



NASA STEM ENGAGEMENT HIGHLIGHTS 2020





INSPIRE - ENGAGE - EDUCATE - EMPLOY
The Next Generation of Explorers

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NASA STEM Engagement at a Glance

In 2020, the National Aeronautics and Space Administration (NASA) invested in endeavors in science, technology, engineering, and mathematics (STEM) engagement provided exciting and compelling learning experiences for students across our nation. With contributions from the Office of STEM Engagement (OSTEM), directorates, centers, and functional organizations, the STEM engagement portfolio comprises a diverse set of activities, and products designed to attract, engage, and educate students, and to support educators, and educational institutions. Through these efforts, NASA makes vital contributions to federal education goals to build a strong foundation for STEM literacy, prepare the STEM workforce of the future, and increase diversity, equity, and inclusion in STEM.

In the midst of the COVID-19 pandemic, NASA's STEM engagement community rapidly shifted to a new model of virtual implementation of its student, and educator activities. While serving students, educators, and institutions during the pandemic offered unique challenges, it also presented opportunities to explore how to better meet students where they are. Adapting and responding to needs in the midst of this unprecedented time, NASA STEM Engagement led the way to reinvent and rapidly evolve efforts already underway and create new opportunities.

NASA's congressionally appropriated \$120 million STEM Engagement program and its four constituent projects executed a wide reaching set of activities for the benefit of students via: direct student awards for NASA internships and fellowships; student challenges and competitions; educator resources and opportunities; competitive awards to educational institutions for conducting research and development, building capacity, and creating student learning opportunities.

These 2020 highlights provide a glimpse of the vibrant and fruitful efforts conducted across the spectrum of NASA STEM engagement, painting a vivid picture of the vital impact and contributions of this work toward building a diverse future STEM workforce.



NASA Strategy for STEM Engagement

VISION

We immerse students in NASA's work, enhance STEM literacy and inspire the next generation to explore.

MISSION

We engage students in NASA's mission.

STRATEGIC GOAL 1

Create **unique opportunities** for a diverse set of students to contribute to NASA's work in exploration and discovery.

OBJECTIVES:

- 1.1 Provide student work experiences that enable students to contribute to NASA's missions and programs, embedded with NASA's STEM practitioners.
- 1.2 Create structured and widely accessible experiential learning opportunities for students to engage with NASA's experts and help solve problems critical to NASA's mission.

STRATEGIC GOAL 2

Build a **diverse future STEM workforce** by engaging students in authentic learning experiences with NASA's people, content, and facilities.

OBJECTIVES:

- 2.1 Develop and deploy a continuum of STEM experiences through authentic learning and research opportunities with NASA's people and work to cultivate student interest, including students from unrepresented and underserved communities, in pursuing STEM careers and foster interest in aerospace fields.
- 2.2 Design the portfolio of NASA STEM engagement opportunities to contribute toward meeting agency workforce requirements serving the nation's aerospace and relevant STEM needs.

STRATEGIC GOAL 3

Attract **diverse groups of students to STEM** through learning opportunities that **spark interest** and **provide connections** to NASA's mission and work.

OBJECTIVES:

- 3.1 Attract a broad and diverse set of students to STEM through targeted opportunities and readily available NASA STEM engagement resources and content.
- 3.2 Foster student exposure to STEM careers through direct and virtual experiences with NASA's people and work.

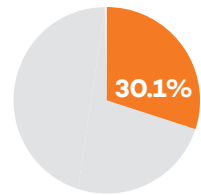
STEM Engagement Summary of Impact

Internships, Fellowships, and other Higher Education Awards

6,412 **\$35M**

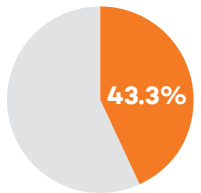
internships, fellowships, and other higher education awards

direct financial support to higher education students



30.1%

of higher education awards were to racially or ethnically underrepresented student participants



43.3%

of higher education awards were to women, up from 39.5% in FY 2018

Research and Development

2,015

peer-reviewed publications, technical papers, and presentations reported by



Space Grant, MUREP, and EPSCoR grantee and awardee institutions

50%

of the peer-reviewed publications were authored, or co-authored, by students

8 patents were awarded to higher education institutions as a direct result of their NASA STEM Engagement program grants or cooperative agreements

Collaborators

OSTEM collaborated with **2,097**

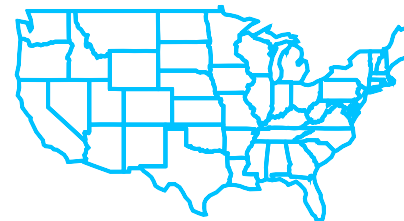
institutions and organizations



Collaborators were funded and unfunded from across all

50

states, plus the District of Columbia, Guam, Puerto Rico, and U.S. Virgin Islands



Partnerships, Students, and Educators

95

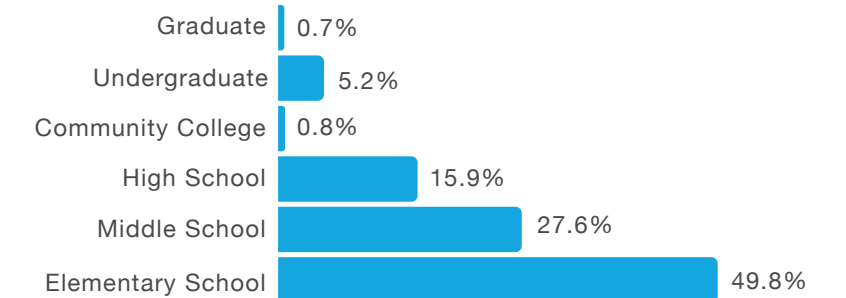
educational institutions awarded competitive grants and cooperative agreements across

50

states, plus the District of Columbia, Guam, Puerto Rico, and U.S. Virgin Islands

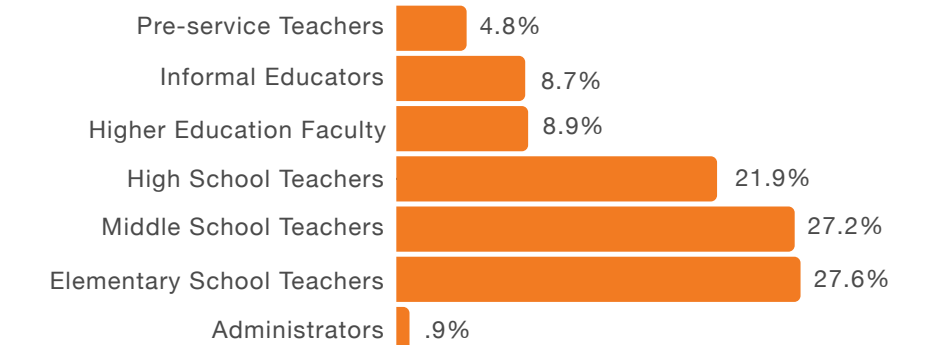
691,753

students participated in NASA STEM engagement activities



86,441

educators participated in NASA STEM engagement training activities



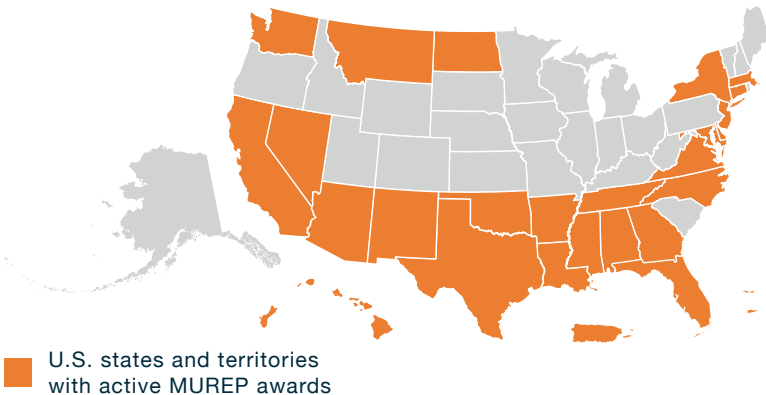
STEM Engagement Program Snapshot

MUREP (\$36M)

The Minority University Research and Education Project (MUREP) provides financial assistance via competitive awards to minority-serving institutions, or MSIs. These opportunities are available to Historically Black Colleges and Universities (HBCU), Hispanic-Serving Institutions (HSI), Asian American and Native American Pacific Islander-Serving Institutions (AANAPISI), Alaska Native and Native Hawaiian-Serving Institutions (ANNH), American Indian Tribal Colleges and Universities (TCU), Native American-Serving Nontribal Institutions (NASNTI), Predominately Black Institutions (PBI) and others. MUREP investments enhance the research, academic and technology capabilities of MSIs through multiyear cooperative agreements. Awards assist faculty and students in research and provide authentic STEM engagement opportunities related to NASA missions, affording NASA-specific knowledge and skills to students from groups that have historically been underrepresented and underserved in STEM. For more information, visit nasa.gov/stem/murep.

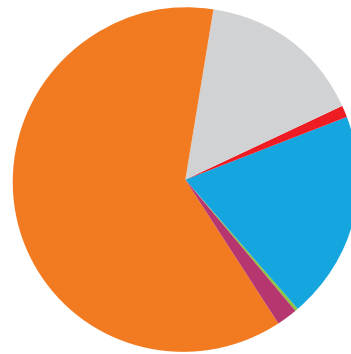


28 U.S. states and territories represented



100+
active MUREP awards granted to

71
U.S. MSIs



FY 2020 MSI Awards

- HSI - 61.6%
- HBCU - 19.6%
- Other - 15.9% (Dual Designations)
- TCU - 2.0%
- AANAPISI - 0.9%
- PBI - 0.1%

Space Grant (\$48M)

The National Space Grant College and Fellowship Project, or Space Grant, is a national network of colleges and universities with over 1,000 affiliate institutions and organizations working to expand opportunities for students to participate in NASA's aeronautics and space projects. Space Grant is made up of 52 consortia located in all 50 states, the District of Columbia, and Puerto Rico. The project funds internships, fellowships and scholarships and offers programs and learning opportunities that enable and support STEM education, research, and student engagement. Space Grant also engages students and educators from elementary to secondary levels through hands-on experiences, faculty development, curriculum enhancement, and precollege education. For more information, visit nasa.gov/stem/spacegrant/home/index.html



Space Grant Consortia provide state-wide opportunities that contribute to NASA's mission in:

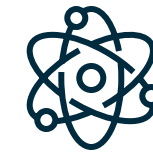
AERONAUTICS



HUMAN EXPLORATION



SCIENCE



SPACE TECHNOLOGY



1,000+

affiliates from universities, colleges, industry, museums, science centers, and state and local agencies

52

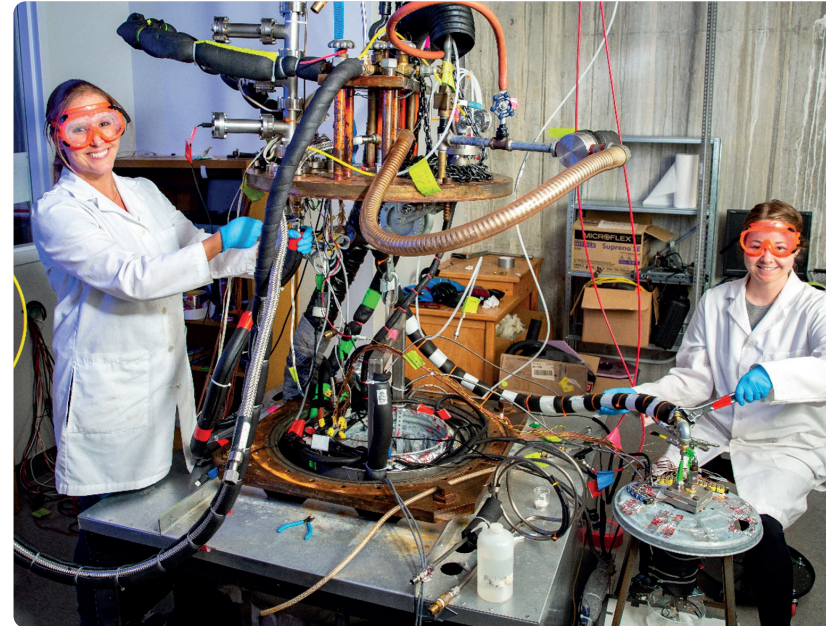
nationwide consortia from 50 states, plus the District of Columbia and Puerto Rico, represented

NASA STEM Engagement Program Snapshot

EPSCoR (\$24M)

The Established Program to Stimulate Competitive Research (EPSCoR) establishes partnerships with government, higher education, and industry that are designed to effect sustainable improvements in research infrastructure, research and development capacity and competitiveness in eligible jurisdictions. EPSCoR is directed at those jurisdictions that have not participated equably in competitive research and development activities. Twenty-five states, the Commonwealth of Puerto Rico, the U.S. Virgin Islands and Guam currently participate. Five federal agencies, including NASA, conduct EPSCoR programs.

In 2020, NASA EPSCoR conducted four competitive awards processes aimed toward increasing research and development capacity and improvement, while enabling valuable contributions to NASA mission needs and challenges. Four competitive solicitations yielded 78 awards for a total of over \$19 million in direct awards to institutions. For more information, visit nasa.gov/stem/epscor/home/index.html

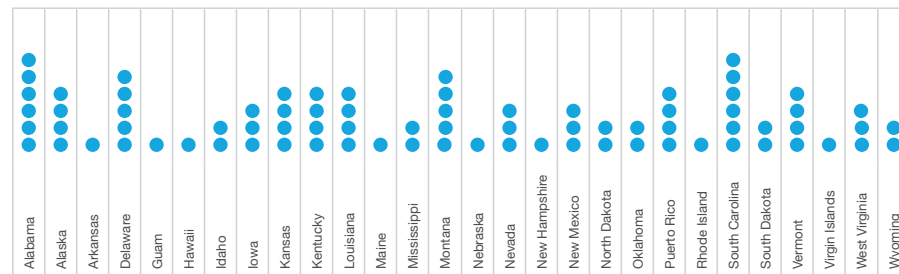


Next Gen STEM (\$12M)

The Next Generation (Next Gen) STEM Project provides a platform for students to contribute to NASA's endeavors in exploration and discovery through mission-driven activities, evidence-based education products, and authentic STEM experiences. With its primary focus on K-12 and informal education, Next Gen STEM aims to help attract and retain students toward building a vibrant next-generation STEM workforce, focusing on reaching underrepresented and underserved populations. Next Gen STEM conducts competitive opportunities for informal educational institutions through Teams Engaging Affiliated Museums and Informal Institutions (TEAM II). Next Gen STEM operates the Museum and Informal Education (MIE) Alliance, which offers learning institutions educational resources and services. For more information, visit nasa.gov/stem/nextgenstem.



Students participating in activities prior to COVID-19 restrictions.



FY 2020 EPSCoR Awards

- Research Infrastructure Development - \$3.5M
- Rapid Response Research - \$2.4M
- International Space Station Flight Opportunity - \$0.5M
- Research - \$12.7M

78 total awards across **28** jurisdictions

Teams Engaging Affiliated Museums and Informal Institutions, or TEAM II

65 organizations across **34** states, plus the District of Columbia

Museum and Informal Education Alliance

1,270 organizations across **39** countries, including the U.S.

