with one student performing the movements and the other student collecting the data before they switch places.

Before beginning each activity, students take a resting pulse by lying in a flat position and performing each movement in the order listed in the data table in Figure 1. Stations were set up around the room for different positions to ensure students had plenty of space. After briefing students on the warning signs of overexertion and going through warm-up stretches, we assign students to a station. In the station where students lie flat, students take turns lying down across a row of chairs that have been set up by the teacher and monitored by an adult volunteer. At each station, students monitor heart rate for the one minute in the position or after doing the exercise. *Safety note*: The teacher should monitor students for overexertion and allow any students with pre-existing health issues (e.g., broken limbs, heart condition, and physical disabilities) to serve as the "official researchers," helping to collect data. Teachers should also consult with the school nurse to make sure all students can participate.

**FIGURE 2:** Astronaut Randy Bresnick training on an Advanced Resistive Exercise Device (ARED), which helps maintain muscle strength

SAM MCADAMS

**FIGURE 3:** Astronaut Randy Bresnick on a Treadmill with Vibration Isolation and Stabilization System (TVIS), which helps maintain muscle and bone strength

SAM MCADAMS

Once students complete all stations, they calculate the difference in beats per minute among the various positions and movements by determining mean, median, and mode. Then, students record their calculations in the data table and make comparisons across positions, movements, and students. For example, students can subtract beats per minute standing from beats per minute sitting to get the difference in heart rate across positions. Students discuss differences within their groups. Groups that have additional time can also graph the data. This lab generally takes 30 to 45 minutes, depending on the technology and exercises used.

## Explain

We begin the Explain phase with a discussion about the human body in space to prepare students for a collaborative research project. We tell students that the heart is made up of the unique cardiac muscle, which tirelessly contracts approximately 100,000 times a day, and then we ask why they think the heart needs to contract. Student answers varied, but many said that the cells in our body require oxygen and nutrients and that we need an efficient delivery system to supply the cells with their requirements and remove waste products.

We provide students with specific examples focusing on the role of the heart in the human body, saying: "Every time it contracts, the heart ejects blood at a high force around the body. Cells that work more need a greater supply of blood. For example, during exercise, muscle cells are working harder and need more oxygen and nutrients. The heart is also beating faster, generating a greater force and pumping blood around the body at a faster pace."

We then ask the class: "When an astronaut in space moves, does their heart have to work harder or contract faster to make sure all of the muscle cells are adequately getting their supply?"

In our discussion, students said that an astronaut does not need extra nutrients or oxygen because "he is floating from one place to another." When one student asked whether that is a good thing, we explained that the heart needs its own workout to remain strong and healthy. Otherwise the muscle can begin to waste away in a process known as muscle atrophy.

Next, we ask students to imagine an astronaut floating and directing themselves in any direction without using skeletal muscles. We then describe a process known as *detraining*, during which the muscles, just like the heart, begin to waste away. This helps students understand that astronauts must use their muscles in space to prevent muscle atrophy. To give students an idea of exercising in space, we suggest showing them the "Running in Space" video (see Resources), in which NASA astronaut Karen Nyberg shows viewers how to run on a treadmill in a weightless environment.

After the discussion, group students into teams of three or four and have students select the heart,

## FIGURE 4: Activity tracker wristband design choices

**Your challenge:** Design an activity tracker wristband for an astronaut on the International Space Station that costs $100 or less. The base band starts at $60 and can be customized with the following options

