Introduction to NASA's BEST Educator Guide

Resources in this Introduction are provided to help educators engage and support all students in learning, plan instruction and learning activities, and assess student learning. The following sections are included:

INTRODUCTION TO NASA's BEST EDUCATOR GUIDE

This NASA's BEST Educator Guide was originally designed to showcase NASA's Technology Demonstration Missions (TDM). In 2017, these activities were revised to emphasize technologies used to support deep space exploration. These technologies allow NASA missions to pursue bolder and more sophisticated science, enable safe and rewarding human missions beyond low-Earth orbit, and enable entirely new approaches to U.S. space operations. The student challenges focus not only on the engineering design process but also on bringing real world science, math, and technology to the middle school classroom.

WHAT MAKES NASA'S BEST EDUCATOR GUIDE UNIQUE

- There are no specific instructions or "recipes" for building the products. Given the challenge requirements, constraints, and materials, students work together to come up with the best solution. This can be challenging for teachers and students at first, but once the students start thinking this way, it will come naturally.
- Challenges are designed to allow the teacher flexibility in terms of materials, time, students' abilities, and resources. This also is helpful for adding cross-curricular engagement, such as including the use of available technology, writing reports, budgets, historical background, etc.

- There is limited information about what the final solution should "look like. The emphasis is for students to understand that engineers must "imagine and plan" before they begin to build and experiment. Often engineers just know the problem they would like to solve and are not sure what it will look like when they first start working.
- Activities help develop a unique combination of 21st century learning and innovation skills that include creativity, critical thinking, problem solving, communication and collaboration.
- NASA's latest technological developments may be brought to the middle school classroom in real time. These projects have ongoing missions that will engage students in the excitement of NASA for years to come as development and testing of new technologies continue, launches occur, and data is analyzed.

COMPREHENSIVE MATERIALS LIST

Below is a suggested list of materials needed to complete all activities for a group of 24–32 students (about 8 teams of students in small groups of 3–4). Most items may be commonly found at home or in the classroom. Encourage using recycled materials. Most materials can be reused for another activity.

Required for all Challenges (per team unless otherwise noted)

- Digital scale or balance (1–2 per class)
- Drop cloth
- Hairdryer (2–3 per class)
- Meter sticks and rulers
- Measuring tapes
- Stopwatches
- Thermometers (not required for all challenges)
- Scissors (2 per team)
- Tape (masking/clear & heavy duty [duct], 1 roll per team)

General Building Supplies

These materials are for common use, so depending what students select to use for the challenge, amounts will vary class to class. Refer to the material list within each challenge for more information. Materials can be found in local hardware stores or online.

- Aluminum foil
- Baking soda
- Balloons
- Bamboo skewers
- Binder clips
- Bubble wrap
- Buttons or beads
- Cardboard, cardboard boxes, card stock
- Clear/white film canisters (purchase online)

- Clothes pins
- Colored pencils and crayons
- Cotton balls
- Drop cloth (plastic)
- Effervescent tablets
- Embroidery or quilting thread
- Empty paper towel and toilet paper tubes
- Fishing line (~20 lb. test)
- Fun size candy bars
- Glow sticks
- Glue sticks and glue bottles
- Hot glue gun/glue sticks (optional)
- Hand sanitizer
- Index cards
- Modeling clay
- Oatmeal empty container (for size constraint)
- Paper clips
- Plastic Easter eggs (1 per team)
- Plastic and foam (thermal) cups
- Plastic trash/grocery bags
- Plastic "people" represent astronauts (or "hand make" astronauts)
- Plastic wrap
- Pipe cleaners
- Rubber bands (various sizes)
- Safety goggles
- Sealable storage bags (sandwich and gallon)
- Staplers and staples
- Stirrer sticks
- Straws
- Small weights/washers
- Vinegar
- Wire mesh

Included in Each Activity

Each activity is divided into four sections:

- *Background Information* - include background and contextual information.
- *Student Pages* - include an introduction to the design challenge requirements and constraints, vocabulary, recommendations for moving through each of the steps in the engineering design process. Images and sidebars expand contextual information and engage students in related NASA missions and themes. A section on *More Fun with Engineering* provides suggestions for extending the evaluation of the design (*Extend Your Research*) and exploring related topics (*Explore Further*).

- *Student Worksheets* - designed to provide progress monitoring, improve student collection and analysis of data, and facilitate student reflection on learning. Each activity includes five worksheets: *Design Plan, Testing Data Table, Final Design, Quality Assurance Form*, and *Discussion Questions*. Worksheets are provided as independent Word files to allow for digital completion, submission, and storage.
- *Teacher Pages* - provide pre-activity considerations, a list of materials and safety concerns, student engagement strategies, common misconceptions, suggestions for supporting students as they move through the engineering design process, and alignment with Next Generation Science Standards (NGSS), Common Core Standards for Mathematics, and Common Core Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects.

Safety Considerations

NASA is very mindful about safety, and concerns are included in call-out boxes and identified throughout the activities with a special symbol. Below is an example of how safety concerns are identified in *Teacher* and *Student Pages*.

SAFETY CONCERNS

It is important to keep safety a priority with all activities! Here are five critical strategies:

- Teachers and students should always wear safety goggles! Closed-toed shoes with rubber soles are also encouraged.
- Before students begin building, the teacher should formally approve all drawings and materials lists.
- When reviewing designs, teachers should look for potentially hazardous combinations of chemicals or flimsy designs of structures.
- Students should NOT bring additional materials for their designs without the teacher's prior approval.
- Teachers should always check materials in advance and replace any that are damaged or in disrepair.

Activity Management

- Activities are designed for students to work in small teams of 3–4.
- Most activities require at least two 60-minute class periods, but may also be expanded to fill several days. Time management tips are provided in the *Teacher Pages* for each activity.
- Challenge complexity may be increased by adding budget and time constraints or expanding on mathematical and science content.
- Activities are designed for use during the school day or as activities in after-school clubs.
- Activities can be done as stand-alone activities or as part of a complete unit. We provide

a "story-line" for complete implementation (see *Summary of Activities* in this document).

Summary of Activities and Alignment with Selected Standards

Each activity aligns with at least one standard in science and/or mathematics. This alignment is demonstrated in *Table 1: Matrix of Activities, Selected Standards, and Alignment*. We have identified only those standards for which the activity significantly develops students' understanding and skills. Additional standards are also applicable.

In addition, all activities are aligned with a number of standards for grades 6-8 in Next Generation Science Standards, Common Core Standards for Mathematics, and Common Core Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects. This alignment is demonstrated in Table 2: Alignment of Activities with Common NGSS, CCM, and CCELA Standards, and includes the following domains/practices:

- **NGSS Practices** - NGSS identifies eight practices of science and engineering that are essential for all students to learn and which are addressed throughout NASA's BEST activities.
- **NGSS Middle School Standards for Engineering, Technology, and Application of Science** – NGSS identifies four standards on Engineering Design that are addressed throughout NASA's BEST activities.
- **CCM Mathematical Practices** – CCM identifies eight practices of mathematics that are addressed throughout NASA's BEST activities.
- **CCM 6-8 Standards for Statistics and Probability** – CCM identifies 17 standards for statistics and probability for grades 6-8. Many of these are addressed throughout NASA's BEST activities.
- **CCELA 6-8 Standards for Science and Technical Subjects -** CCM identifies a significant number of standards in for grades 6-8. We have selected key standards to demonstrate how they are addressed throughout NASA's BEST activities. Additional standards are also applicable.