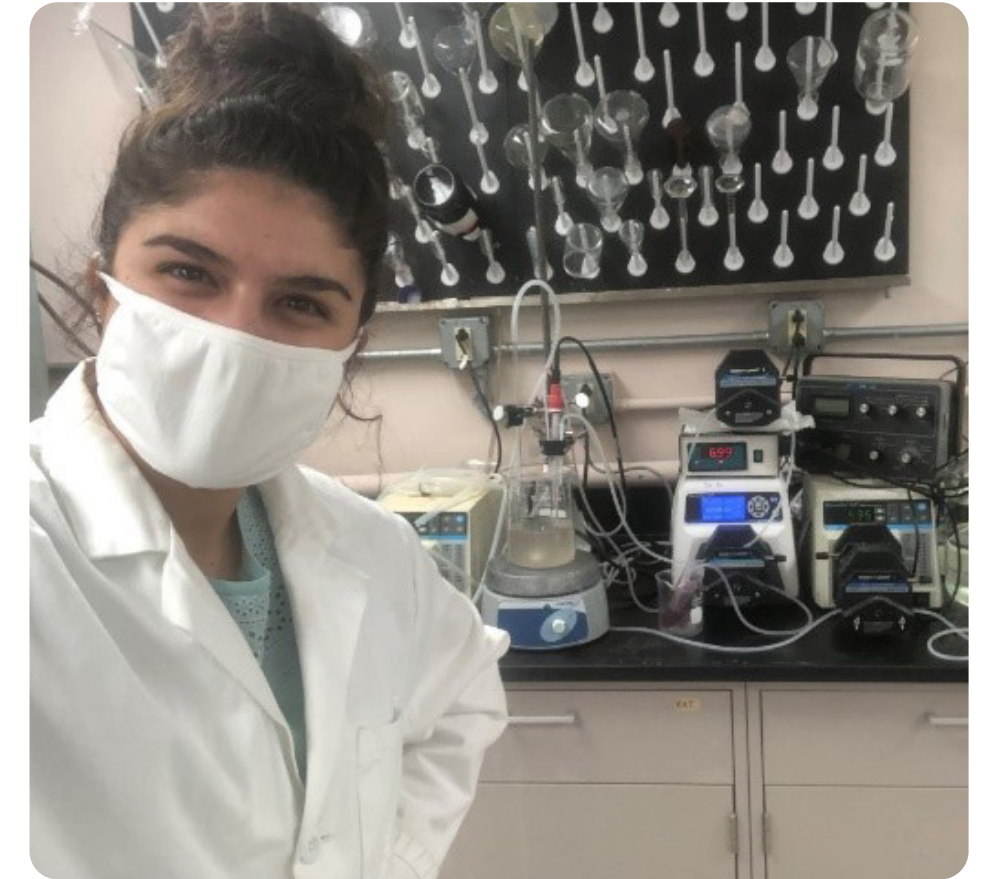
ENGAGING STUDENTS DURING A PANDEMIC



Adapting in the Midst of a Pandemic

In 2020, NASA's STEM Engagement community rapidly adapted opportunities and programs in order to reach students. While the COVID-19 pandemic presented a unique set of challenges, it also created the space to explore how to reach more students through virtual experiences. At the close of fiscal year 2020, over 500 student and educator activities had been re-planned in response to the pandemic. In order to adapt and shift to a virtual environment, NASA created new opportunities, put in place new platforms, and piloted innovative methodologies to reach and engage students remotely. For example, NASA created NASA STEM@Home, a digital platform to enable students and their families to engage in learning at home; and developed and deployed remote opportunities for educators and educational organizations.

Overall, NASA has made changes this year that will outlive the pandemic, as the STEM Engagement portfolio continually evolves and adjusts projects to meet students where they are. The pandemic also illuminated the challenges inherent in the digital divide. In response, NASA has embarked on a strategy for broadening student participation to more effectively reach underserved and underrepresented student communities in STEM.

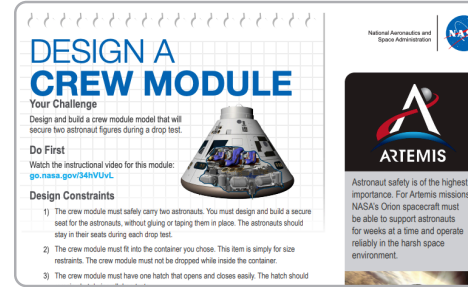
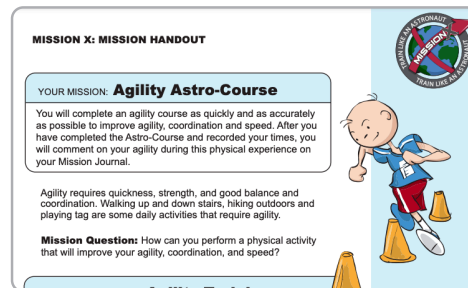


Creating New Digital Platforms to Reach Students at Home

NASA STEM @ Home

NASA STEM @ Home was created early in the pandemic, offering a variety of educational resources to engage students and their families in STEM learning and activities at home. In March 2020, as COVID-19 stay-at-home orders came into effect, the NASA Kids' Club website received over a half-million page views in the first week of the quarantine. The website saw a 316% increase in views from February 2020 to March 2020. Dedicated to serving this influx of at-home learners, NASA created NASA STEM @ Home to provide tools parents and caregivers could use for at-home STEM learning.

STEM @ Home offers age-appropriate, mobile-friendly resources grouped by grade level. Resources include immersive STEM activities; webinars produced in English and Spanish featuring NASA subject-matter experts; Aeronautics @ Home aerospace-based activities; and programs that encourage physical exercise to be a part of students' at-home curriculum, such as the Train Like an Astronaut program. Parents and caregivers can also access teaching tips in an online series that offers guidance in teaching STEM at home.



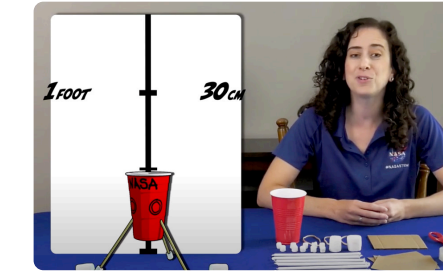
NASA STEM @ home for students

- K-4 www.nasa.gov/stem-at-home-for-students-k-4.html
- 5-8 www.nasa.gov/stem-at-home-for-students-5-8.html
- 9-12 www.nasa.gov/stem-at-home-for-students-9-12.html

NASA @ Home video series

To improve the accessibility of NASA information to underserved communities during the COVID-19 pandemic, NASA partnered with the Science Matters television program at Virginia Public Media, or VPM to provide high-quality instruction for students and families without access to internet or cable TV. In 2018, the U.S. Census Bureau reported that around 15 million households have no internet access — an estimated 360,000 of which are in Virginia. Through its collaboration with Science Matters, NASA @ Home Programming has been shared through VPM's regional broadcast and across its multimedia platforms, using VPM's potential to reach 710,150 households.

Each NASA @ Home episode has a distinct STEM-based theme and contains at least one hands-on activity that students can participate in from home. VPM also created three pilot episodes showcasing NASA STEM careers, which premiered in July and aired again in the fall. The content was also shared on NASA websites, including the NASA STEM YouTube channel and the NASA @ Home website, where students from all over can access and benefit from the videos.



Episode 1:
NASA at Home:
Zoom Without the Boom
vpm.org/articles/14426/nasa-at-home-zoom-without-the-boom

Episode 2:
NASA at Home:
Launching America
vpm.org/articles/14768/nasa-at-home-launching-america

Episode 3:
NASA at Home:
Mars 2020 – Perseverance
vpm.org/articles/14895/nasa-at-home-mars-2020-perseverance

Episode 4:
NASA at Home:
To the Moon and Beyond!
youtube.com/watch?v=b8xBlk_4V0g

Developing Remote Opportunities for Educators and Educational Organizations

Remote Opportunity Rapid Response

The TEAM II Remote Opportunity Rapid Response (RORR) was a new competitive solicitation issued in response to the unique learning challenges presented by the COVID-19 pandemic. RORR provided financial support in the range of \$100,000 to \$175,000 for up to one year for competitively selected informal education institutions to amplify or create innovative remote or distance-learning programs, opportunities, or projects to reach K-12 students using relevant NASA content.

Due to an impressive selection of qualified proposals, more projects were funded than originally planned, including: an augmented-reality environment for students to work collaboratively on the virtual surface of Mars; activity kits for students to do at-home research on growing food in space; live virtual engagement and spotlight videos highlighting STEM careers and diverse speakers; and school and community ozone gardens for the collection of plant injury data. The rapid-response nature of this opportunity allowed projects to be successfully implemented as quickly as possible during the 2020-2021 school year.



\$1.15M in awards:

Abrams Planetarium Michigan State University East Lansing, Michigan	World Building on Mars, an Educational Program for Middle School Students
Boys & Girls Club Pueblo, Colorado	Indoor Farming Innovation Zone Remote Learning Program
Museum of Science Boston, Massachusetts	EVOLVE (Expanding Versatile Offerings for Learning in Virtual Environments)
Virginia Living Museum Newport News, Virginia	Understanding the Invisible: Studying Ozone through Bioindicator Gardens Under NASA's TEMPO Mission
Fairchild Tropical Botanic Garden Coral Gables, Florida	Growing Beyond Earth: Distance Learning for Underserved Communities
Sharespace Foundation Los Angeles, California	Project Ianos: Inspirational Space Education, Past, Present and Future
Nevada State Library and Archives Carson City, Nevada	NASA HOLA: STEM Hands-On Learning Activities to Inspire a Diverse Population

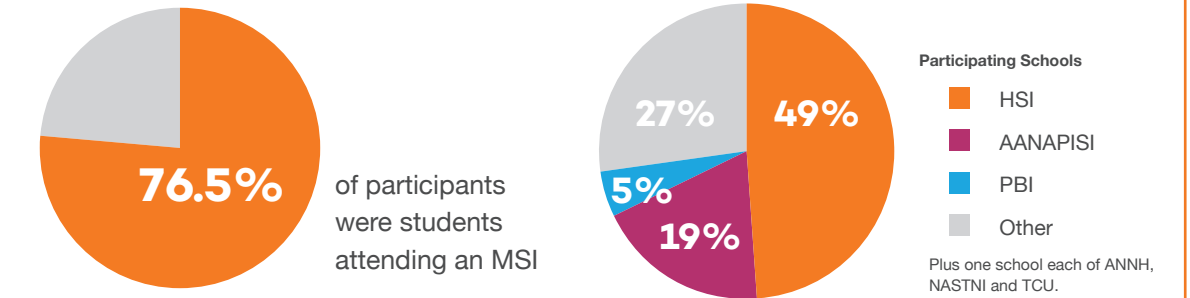
NASA Community College Aerospace Scholars

In response to the impacts of the COVID-19 pandemic, NASA Community College Aerospace Scholars (NCAS) collaborated with representatives from all 10 NASA centers to move 11 in-person events online in the form of a virtual NASA experience for 419 students from 228 schools. Scholars were able to virtually tour several NASA centers, participate in subject-matter experts' lectures, and attend a resume workshop and internship presentations. NASA mentors also guided groups of students through a simulated mission to the Moon or Mars. Students who successfully completed the virtual NASA experience were each awarded a \$550 stipend. In total, NCAS reached 228 schools across 36 states and Puerto Rico.



NCAS student team works on their project at Johnson Space Center prior to COVID restrictions.

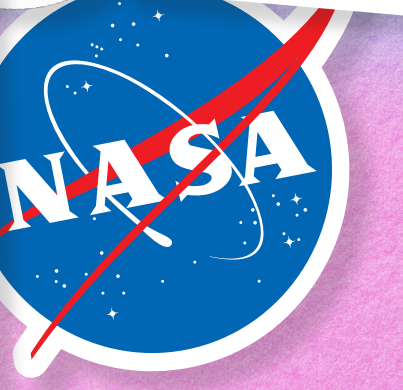
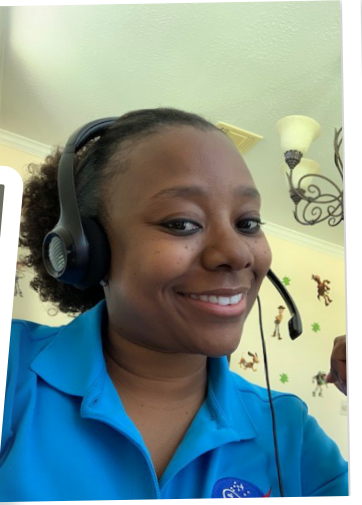
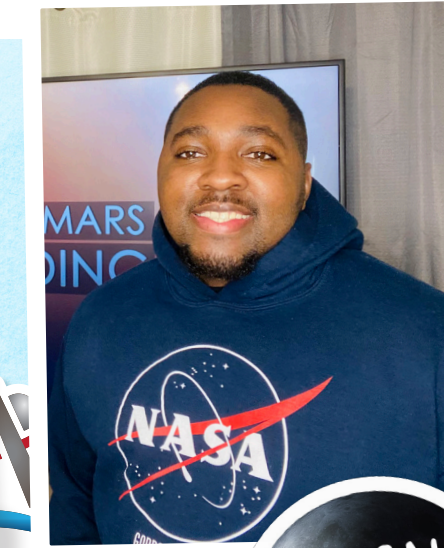
419 students, from **228** schools, representing **36** states and Puerto Rico



“ Thank you for everything you've taught us over this experience and thank you for your words of encouragement. I have learned so much in my time here not only about NASA, but about myself. I have to say your stories of being a woman in education really have inspired me to 'lean in' in the STEM world. ”

– Emma R.
California community college student

STUDENT WORK EXPERIENCES



Internships

Amid the global COVID-19 pandemic, the NASA Internships program provided virtual internships to 1,861 interns in 2020 — a 3% increase from 2019. Of those interns, 388 were rapidly and seamlessly transitioned from on-site to virtual experiences mid-session in March. The program worked with NASA mentors and their interns to convert 1,675 on-site internships into meaningful virtual projects that could be completed remotely. Virtual internships demanded shipment of over 1,500 laptop computers to interns located across the country and U.S. territories, and the institution of new processes for credentialing and onboarding remote interns. Pivoting to virtual internships for summer and fall 2020 increased accessibility, allowing the program to serve even more students, especially those from underserved and underrepresented groups in STEM.

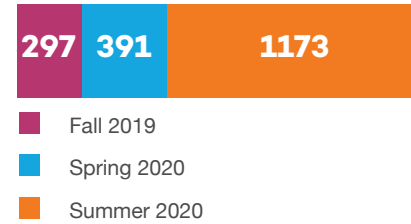
To better connect students with one another and NASA's people in a virtual program, and help expand their exposure to work being conducted at all of NASA's centers, the Internships program created over 30 virtual student-engagement events. Interns could readily access these large-scale online events via a new comprehensive NASA internships mobile app.

1,861 total interns

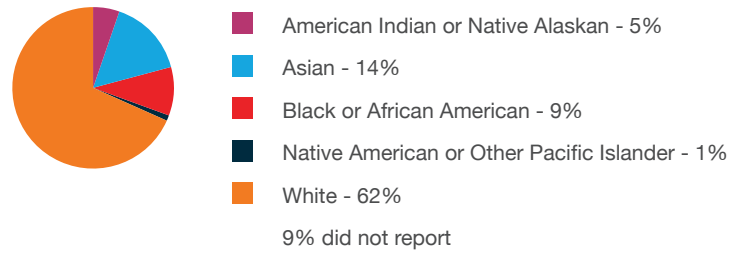
Interns represent all 50 states plus the District of Columbia, Puerto Rico, and, U.S. Virgin Islands



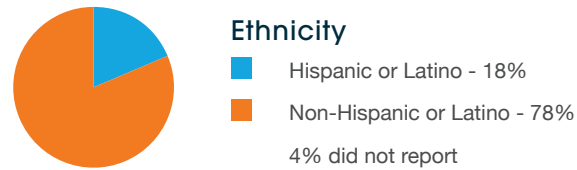
Internships by Session



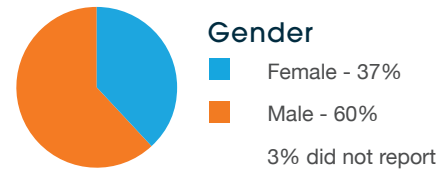
Race



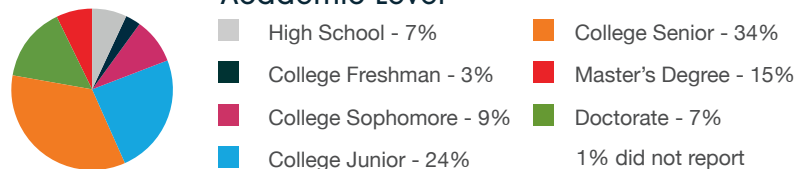
Ethnicity



Gender



Academic Level



Self-reported data captured during FY 2020.

Fellowships

NASA fellowships are competitive awards that support independently conceived or designed research by highly qualified undergraduate and graduate students with a faculty advisor. Fellowships afford students opportunities to directly contribute to NASA's mission and gain valuable learning experiences in STEM disciplines. Fellowship opportunities are focused on innovation and generating measurable research results that help advance NASA's current and future science and technology goals.