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Band size** | | | **Screen size** | | | **Band color** | | |
| .75" x .5"<br>$5 | 1" x .5"<br>$0 | 1.5" x .75"<br>$10 | Small<br>$5 | Medium<br>$0 | Large<br>$10 | Black<br>$0 | White<br>$10 | Gray<br>$0 |
| **Button placement** | | | **Screen brightness** | | | Purple<br>$10 | Pink<br>$10 | Green<br>$10 |
| Left<br>$5 | Below<br>$5 | Right<br>$10 | Dull<br>$0 | Bright<br>$10 | | Other: $15 | | |
| **Downloadable mobile app** | | **Shape of face** | | **Button style** | | | | |
| No<br>$0 | Yes<br>$15 | Round<br>$10 | Rectangle<br>$5 | Flush<br>$10 | | Raised<br>$5 | | |
| **Features** | | | | **Band material** | | **Band weight** | | |
| Heart rate<br>$2 | Steps<br>$2 | Sleep<br>$2 | Extended battery<br>$14 | Rubber<br>$5 | Plastic<br>$10 | .5 oz.<br>$20 | .75 oz.<br>$15 | 1 oz.<br>$10 |

bones, or muscles as their research topic. We suggest using heterogeneous grouping, as this allows students to better understand their classmates' strengths. To ensure that all research topics are represented, the teacher may also decide to assign students to a topic. Using the NASA website and other online resources, including news articles and videos, the teams create a three- to five-minute presentation explaining how astronauts exercise the heart, bones, or muscles on the ISS by answering the following questions:

- What types of exercise target the selected research topic (heart, bones, or muscles)?
- What specific exercise or piece of exercise equipment would the astronaut use on the space station? (We provide students with a photos of space exercise equipment—see Figures 2 and 3.)
- How long do astronauts need to exercise?

Students' grades were based on the Oral Presentation Rubric (see Online Supplemental Materials).

## Elaborate

In the Elaborate phase, students select an astronaut currently serving on the ISS, design an activity tracker based on that astronaut's profile, and create a video advertisement to sell their activity tracker to their selected astronaut. These activities engage students in authentic design-based thinking and problem solving and can be linked to technology, mathematics, and English/language arts standards.

### Designing an activity tracker

To connect to previous learning and to engage students in debate about design choices and constraints, we tell students to think about what they had previously learned about heart rate and life in space and to keep costs below $100. Student pairs then discuss a variety of design features (e.g., width, button style, band material); debate the advantages and disadvantages of each design feature for their astronaut; and construct their activity tracker using cardstock, foam paper, laminating paper, glue, and scissors according to the specifications and materials list in Figure 4. As a safety precaution, we demonstrate how to use the scissors to cut different types of materials, including the laminating paper, foam paper, and band plastic. Students' conversations focused on topics such as visual design (e.g., color and the merits of a slimmer versus larger band), functionality (e.g., using larger battery or a brighter screen), and audience (e.g., discussing their selected astronaut's characteristics and interests), all of which illustrate design thinking.

While this activity generally takes about an hour, it could be shortened or extended based on time constraints and student learning needs. For instance, allotting more time for students to research commercially available activity trackers and health bands could lead to rich and authentic discussions about design features and limitations. Figure 4 could also be adapted to meet the needs of different students and classrooms. Students who are unable to cut and glue could draw or digitally construct the health bands. Materials, such as foam paper and buttons, could be chosen or modified to support blind or visually impaired students' with the activity. To support students with learning disabilities, teachers can use collaborative grouping or a selected set of design features. Finally, to adapt this activity for more advanced students or for high school classrooms, students could research other design features and add their own design elements to the bands.

### Creating a multimodal video advertisement

In the second part of the health band activity, students create a 30- to 60-second video advertisement to persuade their selected astronaut to purchase their activity tracker. As a class, we discuss how modes such as language, movement, music, sound, and images work together to convey meaning to an audience. Then we share a variety of advertisements and ask students to discuss and analyze rhetorical devices and persuasive techniques. We suggest showing the "Art of Rhetoric" video from readwritethink.org, as well as selected examples (see Resources). After discussing the assessment criteria (Figure 5), we share a variety of storyboard options (see Resources) and discuss different video editing tools (e.g., Animoto, Magisto, and Spark Video).