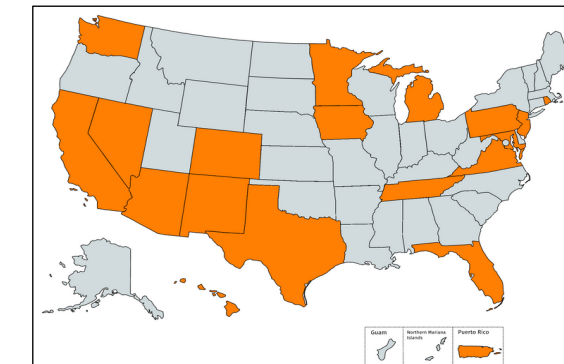
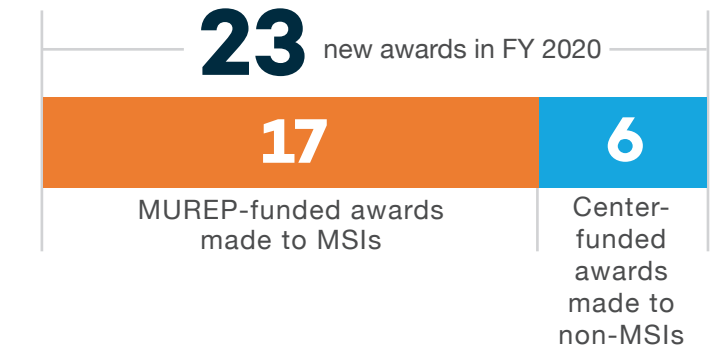
In response to impacts associated with the COVID-19 pandemic, adjustments were made working with the students and their advisors as needed to accommodate work in a virtual learning environment. In addition, the planned 10-week onsite Center Based Research Experience was converted to an 8-week virtual experience for the students.



Learn more about NASA fellowships and how to apply at: nasa.gov/stem/fellowships-scholarships

55 total active fellows from 2018 to 2020

\$3M+ awarded to institutions to support graduate student research over a three-year period



Fellows represent 18 states and Puerto Rico

Intern Profiles



Akosua Dufie

Armstrong Flight Research Center

Akosua is an undergraduate student at Queens College, City University of New York and is majoring in pure mathematics and economics. As a NASA intern, Akosua worked on the development of the X-59 Flight Simulator emergency procedures training.



Makai Kost

Stennis Space Center

Makai is studying economics and business administration with a focus on statistics, forecasting and big data analytics at Sonoma State University. As a Spring 2021 intern, she will continue her project assisting with NASA Technology Transfer data analytics.



Christian J. Rivera

Goddard Space Flight Center

Christian is a recent computer science graduate from the University of Puerto Rico at Bayamón. As a Summer 2020 intern, Christian worked with the Laser Communications Relay Demonstration mission team, continuing work on a tool he had developed for the ground team in Summer 2019.



Omaid Sharifi

Kennedy Space Center

A physics and electrical engineering major at Jackson State University, Omaid worked on the development of a new programming and robotics educational activity station as an intern with Exploration Station. He created a building blocks project for students to simulate utilizing lunar-based resources.



Yohn Ellis

Jet Propulsion Laboratory

Yohn is completing his master's degree in electrical engineering at Prairie View A&M University. During his internship, he worked with the radar technology team in researching nanotechnologies and how they can be utilized in future NASA projects.



Nohemi Sepulveda

Johnson Space Center

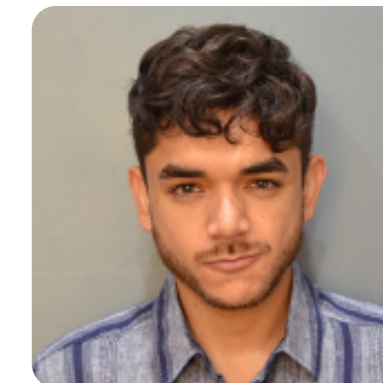
Nohemi is a student at Williams College. During her internships, she worked on the SUITS Artemis Design Challenge and worked with the Advanced Space Suit Pressure Garment Technology team to help further the development of the Exploration Extravehicular Mobility Unit.



Paije Johnson

Kennedy Space Center

Paije is a mathematics major from Bethune-Cookman University. She interned with the Immersive Simulations Engineering Environment team, analyzing the stresses on a human body incurred from physical work to help make working environments safer.



Jesus Gonzalez Camba

Glenn Research Center

Jesus, a student from Chabot College, interned with the Office of STEM Engagement researching diversity and inclusion within the Internship Program. He served as a research assistant on a longitudinal pilot study examining whether participation in NASA internships increases the future participation of underrepresented students in employment within NASA STEM fields.

Fellow Profiles



Yuen Yee Li Sip

University of Central Florida

Yuen Yee is a doctoral candidate researching ways to increase the durability of metals in space. Her research with Kennedy Space Center focuses on fabricating polymer nanocomposites of metal nanoparticles and investigating how the polymeric matrix affects nanoparticle structure and properties. Such composite materials have various potential applications in biomedical devices, sensors, biofilm prevention, catalysis and environmental remediation.



Timothy Darrah

Vanderbilt University

Timothy Darrah is a third-year doctoral student. His research with Ames Research Center is on helioseismic imaging of emerging magnetic flux for forecasting of space weather events. His thesis work will focus on the process of evaluating and certifying decision making algorithms on resource-bounded processors under realistic conditions. These contributions will enhance the body of knowledge for this class of algorithms and have an impact on future NASA space and aerospace activities.



Ali Hyder

New Mexico State University

Ali is a third-year graduate student studying Jupiter. His research connects observations at Jupiter's troposphere, such as the "weather" seen from the Juno spacecraft, with the deep chemistry of the planet. Ali's research with Goddard Space Flight Center aims to gain better understanding into how gas giants started, how they evolved and what effect they had on the whole solar system.



Samantha Sharp

University of California Davis

Samantha is a third-year civil and environmental engineering doctoral student. Her research with Ames Research Center aims to understand cyanobacteria blooms in freshwater lakes. These algal blooms are an emerging water quality concern, as the toxins they produce are harmful to ecosystem health. The results of Samantha's work will support decision-makers with the management of water resources.



Elizabeth Klovenski

University of Houston

Elizabeth works with the Goddard Institute for Space Studies Earth System Model (GISS-ModelE3) to alleviate the model's uncertainties regarding drought. She is developing the biogenic emissions model in GISS-ModelE3 to better capture the effects of drought on isoprene emissions produced by living organisms.



Alexandrea Washington

University of Nevada, Las Vegas

Alexandrea Washington is a first-year mechanical engineering doctoral student. Alexandria's research with Langley Research Center focuses on robotic platforms that utilize soft actuation systems and smart and compliant materials. Her dissertation will focus on the characterization and application of liquid-based electroactive polymer actuators.



Claudia Bernier

University of Houston

Claudia is a fourth-year graduate student working on air quality modeling. Her research with Langley Research Center focuses on characterizing surface ozone lidar measurements acquired during multiple air quality campaigns in the northeastern United States. The goal of her research is to improve air quality models and satellite retrievals.



Ariana Bueno

University of Michigan

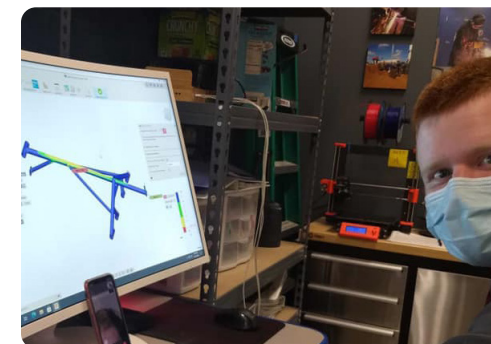
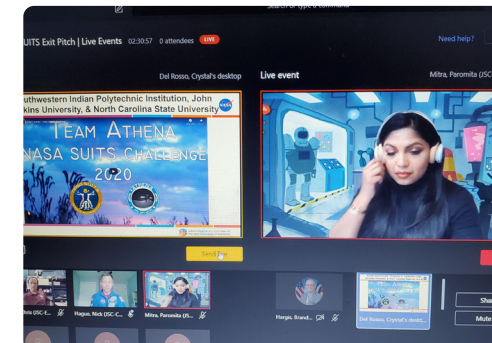
Ariana is a second-year doctoral student in applied physics researching Lunar Rocket Plume Surface Interactions. She works with the Jet Propulsion Laboratory MSL Operations - Environmental Team, M2M X-Hab, and Bioastronautics and Life Support System teams.

STUDENT LEARNING OPPORTUNITIES



Artemis Student Challenges

Artemis Student Challenges comprise seven engineering and technological design challenges for collegiate and high school students across the country and around the globe. The challenges provide unique and valuable learning opportunities for students to build foundational knowledge and introduce them to topics and technologies critical to the success of NASA's work in human spaceflight. The end of the academic year typically includes culminating events for many of NASA's student challenges, where student teams come together to demonstrate their technologies. However, due to the COVID-19 pandemic, NASA and its partners quickly worked to modify the 2020 student challenge activities to ensure the health and safety of team members, staff, and judges. Most student teams had already completed the majority of the work for their projects and NASA wanted to ensure their commitment and efforts did not go unnoticed. NASA hosted virtual presentations, award ceremonies, design reviews, and technology demonstrations. The First Nations Launch and Lunabotics 2020 challenges were postponed, with virtual challenges for those planned in 2021. For the other five challenges student teams participated in a range of virtual experiences and were invited to be part of a downlink with astronaut Bob Behnken aboard the International Space Station. To learn more visit stem.nasa.gov/artemis.



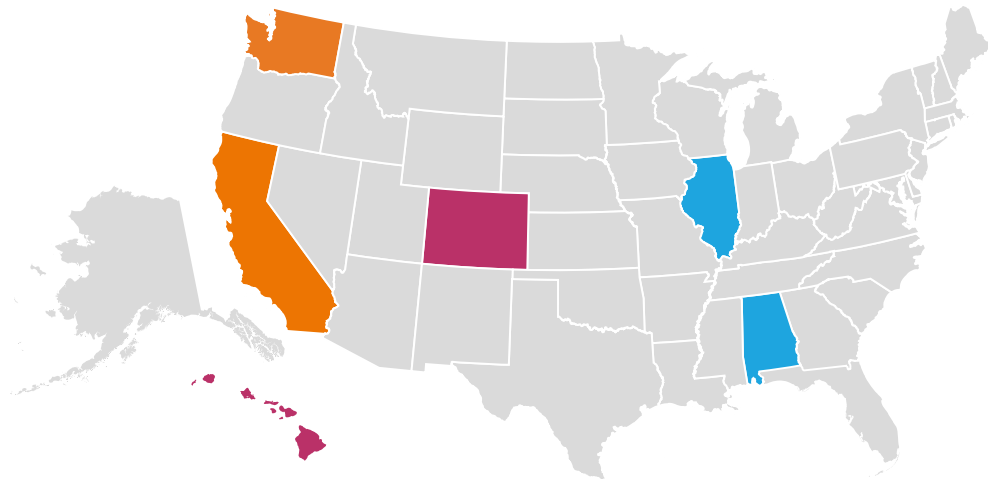
Artemis Student Challenges in action pre-and post-pandemic.

Expanding into the future



As a part of Artemis Student Challenges in 2020, the Space Grant project partnered with NASA mission directorates to design and execute a competitive solicitation for the development of Artemis Student Challenges, open to the national Space Grant Consortia network. As a result, nearly \$2.4M was awarded to six Space Grant Consortia to advance the quality, relevance, and overall reach of opportunities to engage with students. Each of these opportunities will build foundational knowledge and introduce students to topics and technologies critical to the success of the Artemis program.

Consortium	Challenge Focus
Alabama	UTeaching the Moonshot: Getting There and Back with Multi-Body Dynamics
California	Leapfrog: Next Generation Lunar Lander Prototype for Nation STEM Competition
Colorado	Great Lunar Expedition for Everyone
Hawaii	Low-Cost CubeSat Kid and Course Development for Undergraduate Research Projects
Illinois	Efficacy of Student Self-Study of Foundational Artemis Information
Washington	Lunar Technology Exploration Challenge



- Theme 1: Online Learning
- Theme 2: Building Hardware
- Theme 3: Artemis Student Challenges

BIG Idea Challenge



Arizona State University

Colorado School of Mines with the University of Arizona

Dartmouth College

Massachusetts Institute of Technology

Michigan Technological University

Northeastern University

Pennsylvania State University

University of Virginia

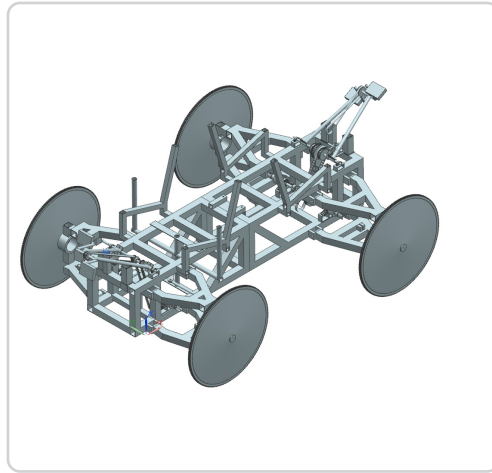
Through the Breakthrough, Innovation and Game-changing (BIG) Idea Challenge, NASA seeks innovative ideas from the academic community for a wide variety of concepts, systems, and technology demonstrations. Supported by solid engineering rigor, these ideas address near-term technology capability requirements in support of NASA's exploration objectives. The competition is an open innovation challenge with minimal constraints, meaning that proposing teams can create highly unique, out-of-the-box solutions.

The 2020 BIG Idea Challenge provided undergraduate and graduate students the opportunity to design, build and test a low-cost sample payload targeted for delivery to the lunar surface. Teams of students and their faculty advisors proposed innovative solutions with supporting original engineering and analysis. The Game Changing Development Program within NASA's Space Technology Mission Directorate partnered with OSTEM's Space Grant project to award nearly \$1 million to eight university teams to build sample lunar payloads and demonstrate innovative ways to study the Moon's darkest areas. The selected teams will develop ways to collect data in and around permanently shadowed regions, generate wireless power for future infrastructure, enable autonomous mobility even in the most extreme environments, and more. Visit BIG Idea Challenge at <http://bigidea.nianet.org/>

Human Exploration Rover Challenge



More than 580 students from schools all over the world participated in the 2019-2020 Human Exploration Rover Challenge (HERC). The challenge required teams to design, build, and test technologies that enable rovers to traverse a variety of challenging terrains. The competition course requires two students — at least one being female — to navigate a half mile of terrain, including obstacles, while completing tasks. Despite cancellation of in-person events due to the COVID-19 pandemic, students participated in virtual design and outreach-related awards events.



Teams designed, built and tested their rovers remotely and submitted their designs and results as part of the 2020 HERC virtual challenge.

580+ student participants

109 teams

82

U.S. teams

28

states, the District of Columbia, and Puerto Rico represented

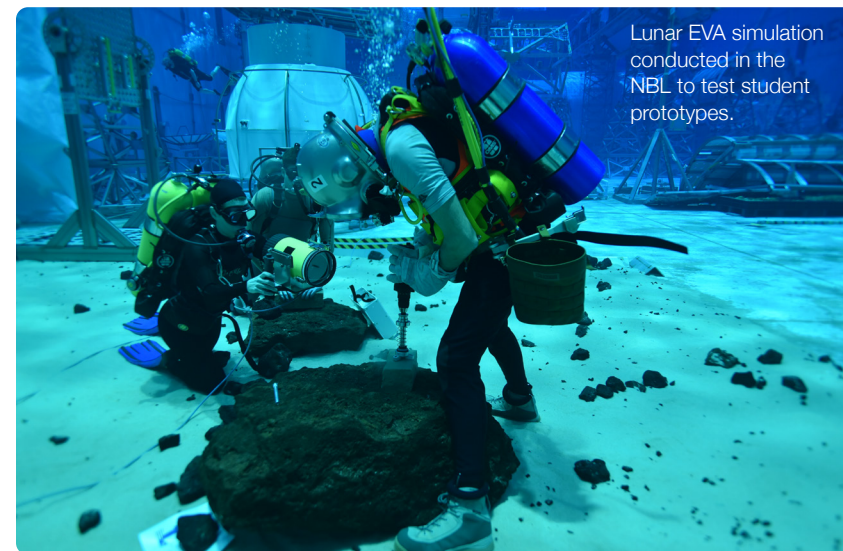
27

international teams

11

countries represented

Micro-g NExT



Lunar EVA simulation conducted in the NBL to test student prototypes.



Students communicate in real-time during prototype testing sessions in the NBL.

Micro-g Neutral Buoyancy Experiment Design Teams (Micro-g NExT) challenged undergraduate students to design, build, and test a tool or device to address an authentic, current space exploration challenge. The experience included hands-on engineering design and test operations conducted in the simulated microgravity environment of the Neutral Buoyancy Laboratory (NBL). During the COVID-19 pandemic, undergraduate teams participated in the 2020 challenge virtually through hardware unboxing sessions, test readiness reviews, an exploration panel, and a prototype-testing session in which each team directed lunar extravehicular activity (EVA) simulations in the NBL remotely from locations nationwide. The prototype testing day allowed student teams to test their EVA tools and devices intended for the collection of lunar rocks, regolith, and potential ice cores during Artemis III. Students benefited from virtual interactions with NBL divers and NASA STEM professionals, and the remote teams were able to successfully complete the full design experience.



129 students



15 student teams



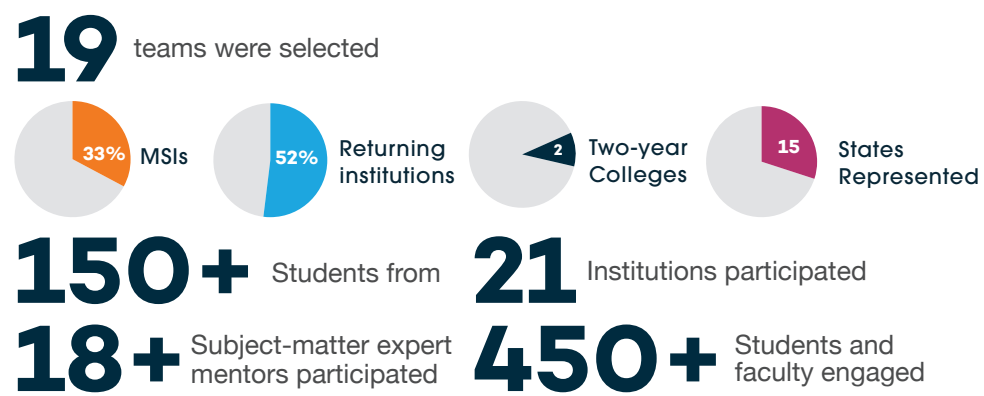
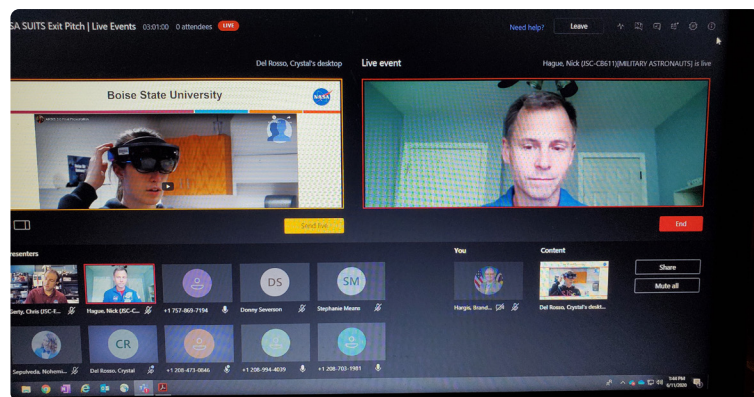
8 states represented

Spacesuit User Interface Technologies for Students



The Spacesuit User Interface Technologies for Students (SUITS) Challenge gives students an authentic engineering design experience supporting the Artemis program. This activity challenges students to design and create spacesuit information displays within augmented-reality environments. After development, student teams typically travel to NASA's Johnson Space Center in Houston to test their software designs with unique NASA assets.

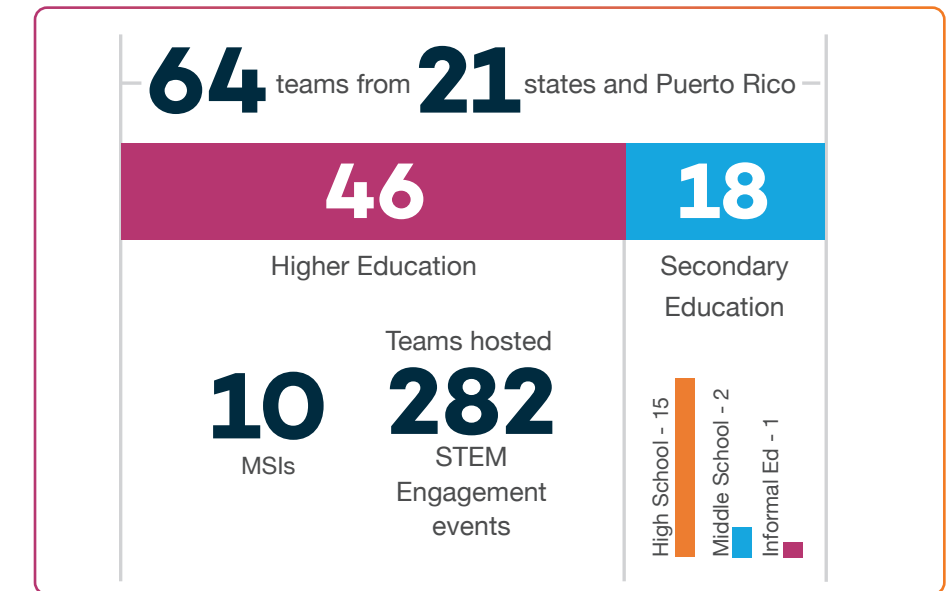
After development, traditionally 10 student teams would travel to the Johnson Space Center to test their software designs with unique NASA assets. Due to COVID-19 restrictions, the 2020 challenge was modified to an online event which, ultimately, allowed more teams to take part. Nineteen teams participated virtually to complete a graduated list of requirements that they accomplished while fully remote. The 2020 teams reported four research manuscripts, and twelve of the teams took part in a SUITS virtual exit pitch with a panel that included NASA astronaut Nick Hague.



Student Launch



Student Launch is a research-based, competitive, experiential exploration activity that provides students with relevant, cost-effective research and development projects for rocket propulsion systems. Student Launch offers multiple challenges that engage student teams from middle schools, high schools, colleges, and universities across the nation. In addition to their technical work, launch teams are required to conduct STEM engagement and outreach activities in their communities. The 2020 NASA Student Launch in-person events were cancelled due to the COVID-19 pandemic; however, 54 of the 64 teams were able to safely fly their rockets at least once at home to complete the activity. The teams took part in a virtual award ceremony that named the top three finishers and honored teams with 17 awards. Students also participated in several other virtual events, including a downlink event with astronaut Bob Behnken aboard the International Space Station.



Student Launch Teams, fall 2019

NASA Community College Aerospace Scholars

NASA Community College Aerospace Scholars (NCAS) is an agencywide, MUREP-funded activity that engages two-year degree-seeking STEM students in NASA's missions and research in a five-week online course. The course teaches students about NASA's past, present, and future missions. This year, two projects were added that were directly tied to the Artemis missions. In 2020, prior to the COVID-19 pandemic, NCAS was able to host five face-to-face events at Johnson Space Center, Ames Research Center, Stennis Space Center, the Jet Propulsion Laboratory, and Wallops Flight Facility. At these sites, NCAS scholars participated in a team engineering design challenge led by a NASA scientist or engineer. The students toured the facilities, attended subject-matter expert lectures and career development seminars, a resume workshop, and learned how to apply for NASA internships. NCAS contributes to the strategic goal of building a diverse future STEM workforce by targeting MSIs to participate in authentic learning experiences with NASA's people, content, and facilities.



NCAS students participating in events hosted in early 2020.

For FY 2020, NCAS scholars' racial and ethnic makeup exceeded the national average.

16.2% Asian American compared to 5.9% for the U.S.

6.8% Native American compare to 1.3% for the U.S.

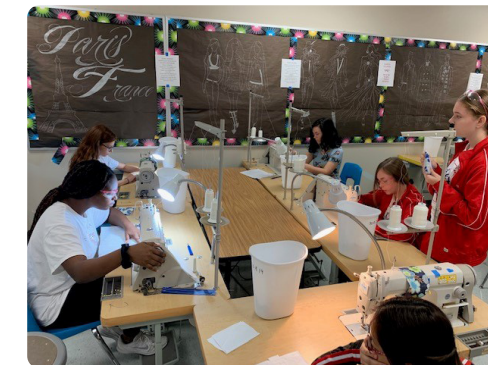
34.1% Hispanic compared to 18.5% for the U.S.

66% Higher Native Hawaiian than the national average

High Schools United with NASA to Create Hardware

The High Schools United with NASA to Create Hardware (HUNCH) empowers high school students through a project-based learning program to learn skills through participation in the design and fabrication of products for NASA.

Students across the nation participate in projects dedicated to design and prototyping, hardware, software, soft goods, culinary and video/multimedia challenges under the guidance of NASA and industry mentors. In FY 2020, HUNCH delivered hundreds of projects, including 600 spacewalk ties, 177 flight design developments, 131 soft goods, 25 lockers, two prototypes for flight, and a culinary item. In total, HUNCH partnered with 277 schools in 38 states, two U.S. Department of Defense schools in Belgium, and Puerto Rico. For more information visit www.nasahunch.com.



HUNCH students participating in events hosted in the fall of 2019.



300
student teams developing new prototypes for space exploration



177
design developments for flight



277
partner schools



38
states represented



2,500+
students participated



230
educators participated

App Development Challenge

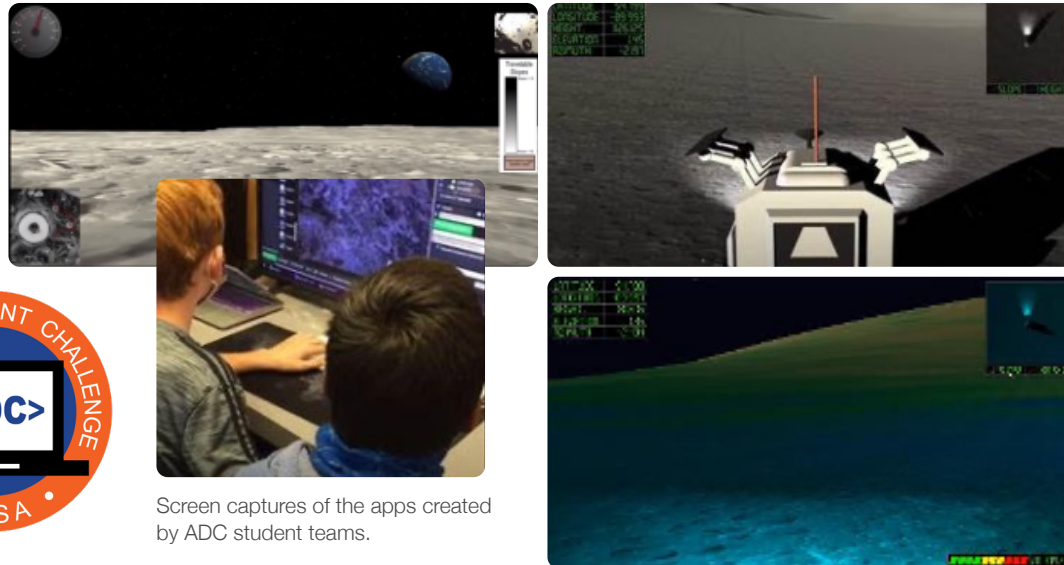
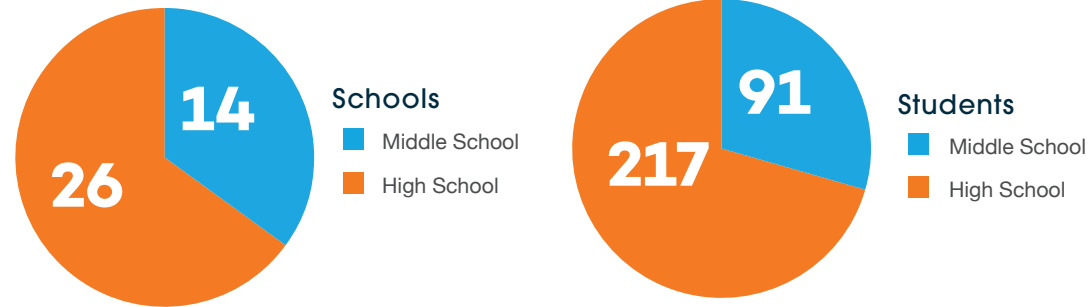
The App Development Challenge (ADC) is a coding challenge where NASA presents technical problems to middle and high school students for meaningful contributions to future exploration missions. By responding to the ADC, students took part in endeavors related to the Artemis program. The 2020 ADC, developed in collaboration with NASA's Space Communications and Navigation Team or SCan, asked students to work in teams to develop an application that visualizes the South Pole region of the Moon for future mission-planning and training activities.

“We are so grateful to NASA for providing us with this opportunity to engage in such a cool and unique challenge, especially during a year when we cannot engage in some of our typical face-to-face coding and programming experiences with our students.”

— **Katie S.**
Middle School Teacher
Baltimore Maryland



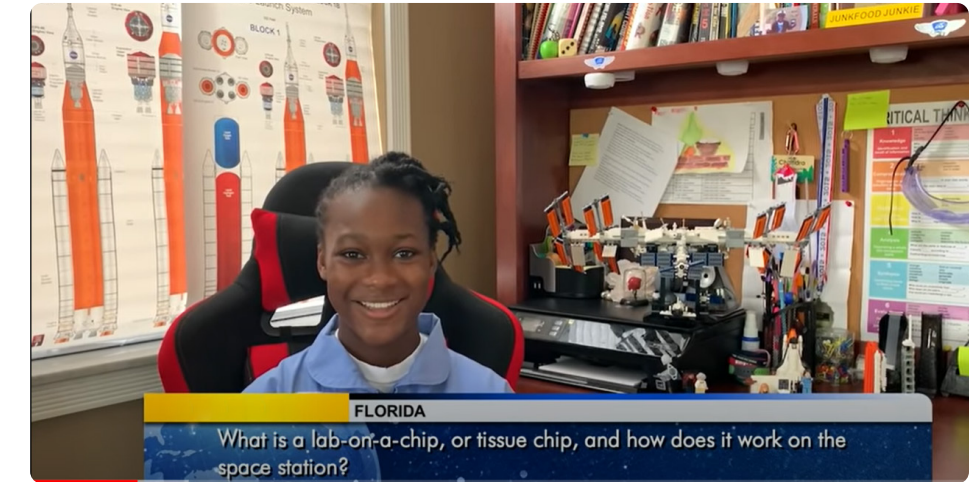
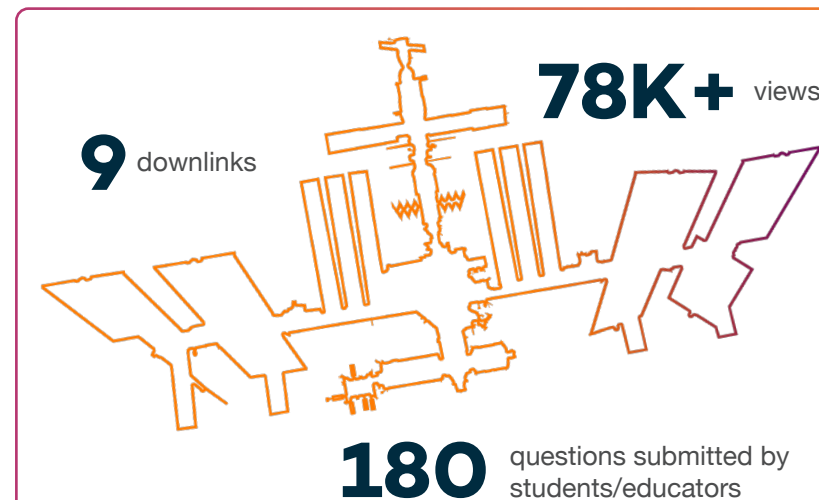
40 teams registered from across **35** institutions/organizations, representing **15** states



Screen captures of the apps created by ADC student teams.