Students try at least two to three different tools for 10 to 15 minutes while following the Digital Citizenship guidelines that are part of their school's curriculum (see Resources). Students use their personal devices such as cell phones and tablets to experiment with the video editing tools, to understand the affordances and constraints of the tools, and to select a tool to use to create their advertisement. For example, many students select Spark Video, a free, easy-to-use editing tool. However, Spark Video does have limited editing options, so students with previous video-editing experience may choose Magisto, which is more difficult to use but offers more options in terms of music and image editing. For schools with one-to-one device or device checkout programs, students can use the tools listed above or pre-installed video software, such as iMovie.

Students then choose a storyboard template (see Resources), plan their compositions, and present their storyboard to the teacher for an informal check before recording their advertisements. During the storyboard process, some students draw pictures of what each frame of their advertisement might look like, while others describe the scenes using words or a combination of words, images, and colors. After recording and editing their advertisements, students present their video advertisements to the class and reflect on the process of planning and creating their work. Students may spend about 45 minutes on designing and recording advertisements and about 15 minutes for presentations and reflections. Advertisements were assessed according to the rubric in Figure 5, which could be adapted or used as part of an interdisciplinary unit involving persuasive writing or multimodal composition. This activity works particularly well for ELL students, who benefit from multi-sensory instruction that incorporates technology and visual representations (Hur and Suh 2012).

## Evaluate

In the culminating assessment for this lesson, students have a conversation with an astronaut on the ISS. To prepare for the conversation, students create questions that draw upon their experiences with the

**FIGURE 5:** Advertisement rubric

| | 4 | 3 | 2 | 1 | Total |
|---|---|---|---|---|---|
| **Purpose and content** | Clearly relates to the learning objective or illustrates a concept | Relates to the learning objective or illustrates a concept | Some relation to the learning objective or concept | Does not relate to the learning objective or does not illustrate a concept | |
| **Storyboard planning** | Completed detailed storyboard with all of the following: statement of purpose, script, and storyboard of the video clips | Completed storyboard with all of the following: statement of purpose, script, and storyboard of the video clips | Completed storyboard with at least two of the following: statement of purpose, script, and storyboard of the video clips | Storyboard not completed | |
| **Titles, transitions, and effects** | Titles or transitions enhance the video | Titles or transitions do not detract from the video | Attempts to use titles or transitions, but they detract from the video | No titles or transitions exist | |
| **Video/ photos** | Video and photos relate to the subject | Videos and photos mostly relate to the subject | Videos and photos are limited and some are off topic | No videos or photos relate to the subject | |
| **Audio** | Movie includes voice and music. Audio levels are just right | Movie includes voice and music. Audio levels are too low or too loud. | Movie has only music. Audio levels are too low or too loud. | Movie has no sound | |
| **Use of technology** | Skilled operation of computer and program enhances presentation | Satisfactory operation of computer and program during presentation | Minimal operation of computer and program during presentation | Incorrect operation of computer and program detracts from presentation | |
| **Presentation** | Shared final product with audience, answered all questions in knowledgeable way, and explained the steps to production clearly | Shared final product with audience, answered some questions in knowledgeable way, and explained the steps to production | Shared final product with audience and attempted to answer questions and explain steps to production | No final product to share | |

class discussion, lab, and health band activities. As a class, students debate the merits of various questions and select five questions to ask astronaut Randy Bresnik during the LiveLink conversation.

The LiveLink discussion allows students to synthesize their learning and engage in an authentic conversation with an astronaut. For about 20 minutes, students ask the questions that had been voted

## Connecting to the *Next Generation Science Standards* (NGSS Lead States 2013)

- The chart below makes one set of connections between the instruction outlined in this article and the *NGSS*. Other valid connections are likely; however, space restrictions prevent us from listing all possibilities.
- The materials, lessons, and activities outlined in the article are just one step toward reaching the performance expectations listed below.

### Standards

MS-LS1 From Molecules to Organisms: Structures and Processes
*www.nextgenscience.org/pe/ms-ls1-3-molecules-organisms-structures-and-processes*

MS-ETS1 Engineering Design
*www.nextgenscience.org/dci-arrangement/ms-ets1-engineering-design*

### Performance Expectations

MS-LS1-3. Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.