STEM on Station Education Downlinks

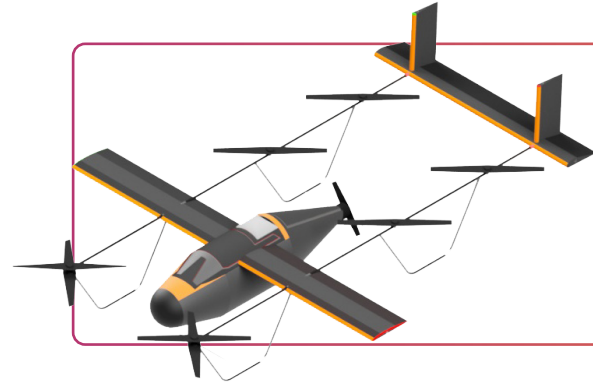
STEM on Station allows students and educators to engage with the International Space Station including talking live with astronauts onboard the International Space Station via in-flight downlinks. Education downlinks incorporate instructional activities pre-and post-event, often utilizing the content of the STEMonstrations – STEM demonstrations on the Space Station. Downlink events normally take place in a large auditorium setting, so a quick pivot was needed to continue these experiences during COVID-19 restrictions. As a result, these exciting educational experiences are now broadcast live incorporating prerecorded video questions submitted by students from across the country. During the live sessions the astronauts answer the students' questions from the space station. These and other downlinks can be viewed at www.youtube.com/playlist?list=PLTUZypZ67cdv9X4DxjUGvN4wfN6EdHTUo.



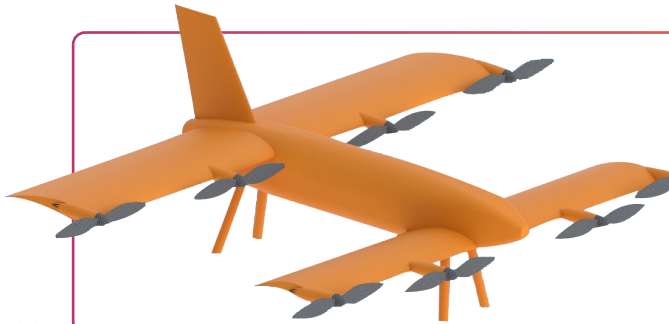
Aeronautics University Design Challenge

NASA's nationwide team of aeronautical innovators are committed to giving university students opportunities to solve some of the biggest technical challenges facing the aviation community today. Through NASA-sponsored challenges and competitions, students representing multiple disciplines put their skills to work by designing and building solutions to real-world problems.

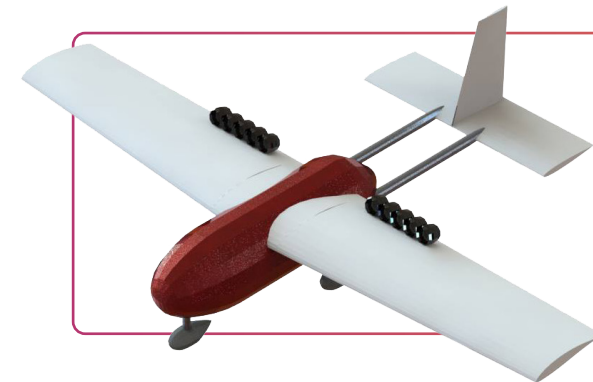
The 2019-2020 design challenge was to design an uncrewed aerial vehicle and logistics system for delivering packages in support of Aeronautics Research Mission Directorate's (ARMD) Urban Air Mobility efforts. The student teams design reports addressed safety, reliability, business case, ground and vehicle performance, operations, and noise. Despite the challenges of the pandemic forcing teams to work virtually, twelve teams completed the challenge. The Virginia Tech team placed first, University of Virginia placed second, and University of California Davis placed third.



FIRST PLACE
RAAVEN air vehicle.
Virginia Tech 2019-2020 Team



SECOND PLACE
Corvus
UVA 2019-2020 Team



THIRD PLACE
P34NUT
UC Davis 2019-2020 Team

Moon Pod Essay Contest

The Moon Pod Essay Contest takes remote learning a little further — as in 250,000 miles further! NASA's Office of STEM Engagement partnered with NASA's Human Exploration Operations Mission Directorate, challenging participants to imagine leading a one-week expedition to the Moon's South Pole. U.S. students in grades K-12 submitted essays detailing what it would be like to explore the lunar surface as part of a crew of astronauts, the traits and skills of their fellow crew members, and what technologies they would leave behind to assist future Moon explorers.

Students entries were divided into three groups to be judged by the grade-level categories K-4, 5-8 and 9-12. With final selections occurring in 2021, every student who submitted an essay will receive an official certificate and be invited to a NASA virtual event featuring an astronaut. Semifinalists will be invited to represent their state or territory in a series of Artemis Explorer sessions with NASA experts. Nine finalists will have the opportunity to travel with a parent to NASA's Johnson Space Center to learn about lunar exploration. The national winner in each grade division will win a family trip to see the first Artemis flight test and witness the most powerful rocket in the world launch from NASA's Kennedy Space Center in Florida. As the COVID-19 situation continues to evolve, NASA will closely monitor and follow guidelines from federal, state and community officials regarding travel and on-site participation.

ARTEMIS

MOON POD ESSAY CONTEST

2021

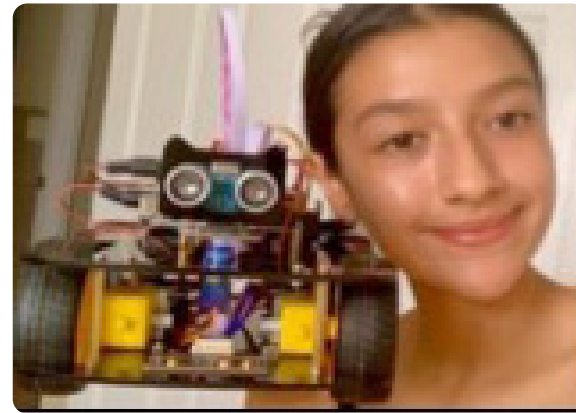
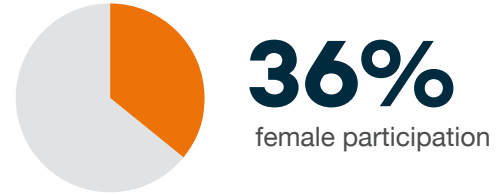
- Semifinalists Announced: 17 MARCH
- Finalists Announced: 7 APRIL
- Finalist Interview: 29 APRIL
- Winners Announced: 19 MAY

40K+ registered students **14K+** student entries

MUREP Aerospace Academy

NASA MUREP Aerospace Academy (MAA) uses NASA's unique resources to help build the interest, skills, and knowledge necessary for K-12 students to pursue STEM careers. MAA engages students in authentic and hands-on STEM experiences built around NASA mission content. MAA awardees recruit and increase participation and retention of historically underserved and underrepresented students. MAA awards two-year cooperative agreements with up to \$325,000 to thirteen minority-serving institutions (MSIs) from across the United States. Prior to the COVID-19 pandemic, the primary method of interaction and engagement with students occurred through face-to-face experiential learning opportunities. In response to the pandemic restrictions, MAA sites continue to work diligently to meet the needs of students, families, educators, and other members of the public through virtual outreach and engagement.

15,139 student participants
3,223 educator professional development participants



MUREP Aerospace Academy campers participating from home during summer 2020 virtual camps.

NASA Astro Camp

The NASA ASTRO CAMP® Community Partner Program (ACCP) sparks students' interest in learning the basics of NASA Earth and space sciences, technology applications, engineering, rocketry, robotics, and computer science through fun and engaging experiences. In 2020, ASTRO CAMP was able to serve more students than ever with its adapted virtual format, which allowed youth and community partners to enjoy ASTRO CAMP activities in their own communities.

Ninety-three ACCP sites, youth service organizations, museums, universities, schools, and libraries were trained to provide hands-on, exciting activities centered on exploration and discovery. Participants enjoyed NASA-specific virtual events that gave youth and families opportunities to interact with NASA mission personnel and attend virtual field trips to NASA centers.



ASTRO CAMP campers participating from home during 2020 virtual camps.



93 ACCP sites

18 states represented plus El Salvador and Mexico

6,934 participants attended four- to five- day ACCP camps/afterschool programs with over 35 contact hours

30,166 participants in NASA-Unique STEM Day engagement events, which last one to two days with over 3 hours of student engagement

282 ACCP-trained facilitators in STEM day camps, K-12 classrooms, and unique one-day STEM engagement opportunities

University Student Research Challenge

University Student Research Challenge (USRC) seeks to challenge students to propose new aeronautics ideas/concepts that are relevant to NASA Aeronautics. USRC provides students, from accredited U.S. colleges or universities, with grants for their projects, and it includes the challenge of raising a modest amount of cost-share funds through a crowdfunding platform. The process of creating and preparing a crowdfunding campaign acts as a teaching accelerator, requiring students to act like entrepreneurs. Crowdfunding also raises awareness about students' research among the public.

The solicitation goal can be accomplished through project ideas such as advancing the design, developing technology or capabilities in support of aviation, by demonstrating a novel concept, or enabling advancement of aeronautics-related technologies. The USRC proposal must describe a novel approach to addressing one of six major research thrusts as outlined in the Strategic Implementation Plan for ARMD. Those research concentrations involve commercial supersonic air travel, air-traffic management, system-wide safety, new subsonic transports, Advanced Air Mobility, and autonomy in aviation. In 2020 four student teams were selected for funding in the areas of unmanned aerial systems and aerodynamics.



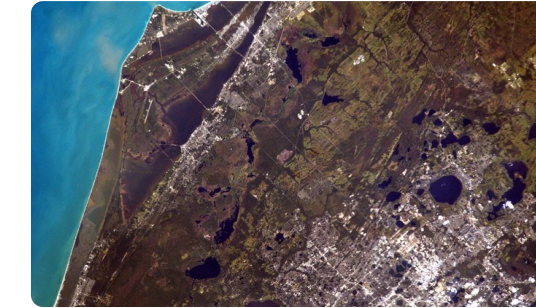
Student from the AVIS team at the Georgia Institute of Technology. Photo Credits: Georgia Tech.

USRC 2020 Selections	Team Name
University of California, Los Angeles	AVIATA: Autonomous Vehicle Infinite Time Apparatus
Embry-Riddle Aeronautical University	Redundant Flight Control System for BVLOS UAV Operations
Rutgers University	Multi-Mode Hybrid Unmanned Delivery System: Combining Fixed-Wing and Multi-Rotor Aircraft with Ground Vehicles
Georgia Institute of Technology	AVIS: Active Vortex Inducing System for Flow Separation Control to Improve Airframe Efficiency

Sally Ride EarthKAM in the Classroom

Sally Ride EarthKAM (Earth Knowledge Acquired by Middle school students), is a program that was initiated in 1995 by astronaut Sally Ride, America's first woman in space. Although "middle school" is in the program's name, both elementary and high school students also participate in EarthKAM missions. An EarthKAM mission is a period of time when a camera located on an Earth-facing window on the International Space Station is active. Students can use the EarthKAM online tool, which shows the orbital path, of the ISS on a world map, to select locations along the station's paths and the camera will take pictures as the ISS flies over the points. During Mission 61 in April 2020, EarthKAM processed more than 16,000 Earth images.

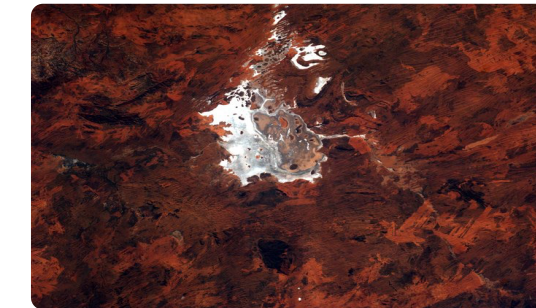
EarthKAM offers free standard-based lesson plans available for download and use before, during, or after the EarthKAM mission. The lesson plans cover multiple topics, such as understanding scale distances, Earth's rotation and orbit, and Earth's place in the solar system.



Orlando and Merritt Island, Florida.



Caspian Sea shoreline.



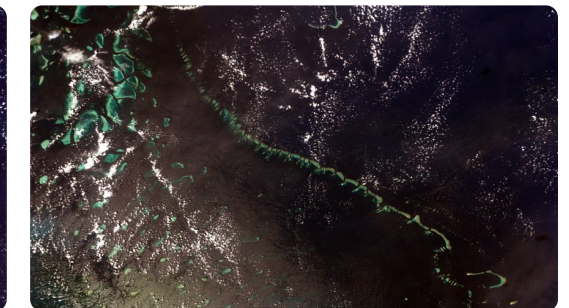
Lake Disappointment in Western Australia.



Buenos Aires, Argentina.



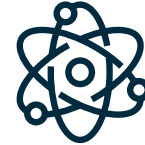
The Gulf of Oman located between Iran and Oman.



Great Barrier Reef.

Student Mission Toolkits

Student mission toolkits are compilations of free downloadable resources with various science, technology and engineering themes related to a specific NASA mission milestone. Toolkits may contain education guides, student learning activities, ready-to-print posters, and social media graphics. Topics include NASA missions, Mars, and more.



Orbital Flight Test-1 Launch Kit

In support of the Boeing Starliner spacecraft's maiden voyage to low-Earth orbit, NASA amplified efforts to connect students and educators to the Commercial Crew Program. On Dec. 18, 2020, the first Commercial Crew Launch Kit for Boeing's Orbital Flight Test was released, providing Commercial Crew K-12 resources to educators, parents, and students.



<https://go.nasa.gov/2MacFIN>

Demo Mission-2 Launch Kit

In preparation for the return of human spaceflight to American soil, NASA released the Demo-2 Launch Kit on May 6, 2020. This robust resource was created to prepare parents, educators, and students for the launch through webinars, broadcast information, at-home activities, print resources, subject-matter presentations, virtual reality experiences, educational videos, and resources to stay connected through social media on launch day. The launch kit was unveiled to 155 participants in a joint webinar with the National Science Teaching Association.



<https://go.nasa.gov/2KTyw0A>

Demo Mission-2 Mission Kit

As an extension to the DM-2 Launch Kit, the Demo-2 Mission Kit provided new additions for educators, parents and students that focused on the crew's time aboard the space station. Supplemental activities to the Demo-2 Launch Kit included STEMonstrations, Spot the Station, the International Space Station Activity Kit and Kit Guide, the Educator's Guide to ISS20 Mission Kit and space station printable materials and multimedia.



<https://go.nasa.gov/39kguOe>

Crew-1 STEM Mission Toolkit

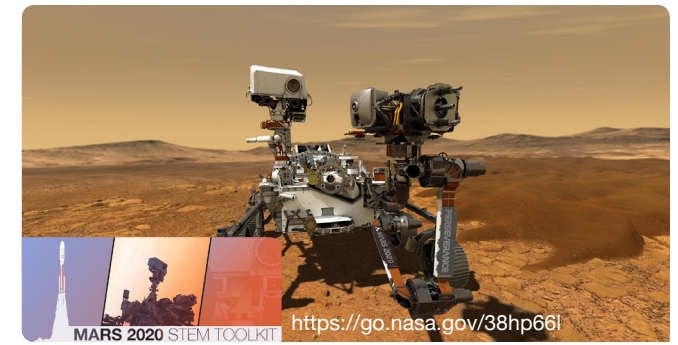
To engage students around the nation in the historic Crew-1 launch with commercial partner SpaceX, NASA released the Crew-1 STEM Mission Toolkit on Sept. 29, 2020. The toolkit's release was followed by a Reddit Ask Me Anything with a panel of STEM education specialists and NASA's lead engineer for the SpaceX Crew Dragon spacecraft.



<https://go.nasa.gov/3l2Pq9v>

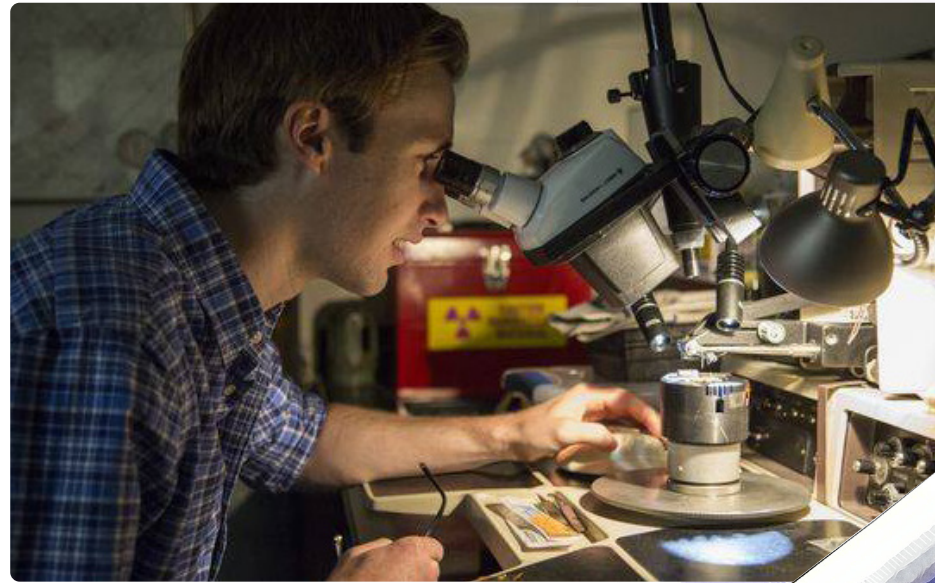
Mars 2020 Perseverance Toolkit

NASA released the Mars 2020 STEM Toolkit to engage educators and students with the July 2020 launch of the Perseverance rover and Ingenuity helicopter. After the launch, this robust toolkit was updated weekly with new resources leading up to the landing of the rover and first Mars helicopter on Feb. 18, 2021. The toolkit for the #CountdownToMars included in-depth information on the mission, its passengers Perseverance and Ingenuity, educational resources, broader Moon to Mars mission information and ways to stay connected.



MARS 2020 STEM TOOLKIT <https://go.nasa.gov/38hp66l>

RESEARCH AND DEVELOPMENT



Space Grant ASCEND

For 16 years, the Arizona Space Grant Consortium (AZSGC) has organized the Aerospace Scholarships to Challenge and Educate New Discoverers (ASCEND) balloon satellite launch program for university and community college students. Twice per year, student teams from three universities and seven community colleges across the state work with a local mentor to build small payloads for launch to the edge of space on high-altitude weather balloons. Balloons can reach an excess of 100,000 feet, where onboard cameras obtain photos and videos to document the flight and capture images from the edge of space.

Students work closely with their team to design their payload, build it, launch it, and then recover it and analyze the data it captured. The COVID-19 pandemic halted the spring 2020 launches but, in the fall, students were able to launch their spring payloads while following Center for Disease Control and Prevention guidelines. The pre-launch workshop and debrief moved to a virtual format; however, launching the balloons required some in-person participation. AZSGC took all precautions necessary to allow one mentor and a few student representatives from a subset of ASCEND teams to attend the outdoor launch, and payload tracking transitioned to one person per vehicle. Data collected on the payload was shared and reviewed remotely post launch.



Highlights from EPSCoR Research

Guam

University of Guam in collaboration with NASA's Jet Propulsion Laboratory

The University of Guam is using novel datasets to characterize reef fish spawning aggregation sites – places where groups of fish of the same species congregate to breed – and corresponding coral reef health around Guam. These datasets include environmental variables related to reef fish spawning aggregation site locations, which are dependent upon healthy reefs. Some of this data is being collected in non-traditional ways to increase the spatial extent of data collection and improve data quality.

One tool the researchers use to characterize reef health is DiveRay, an underwater instrument that records the natural light reflectance of the seafloor. The unique spectral signatures collected by DiveRay are analyzed to indicate different benthic, or bottom-dwelling, reef species and to quantify their presence at study sites. Substrate types and species composition of benthic zone organisms are used as indicators of healthy versus non-healthy reefs. The team's field-collected oceanographic data will be analyzed along with NASA satellite data. The results are relevant to the management of fish-spawning aggregations and maintaining the health of coral reefs, as well as furthering understanding of reef biodiversity and community structure.

Hawaii Institute of Geophysics and Planetology, University of Hawaii, in collaboration with NASA's Jet Propulsion Laboratory

NASA EPSCoR funded construction of the Neutron-1, a 3-U CubeSat by Hawaii Space Flight Laboratory, that will test one of the neutron detectors that will be used for the Luna-H Map Mission. Neutron-1 arrived at the International Space Station on October 5, 2020 and was deployed into orbit on November 5, 2020.



The DiveRay, an underwater instrument that captures hyperspectral reflectances from the benthos, in use at a coral reef off Guam. GEOCORE will use this data, along with other field-collected and satellite datasets, to characterize coral reef fish-spawning aggregation sites.



Neutron-1 is a 3-U CubeSat built by the Hawaii Space Flight Laboratory (HSFL) featuring an Arizona State University neutron detector that will be part of the Luna-H Map Mission to the Moon. Here, Neutron-1 is in HSFL's Thermal Vacuum Chamber.

Puerto Rico

University of Puerto Rico in collaboration with NASA's Ames Research Center

The EPSCoR International Space Station project is a collaborative effort between the University of Puerto Rico and NASA's Ames Research Center to advance the forward osmosis secondary treatment technology (FOST) of urine reclamation in microgravity conditions. In the electrochemical treatment process, ammonia molecules are oxidized to a gas, filtered, and then diffused to produce water for astronauts to reuse. However, formation of stagnant nitrogen gas on the catalyst materials under microgravity conditions disrupts these chemical reactions. By nanostructuring the catalyst materials, the research team has enabled the use of FOST in the space station and other crewed NASA missions.

Alaska

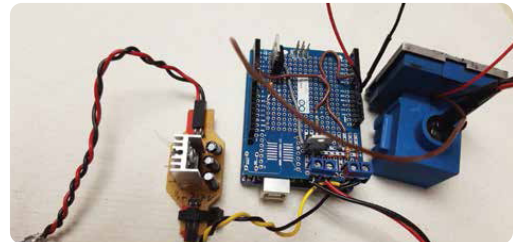
University of Alaska Fairbanks in collaboration with NASA's Glenn Research Center

NASA has a keen interest in mitigating the human health and performance risks associated with exposure to cosmic radiation during human spaceflight missions; however, a scientifically sound estimation of these risks is still deficient. The gaps in knowledge stem from the limitation of the current techniques for quantifying DNA damage from radiation, which requires analysis in a ground-based laboratory.

To mitigate this limitation, a team at the University of Alaska Fairbanks partnered with NASA's Glenn Research Center to develop a portable sampling and detection technique for measuring broken DNA strands, which would allow analysis to happen in space. During the four-year project, researchers have developed a miniaturized electrophoresis device called the Vertical Comet Assay. The portable device – as small as a soda cracker – is able to extract broken DNA strands from a cell model at a relatively low voltage setting, which is ideal in space. The team has also prototyped and tested a few high-sensitivity portable fluorescence detectors, which can measure the existence of extracted DNA strands in a small amount of solution. Palm-sized, lightweight and battery-driven, the portable fluorometer can detect the existence of fluorescence-labeled DNA strands at low concentrations, making it well-suited for in-the-field applications, such as spaceflight.



Willie Williams, NASA technical monitor, discusses the progress of the NASA EPSCoR station project with Walter Alomar, University of Puerto Rico Board of Trustees president, and Carlos Cabrera (Science Lead).



High-sensitivity portable fluorometer (encapsulated in the blue case on the right).



Miniaturized Vertical Comet Assay device in testing.

Highlights from MUREP Research

City College of New York

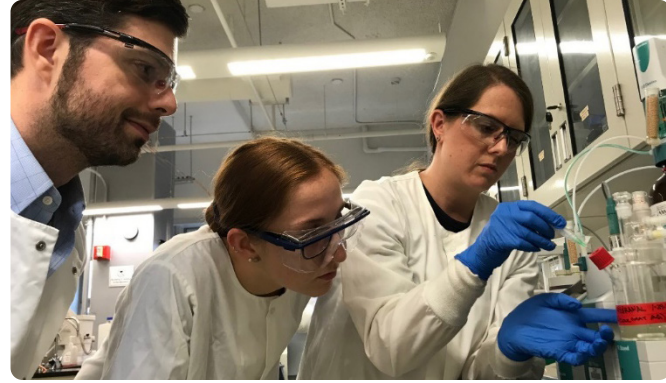
The City College of New York, established the Center for Advanced Batteries for Space (CABS) to develop novel batteries composed of high energy density metal anodes and ionic liquid electrolytes that can operate under the extreme temperatures and radiation encountered by spacecraft. The center's objectives include designing battery prototypes to meet NASA's mission-specific energy storage targets; to produce new scientific understanding of metal-ionic liquid electrochemical systems and devices, including under extreme conditions; and to investigate emerging battery chemistries, engineering concepts, and characterization methods.

During the first year of the three-year award, CABS has continued development of aluminum-graphite batteries and initiated research into aluminum-polymer and aluminum-organic batteries, aqueous alkaline zinc metal batteries, ionic liquids for zinc metal electrodeposition, and methods to assist in electrochemical charge storage mechanisms. Newly purchased equipment will advance capabilities in electrochemical and environmental testing, electrode engineering, and materials characterization.

University of California, Merced

The University of California, Merced established the nAnomaterials Center for Energy and Sensing (MACES) to support students participating in unique NASA-based STEM training and faculty initiating and conducting cutting-edge NASA-relevant research. Over the next two years, MACES will expand research and training efforts in energy, a crucial commodity for supporting life and instrumentation during space exploration.

Research and training efforts will focus on discovering new energy materials and systems that improve energy capacity. There are three focus areas, which include: solar energy harvesting; high-performance energy storage; and energy efficient motors, robots, and sensors. Research encompasses work on efficient and light-weight foldable solar cells, hierarchical 3D carbon-based energy storage systems, 2D solid lubricants that operate at extremely low temperatures, and low-energy actuators and sensors.



Dr. Elizabeth Biddinger demonstrates Karl Fischer titration as doctoral student Nicole Donovan and Dr. Rob Messinger observe.



cSETR graduate students Rene Miranda and Mariana Chaidez working on the rocket engine test set-up.

Xavier University of New Orleans

The Xavier University of New Orleans Materials and Interfaces Center for High Energy Storage and Sensing (MICHESS) was established to understand interfacial issues in materials with high energy storage and sensing. MICHESS research areas are organized into two interdisciplinary research groups. One group is working to develop safer, lightweight, and rechargeable lithium batteries that are based on conversion-type cathodes with high energy density and solid polymer electrolytes. This group will research ionic transport and charge/mass transfer along surfaces and across interfaces. The second research group is working to design and develop electrochemical sensor arrays that are capable of measuring concentrations of critical gases in real-time to monitor environments for personal safety. The team will research ionic transport in room temperature ionic liquid gel/semiconductor systems for the development of lightweight electrochemical sensor arrays.

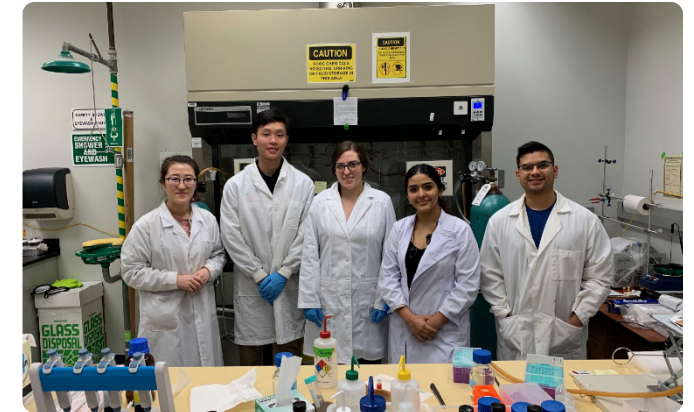
Florida International University

The Center for Research and Education in 2D Optoelectronics (CRE2DO) at Florida International University was established to engage in innovative research and education to explore novel two-dimensional functional materials to be incorporated into sensors, wearable electronics, integrated optics/photonics, detectors, superconducting materials, novel antenna architectures, and small satellite (CubeSats) technology for space applications. This research is organized by three integrated thrusts:

- Thrust 1: Chemical transformations in 2D chalcogenide materials to enable advanced functionality in sensors, integrated optics/photonics, and superconductors.
- Thrust 2: Mechanical integrity of 2D transition metal dichalcogenide materials in polymer composites to enhance reliability of mechanical and electrical components in spaceship devices and wearable electronics.
- Thrust 3: Thin film in-package high-data rate millimeter wave communication development for CubeSats.



MICHESS student Kayla Strong uses the Glovebox to perform research..



The 2D Materials Synthesis Team of MIRO FIU Center CRE2DO

Aeronautics University Leadership Initiative

The University Leadership Initiative (ULI) was created to initiate a new type of interaction between the ARMD and American university communities. This initiative seeks new, innovative ideas that can support the ARMD portfolio and U.S. aviation efforts. ULI provides the opportunity for university teams to exercise technical and organizational leadership in proposing unique technical challenges, defining interdisciplinary solutions, establishing peer-review mechanisms and applying innovative teaming strategies to strengthen research impact.

In April 2020, ULI awards were granted to five teams, each comprising students from three to four universities and one to two industry partners. Notably, the Secure and Safe Assured Autonomy (S2A2) team, led by the North Carolina Agricultural and Technical State University, is the first ULI team awardee with an HBCU as the lead institution. S2A2 will work to advance the industrial deployment of autonomous uncrewed aerial systems in support of NASA's Advanced Air Mobility Mission.

\$32.7M in awards:

Oklahoma State University	Weather Intelligent Navigation Data and Models for Aviation Planning (WINDMAP)
North Carolina Agricultural and Technical State University	Secure and Safe Assured Autonomy (S2A2)
Stanford University	Safe Aviation Autonomy with Learning-enabled Components in the Loop: From Formal Assurances to Trusted Recovery Methods
University of Delaware	Composite Manufacturing Technologies for Aerospace Performance at Automotive Production Rates
University of South Carolina	Atoms to Aircraft to Spacecraft (A2A)



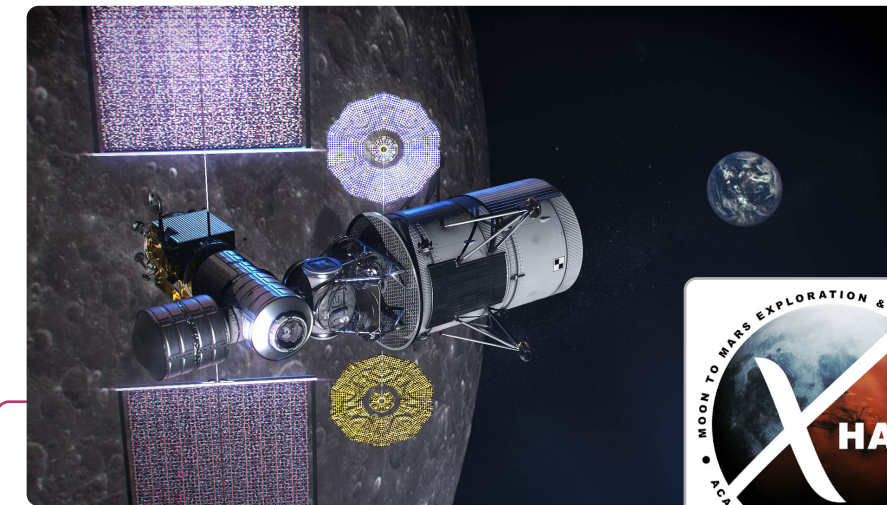
Students participate in design activities prior to COVID-19 restrictions. Photo Credits: Hans Sati Goertz, University of Tennessee

Stimulating MSI Research

With an eye to assisting MSIs in focusing on technology advancement beneficial to NASA missions, two competitive activities successfully increased applications from MSIs and subsequently increased the number of MSI awardees. MUREP created an in-roads to connect with MSIs and fund their partnerships for research. The program has created a significantly larger group of MSI participants from across the country.

In 2020, Marshall Space Flight Center Engineering Directorate dual-use technology solicitation and the eXploration Systems and Habitation (X-Hab) Academic Innovation Challenge provided 10 awards and five awards, respectively, to MSIs. Through these two opportunities, over a million dollars were awarded to 12 MSIs, including HBCUs, HSI, and AANAPISIs.