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.

| DIMENSIONS | CLASSROOM CONNECTIONS |
|---|---|
| **Science and Engineering Practices** | |
| Planning and Carrying Out Investigations | Students design and carry out an investigation of exercise. |
| Obtaining, Evaluating, and Communicating Information | Students research different exercises and exercise devices on the ISS and present their findings. |
| **Disciplinary Core Ideas** | |
| LS1.A: Structure and Function<br>• In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions. | Students compare how the heart, bones, and muscles function on Earth compared to outer space. |
| ETS1.A: Defining and Delimiting Engineering Problems<br>• The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. | Students research an astronaut on the ISS and design an activity tracker that incorporates visual design, functionality, and audience. |
| **Crosscutting Concepts** | |
| Structure and Function | Students research how specific body structures (heart, bones, muscles) function. |
| Cause and Effect | Students research how specific body structures (heart, bones, muscles) are affected by microgravity and the role of exercise in minimizing those effects. |

on and chosen by the whole group. Students' questions directly connected to their experiences within this learning segment. For example, one student asked, "How has it been, adjusting to the microgravity in space?" In his response, the astronaut compared microgravity to going over a bump in a car and being on a roller coaster, and discussed a daily, two-and-a-half-hour exercise regimen designed to prevent muscle atrophy. Other questions asked during the chat included: "What are the psychiatric effects of being in space? What do you think the next big accomplishment or discovery will be in space? What specific jobs do you and your crew perform in space? What classes, majors, or activities did you take in college that helped you become an astronaut? What is the mission of your team on the ISS?"

While LiveLink chats are only available to schools by invitation, this activity can be adapted in many ways: Students could participate in an online NASA Scientist Chat, engage in a fishbowl discussion, or brainstorm questions and research answers. For example, the online NASA Scientist Chat (see Resources) allows students to pose questions to a variety of NASA scientists, such as astrobiologists, physicists, space scientists, and geologists, during a live online discussion or via Twitter.

## Conclusion

This learning segment engages students in a variety of activities, such as discussion, debate, experimentation, design, and multimodal presentation, all of which support active learning about important STEM topics. Students also have the opportunity to think critically about potential STEM careers and career pathways. As astronaut Randy Bresnik stated during the LiveLink, "We need people beyond us to do this job and take us beyond the space station. That's you guys in school, you guys studying and looking at all these neat things in STEM, that are allowing you to figure out how to make things, create things, engineer things. You guys can be the astronauts to take us to Mars and beyond." ●

## REFERENCES


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National Aeronautics and Space Administration (NASA). 2015. Exercising in space. *www.nasa.gov/audience/foreducators/stem-on-station/ditl_exercising*

NGSS Lead States. 2013. *Next Generation Science Standards: For states, by states*. Washington, DC: National Academies Press.


## RESOURCES

Digital Citizenship Curriculum—*www.commonsense.org/education/digital-citizenship*

ISS video clip—*www.youtube.com/watch?v=ouDKD9G9jOE*

NASA scientist chat—*https://science.nasa.gov/get-involved/chat-with-a-scientist*

"Running in Space"—*www.youtube.com/watch?v=_ikouWcXhdO*

**Advertising examples**

Amazon example ad—*www.youtube.com/watch?v=J6-8DQALGt4*

"Art of Rhetoric"—*www.readwritethink.org/videos/rhetoric/video-61.html*

iPod example ad—*www.youtube.com/watch?v=NIHUz99I-eo*

Pepsi example ad—*www.youtube.com/watch?v=0gHYd67OumQ*

**Storyboard samples**

Blank Storyboard Template—*www.readwritethink.org/files/resources/lesson_images/lesson1088/Storyboard.pdf*

Comic Creator—*www.readwritethink.org/files/resources/interactives/comic*

Printing Press—*www.readwritethink.org/files/resources/interactives/Printing_Press*

## ONLINE SUPPLEMENTAL MATERIALS

Oral Presentation Rubric—*www.nsta.org/scope1901*

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