A notable example of the success of the initiative, Dillard University is working on a revolutionary project in spacecraft exploration, "Computational Insight into Ionic Polyimides: New High-Performance Polymers for Additive Manufacturing." The team proposed a novel approach to 3D printing of thermoplastic elastomers with intrinsic and tunable self-healing, or shape-memory properties, for either commercial or research applications. These ionic polyamides represent a truly unique class of materials and first-of-its-kind opportunity to produce flexible, durable, and reusable/remoldable parts for a variety of applications, including those related to planned missions beyond Earth. Their work in this area is significantly shaping the future of science and technology, both for NASA and private industry.



HBCU 3 institutions, awarded **\$436K**

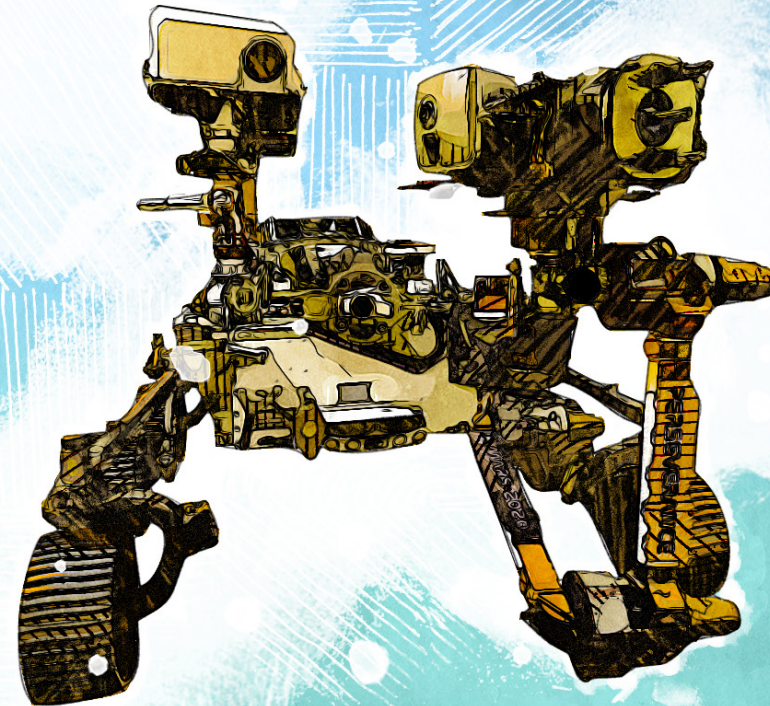
HSI 4 institutions, awarded **\$189K**

AANAPISI 3 institutions, awarded **\$320K**

HSI/AANAPISI 2 institutions, awarded **\$119K**
Dual classification

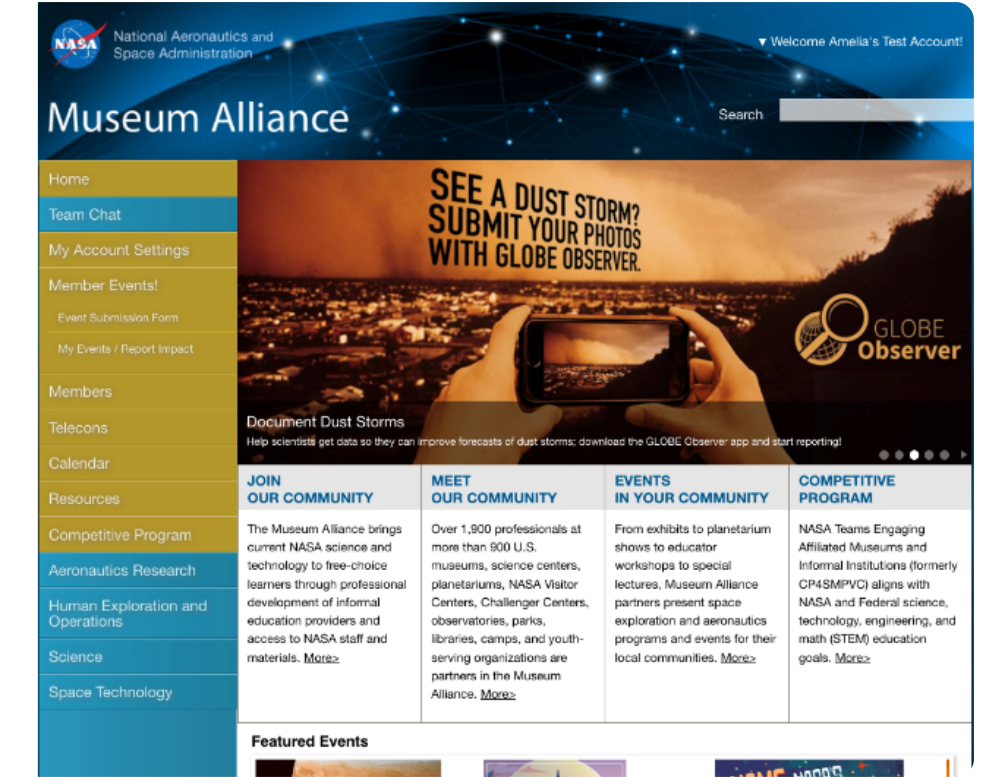


EDUCATOR & INSTITUTIONAL SUPPORT



NASA Museum and Informal Education Alliance

The Museum and Informal Education Alliance (MIE Alliance) serves museums and many other informal education organizations, such as science centers, parks, libraries, planetariums, nature centers, and after-school groups, to better represent the diversity of the alliance member organizations bringing NASA to their audiences. To better represent the diversity of its member organizations, the alliance was renamed in 2020 from what was previously known as Museum Alliance. In response to the COVID-19 pandemic, MIE rapidly rolled out new resources for informal educators to support their efforts in continuing to provide meaningful STEM content remotely. They hosted a “Remote Outreach Best Practices” webinar series giving members a much-needed venue for collaborating and sharing strategies. Webinars were dedicated to participant-identified topics such as virtual summer camps, remote astronomy, and livestreaming.

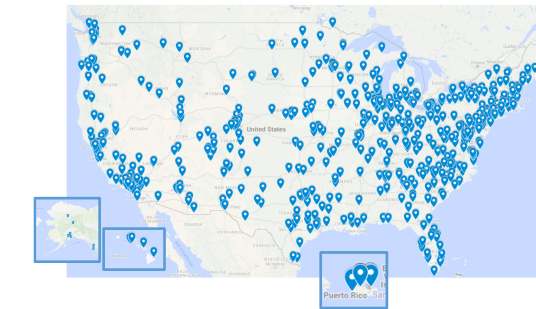


Membership

2,300+ professionals

1,200+ organizations

38 countries represented



1,071

U.S. organizations across

50 states, the District of Columbia and Puerto Rico

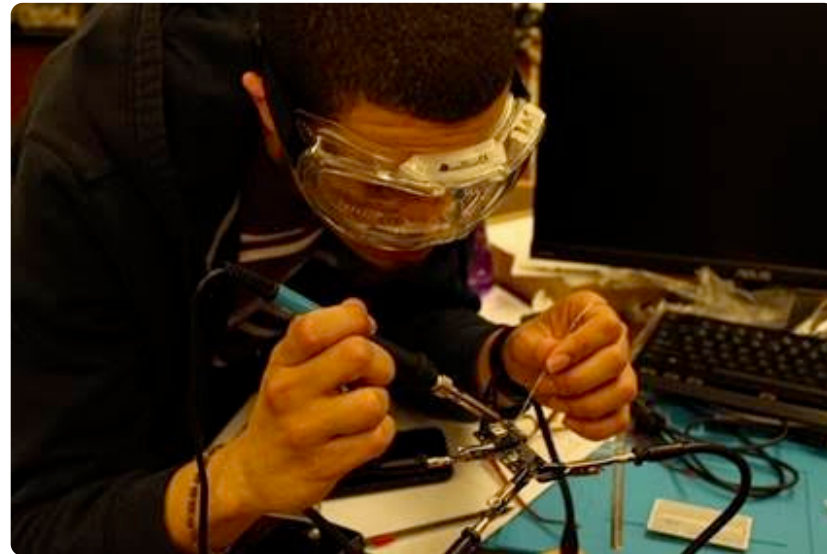
MUREP Innovations in Space Technology Curriculum

MUREP Innovations in Space Technology Curriculum (MISTC) contributes to the preparation, training, and development of NASA's future STEM workforce. MISTC collaborates with two-year/community college MSIs and other academic institutions to develop innovations in curriculum and experiential learning opportunities for underserved and underrepresented students in STEM.

In response to COVID-19 restrictions, several community college MISTC awardees were able to successfully transfer their curriculum-focused activities to an online, or hybrid, format. Over the summer, four MISTC students from CUNY Queensborough Community College participated in virtual internships with NASA's Goddard Space Flight Center. These students worked remotely to successfully develop four CubeSat prototypes, and presented their work at the virtual NASA Internship Symposium. From Aug. 24 to Sept. 4, CUNY Bronx Community College offered an online professional development workshop on image analyses using Earth observation satellite data. The workshop was attended by 13 institutions – including community colleges and high schools. Also, in the fall, Delgado Community College moved its MISTC-developed machine design course to its River City campus, allowing for hybrid online/on-site instruction that adheres to all COVID-19 safety protocols.



CUNY Bronx Community College MISTC online professional development workshop during COVID-19.



CUNY Queensborough Community College MISTC student soldering.

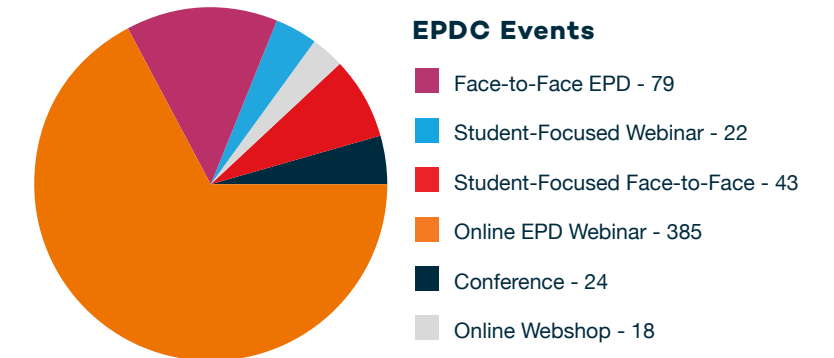
Educator Professional Development Collaborative

The Educator Professional Development Collaborative (EPDC) is a national educator professional development system designed to serve STEM educators at all levels. The EPDC provides professional learning experiences and resources to thousands of educators per year. Due to COVID-19 pandemic, the EPDC moved many of its efforts to virtual formats, which allowed the Collaborative to increase the frequency and flexibility of its STEM professional development opportunities. The EPDC began offering prerecorded STEM teaching overviews, featuring NASA activities. The online videos, called "STEM Quick-Bits" address K-8 science topics for educators and students. Additionally, the Collaborative developed a series of NASA STEM education tip sheets as guides for teachers, parents, guardians, and caregivers for teaching STEM to students who are learning from home. The EPDC also organized Spanish language sets of activities for K-8 students. Educators earned 178 online professional development digital badges.

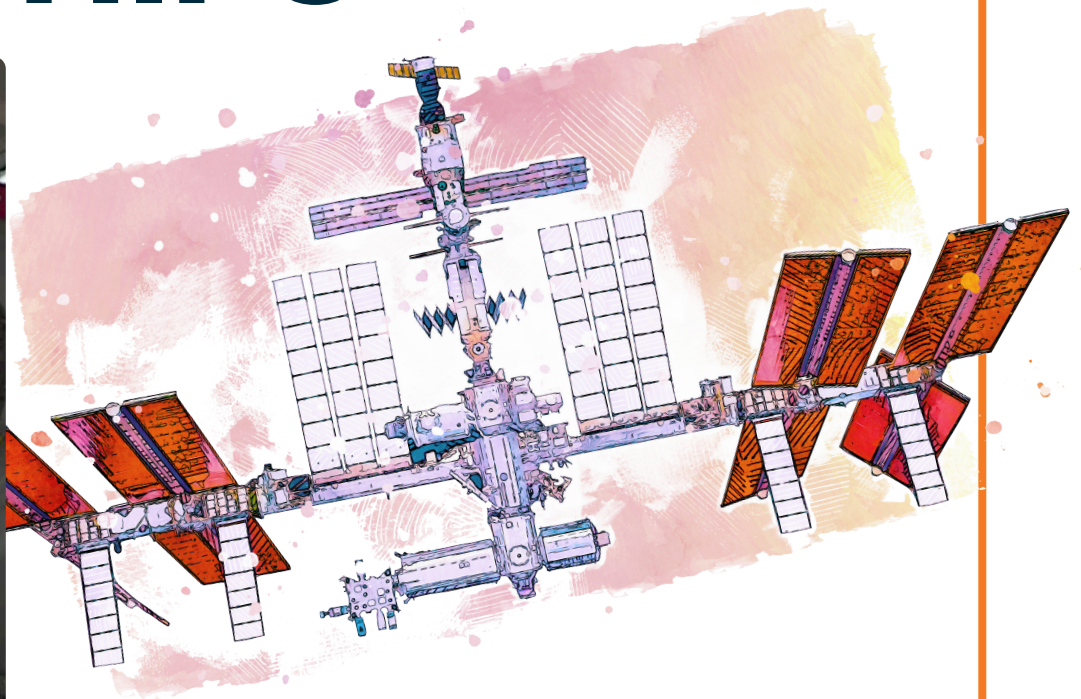


44,405 total participants in EPDC events

3,223 elementary school teachers	135 administrators
6,420 middle school teachers	3,038 informal educators
5,533 high school teachers	23,134 other
1,505 higher-education faculty	



STRATEGIC PARTNERSHIPS



Scalability Through Partnerships and Networks

Strategic Partnerships

NASA has more than 30 Space Act Agreements for STEM Engagement activities with external organizations. NASA is committed to engaging with external organizations to achieve the following goals:

- Engage students across the United States in opportunities connected to NASA missions, themes, or STEM Engagement programs
- Foster innovative models, methods, or approaches tied to National STEM Education and NASA STEM Engagement goals;
- Reach students from groups traditionally underrepresented in STEM careers

The involvement and contributions of NASA STEM professionals are vital to NASA's STEM Engagement efforts. NASA provides partners with access to:

- NASA mission data and imagery
- Subject-matter expertise in scientific and technical disciplines
- NASA-supported national networks of education institutions

The NASA STEM Engagement partnerships team cultivated a diverse set of new partnerships in 2020, yielding formal partnerships with Nickelodeon Noggin and Discovery Education. As a kick-off event for the NASA-Noggin partnership, an in-flight downlink event was held on Dec. 30, 2020, where students from across the country had the opportunity to hear from astronauts Shannon Walker of NASA and Soichi Noguchi of the Japan Aerospace Exploration Agency aboard the International Space Station. The astronauts answered prerecorded questions from pre-K and early elementary school students, who are part of the Noggin Kids community. NASA will work with Noggin in the development of relevant content for the Noggin educational app, designed for children ages 2 to 7 and their families to learn through tools, including interactive games and online books. Through the Noggin Cares initiative, tens of thousands of high-need, low-income families receive access to the Noggin app and service at no cost.



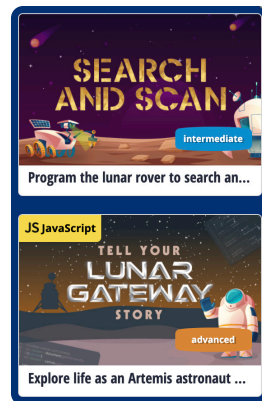
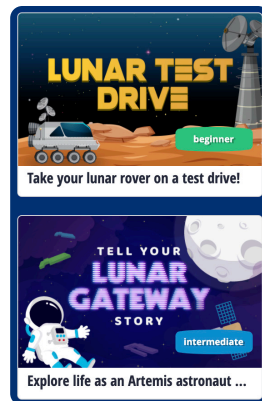
A glimpse of some NASA STEM Engagement strategic partnerships in 2020.



Tynker

NASA and Tynker collaborate on computer science connected to the Artemis missions

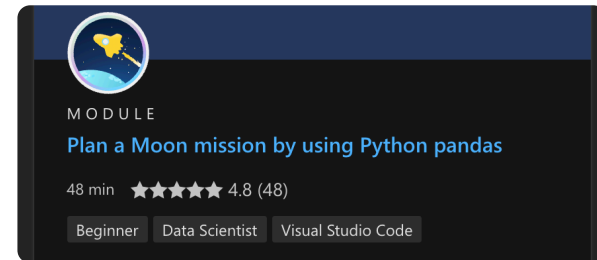
Through a formal partnership agreement, Tynker worked with NASA subject-matter experts to develop a collection of space exploration-themed computer programming resources, which the learning platform provides for students around the world. Students explore common coding languages through block- and text-based courses and are able to design lunar habitats, mission patches, and robotic rovers. Over 67,000 students engaged with the online resources and explored components of the Artemis missions throughout the school year.



Microsoft LEARN

NASA and Microsoft LEARN collaborate on computer and data sciences experiences for students

In a formal partnership with NASA, Microsoft LEARN developed a series of Artemis-themed resources for high school and undergraduate students to explore computer and data sciences topics, such as machine learning, using NASA datasets. With feedback from NASA scientists and engineers to ensure technical accuracy, the Microsoft LEARN team developed and released three modules in August 2020. During the first 60 days that the resources were made available, over 51,000 students visited the modules, with 7,200 earning badges for completing at least one module and 883 students earning trophies for completing the entire series. Through collaborations like this, NASA seeks to help students build the skills and knowledge needed for computer and data science careers.



National Park Service

NASA partners with National Park Service for 50th anniversary of Earth Day

In celebration of the 50th anniversary of Earth Day, NASA partnered with the National Park Service to create three Junior Ranger Space Tech Explorer activities. The activities explore what NASA and our national parks have in common and how space technology benefits parks, the planet, and everyday life. Written for students ages 5 to 12, the Junior Ranger Space Tech Explorer activities complement the existing NASA National Park Service Junior Ranger Spaceflight Explorer activity guide.



Microsoft Hacking STEM

STEM on Station collaborates with Microsoft's Hacking STEM initiative

Using the power of data in Excel, NASA and Microsoft developed an interactive student experience designed to introduce beginning concepts for understanding, visualizing, and using data. The activity explores the story of rockets and humans in space, and was built using the principles of relevance, equity for all, accessibility, and alignment to Next Generation Science Standards. As part of this effort, students from all around the world participated in three live virtual events featuring a panel of subject-matter experts in the aerospace industry. Each of these events garnered a live audience of over 10,000 viewers.



21st Century Community Learning Centers

NASA and U.S. Department of Education design challenges

In collaboration with the U.S. Department of Education, NASA developed seven unique design challenges for afterschool programs in 23 states. The challenges are based on real mission data and experiences from NASA's human and robotic missions. The opportunities connect students in grades 3-8 within the 21st Century Community Learning Centers program with NASA scientists and engineers to discuss proposed solutions to real design challenges. Each challenge includes a STEM facilitation guide, introductory videos, and resources to help educators maximize learning and engage students.



STEM Next Opportunity Fund – Million Girls Moonshot

NASA resources reach students in a variety of different ways — both in and outside the classroom — and through original content and external partnerships. A key component in engaging students in STEM fields is through extracurricular development. Afterschool programs across the country help students explore STEM content and career pathways, building academic knowledge and critical skills like problem solving and teamwork. NASA supports afterschool programs through dynamic partnerships and innovative resources.

This year, a new afterschool partnership emerged with the STEM Next Opportunity Fund, which focused on engaging students in engineering. As STEM fields are traditionally male-dominated, their Million Girls Moonshot initiative emphasizes the vital importance of attracting more females to these specialized careers. To mark the beginning of the partnership, NASA hosted with Million Girls Moonshot, NASA hosted a live event, “Million Girls Moonshot: Meeting the Artemis Generation” on Oct. 23 with astronaut Jasmin Moghbeli. Moghbeli answered student questions, discussed her journey to NASA, and provided information about Artemis and STEM careers.



MUREP INCLUDES

In January 2020, NASA and the National Science Foundation hosted a kick-off event for MUREP and NSF affiliates — including about 45 institutions, organizations and federal agencies — to begin developing a partnership focused on broadening engineering participation through MUREP Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science (INCLUDES). The NASA program is part of NSF INCLUDES, a nationwide initiative dedicated to broadening participation in STEM through networks of organizations.

The NSF INCLUDES National Network website is a valuable tool for member resources, expertise, and connections to support NASA's MUREP INCLUDES participants. MUREP INCLUDES also leverages MSIs to establish MSI-led coalitions to explore broadening participation strategies and partnership opportunities for communities around the country.

In April 2020, as the second phase of the joint effort, NASA released a MUREP INCLUDES Planning Grant solicitation to support concepts leading to new activities, or ways to scale-up current activities, to engage underserved and underrepresented students in STEM.



FOCUSED FEATURES



NASA STEM Stars

NASA STEM Stars connects middle and high school students to NASA specialists through live video chats hosted on the NASA STEM YouTube channel. Each weekly video chat features a different STEM practitioner and introduces a STEM career, addresses a STEM topic, and/or highlights a NASA mission. The video chat includes a short presentation, followed by a question-and-answer session in which the students can ask their own questions using the chat window. At the end of the episode, students and educators are left with a call to action, directing them to an existing NASA STEM activity for sustained learning and engagement. Each month, one episode features a bilingual subject-matter expert for NASA STEM Stars en Español. STEM Stars also has a feature series of James Webb Space Telescope experts highlighting the work of the mission.

Since NASA STEM Stars first aired in April 2020, Next Gen STEM has hosted 32 episodes with 46 different subject-matter experts, including two intern panels, two former astronauts, and a center director. These videos have had nearly 19,000 views and over 270,000 impressions (and growing). The focus of the series is to highlight the diversity of people, jobs, and careers at NASA; provide students with a wide-ranging group of STEM role models; and help them develop their STEM identity.

A full playlist of all STEM Stars videos can be found here:
<https://go.nasa.gov/3pVNz8c>

32 episodes **46** subject-matter experts **19K+** viewers



Hybrid Air Show

The Office of STEM Engagement, the Edwards Air Force Base 412th Test Wing STEM Outreach program and the Air Force Research Lab collaborated to present STEM Days during the Aerospace Valley Hybrid Air Show, October 5-8, 2020. STEM education specialists presented virtual STEM lessons, including hands-on activities in alignment with Next Generation Science Standards and Mathematics Common Core State Standards. These K-12 sessions focused on NASA content and were tailored to elementary, middle and high school students. Live sessions included STEM practitioners who discussed their work experiences and answered questions from students. Sessions in Spanish were also presented.

16
sessions over
four days

2,241
educator participants

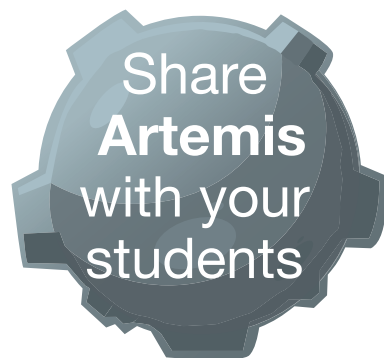
44,965
student participants

Sessions were broadcasted on six different platforms: Zoom, Facebook Live, Twitter Live, Twitch, YouTube Live, and on the Edward's Air Force website



Join Artemis Week

Join Artemis Week, Sept. 14 to 18, kicked off the new school year offering students resources and opportunities to be inspired by and engaged in the future of space exploration. The multi-day activities encouraged students of all ages to become active participants as part of the Artemis Generation. Students learned about NASA's Artemis program and were provided resources allowing them to stay engaged with NASA and the upcoming Artemis missions.



Form Your Artemis Team

Middle, high school, undergraduate and graduate students compete in Artemis Student Challenges while building foundational knowledge on topics and technologies critical to the success of Artemis. stem.nasa.gov/artemis

Code Artemis

Middle and high school students work with NASA's Space Communications and Navigation team to develop an app that visualizes the South Pole region of the Moon. nasa.gov/stem/nextgenstem/moon_to_mars/app_challenge.html

Explore Artemis Resources

Artemis topics aligned with national STEM education standards, NASA educator guides use space exploration as a theme for commonly taught STEM subjects. nasa.gov/stem/foreducators/k-12/index.html

Teach Artemis

Join NASA education specialists in live online sessions to engage and inspire the Artemis Generation. Earn digital badges through participation in various events. nasa.gov/stem/murep/projects/epdc.html

Host Artemis

AstroCamp trains youth-serving organizations to bring hands-on Artemis exploration activities to 2nd-12th graders in their own communities during the summer. nasa.gov/centers/stennis/education/students/astrocamp.html

Make Artemis

Explore hands-on activities and DIY projects. stem.nasa.gov

Support Artemis

Become an Artemis expert with the latest graphics and shareable content for your classroom. nasa.gov/joinartemis

Meet the Artemis Team

Hear from NASA technical experts working on Artemis. Related activities and Spanish-language sessions are available. [NASA STEM Stars on YouTube](https://nasa.gov/stem/stars)

Plan Your Artemis Expedition

K-12 students write an essay describing a one-week expedition to the Moon's South Pole. Choose your crew and tools for exploring the lunar surface. www.nasa.gov/feature/stem/artemis-essay-contest

Follow Artemis

Learn more about Artemis student opportunities.



STEM Journeys

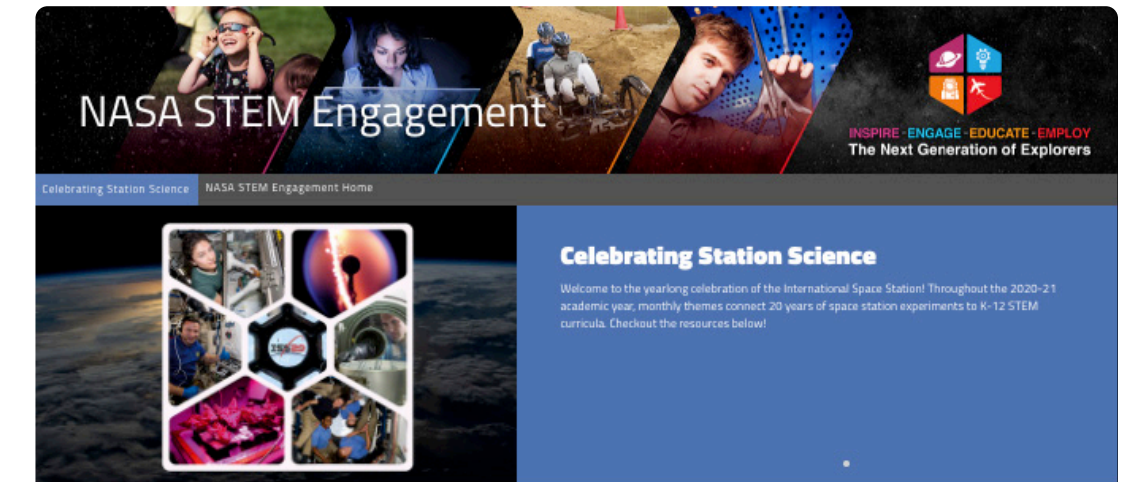
NASA and the U.S. Air Force collaborated to engage and inspire students interested in STEM through an interactive YouTube livestream event featuring Col. Nick Hague, NASA astronaut and flight test engineer for the Air Force, and Maj. Gen. Jeannie Leavitt, the Air Force's first female fighter pilot. During the event, called "STEM Journeys" Hague and Leavitt discussed all things space, leadership, and aiming high. The speakers answered questions submitted by viewers via social media, sharing details from their personal career journeys and offered advice to the next generation of students dreaming to follow in their footsteps. The event, which was focused on high school students, showcased NASA, Air Force, and Space Force career pathways and educational opportunities for students interested in pursuing STEM careers. Although COVID-19 restrictions prevented the event from taking place in person with a live studio audience, the online format created an opportunity to gain greater visibility and participation from students, families, and educators seeking digital- engagement opportunities during the school day. Watch the interview here: www.youtube.com/watch?v=liqnqJIhez0



“ I think it's important for everyone to realize we all face challenges. It's easy to look at someone like Maj. Gen. Leavitt and see her as a general and a fighter pilot, and think that everything worked out for her magically; or to look at an astronaut and think it just worked out for them. In reality, there are challenges throughout your life, and you're really defined by how you respond to those challenges. It took me three applications to NASA and 10 years to convince them that, yes, I had what it took, and I finally got accepted. You have to face those adversities. Many times, life isn't going to unfold how you think it's going to happen. ” – Col. Nick Hague

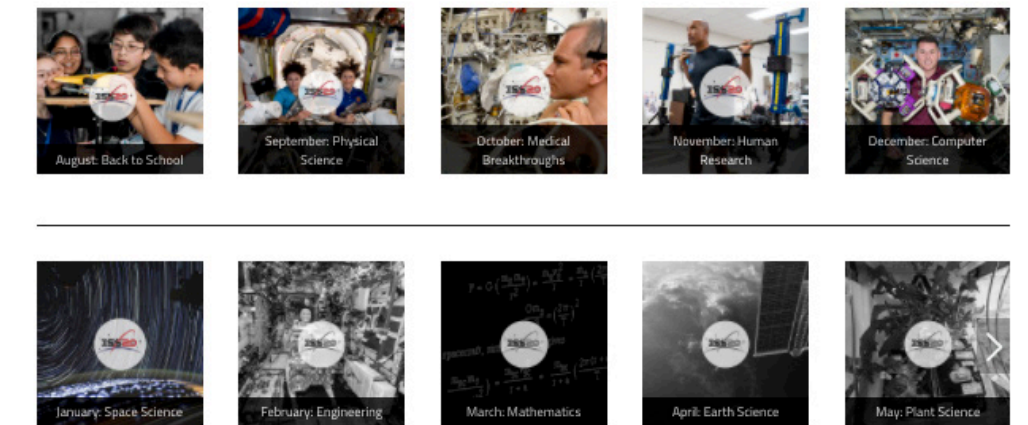
Celebrating International Station Science

On Aug. 8, 2020, NASA released the Celebrating Station Science monthly series. To highlight the agencywide celebration of 20 years of continuous human presence aboard the International Space Station, this series releases a monthly toolkit of resources for parents and educators on the Celebrating Station Science landing page. The initiative will continue to provide formal and informal educators with content through July 2021. Each month's theme celebrates different areas of research conducted by humans aboard the station over the past 20 years that is applicable to K-12 education. Topics currently available include physical science, medical breakthroughs, human research, computer science, and space science. Future topics throughout 2021 will include engineering, mathematics, Earth science, plant science, and next steps in space station research. To highlight these efforts, NASA will also celebrate the 20th anniversary of around-the-clock space station science and research operations from the Payload Operations Integration Center located at NASA's Marshall Space Flight Center. This celebration will take place in a virtual format with students and teachers in March 2021. For more information visit: www.nasa.gov/audience/foreducators/stem_on_station/celebrating-station-science.html.



Celebrating Station Science

Explore through a variety of theme-based resources.



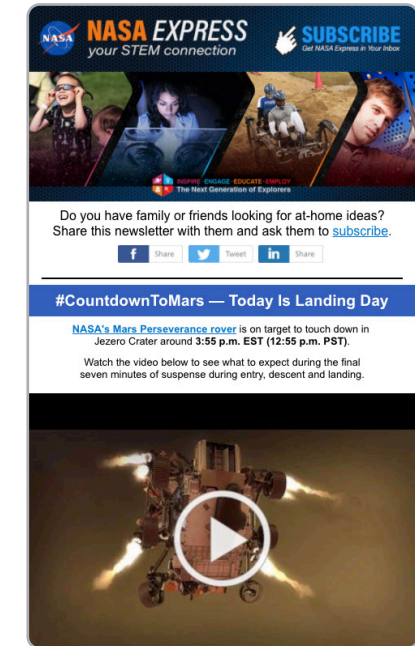
LINK INDEX



NASA Office of STEM Engagement Links



NASA Office of STEM Engagement
stem.nasa.gov



NASA EXPRESS
www.nasa.gov/stem/express

Follow, share and be part of NASA STEM to learn more and see our work in action.

 NASA STEM on Pinterest go.nasa.gov/2Jnor8C

 NASA STEM Engagement twitter.com/NASASTEM

 NASA STEM for Students facebook.com/NASASTEMEngagement/

 NASA STEM Engagement go.nasa.gov/2JqMVhh

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