

PREPARING AND INSPIRING STUDENTS TO PURSUE STEM CAREERS THROUGH IN DEPTH AUTHENTIC RESEARCH BASED SCIENCE PROGRAMS

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Introduction: The Student Planetary Investigator (PI) Program was created by the Johns Hopkins University Applied Physics Laboratory (APL) Space Department Education and Public Outreach office with support from NASA mission and instrument science and engineering teams.

The program is free and open to teams of students across the country, primarily high school through college but has included students as young as 7th grade. This student focused STEM (Science, Technology, Engineering and Math) program combines problem based learning modules, curriculum, authentic research opportunities and career-ready experiences that prepare and inspire students to pursue STEM occupations. The Student PI program model can be applied across data sets. To date three NASA Planetary datasets have been used with a fourth in development. Earth, Heliophysics, or Astrophysics data sets could easily be incorporated and applied to the model.

The program is conducted via distance learning technologies and is designed to provide maximum flexibility for student teams. Live classroom sessions are conducted through ZOOM, an online video conferencing system which connects scientists, mentors and students from around the country. These interactive tutorials are held during after school hours where students are invited to log on as a team or individually to interact face to face with members of NASA science teams. The sessions are archived for students that wish to watch at alternate times. Participants also communicate regularly with peers and science team members through an online bulletin board that is moderated by the Student PI program manager.

Students Exploring Our Solar System: APL has a long history of providing authentic distance learning research experiences for students. Since 2005, APL has been responsible for administering and delivering the Mars Exploration Student Data Team (MESDT) program, which operates with the support of Mars Reconnaissance Orbiter (MRO) Project Office at the Jet Propulsion Laboratory (JPL). In 2008, APL expanded authentic student data programming to include Student PI, a program which brings authentic research experiences to students using resources from across diverse sets of NASA data and mission activities.

The inaugural Student PI Program's focus was lunar. Using data from NASA's Mini-RF instrument, and interacting with scientists from the Mini-RF and NLSI teams, students analyzed radar data looking for water ice at the Moon's poles.

The second Student PI program has students looking to Mercury and working with data and science team members from the MESSENGER spacecraft. In this program, students conduct surface image analysis using tools such as QuickMap, the USGS PILOT (Planetary Image Locator Tool) and NASA's PDS (Planetary Data System) to locate, characterize, and create images using processing software such as GIMP (free, open source image processing software). These images are then featured via the "Featured Image" gallery page of the MESSENGER website.

These programs as well as the Mars Student PI program have been designed from the experience gained through the MESDT (Mars Exploration Student Data Teams) program that was conceived of by Arizona State University's Mars Education Program in 2005 and administered by APL. Since the time of its inception, the MESDT program has evolved greatly. Students and educators involved in the Mars programs work closely with scientists and engineers associated with the Mars Reconnaissance Orbiter's CRISM (Compact Reconnaissance Imaging Spectrometer for Mars) instrument. Each year program aspects are expanded and changes are incorporated into the student data programs based on assessments and feedback from participants and team members directly involved in the programs.

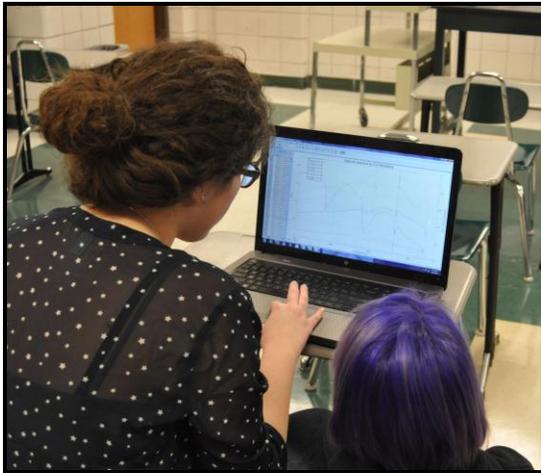
In each Student PI program, students participate in in depth authentic problem based science experiences, learning from and interacting directly with scientists and education experts. Scientists share data, tools, and methods for research and guide students as they begin to conduct their own research similar to scientists. Students develop hypotheses and projects based on data analysis, later presenting their work for peer and science team review.

Student PI Results: On average each Student PI program has had 100-150 students participating annually, with educator team leaders incorporating the program either as a supplementary curriculum through science classes, or as a foundation for planetary research classes. Assessments based on qualitative and quantitative data gathered for each Student PI program have shown that students gain new understanding about the scientific process used by real-world scientists as well as gaining enthusiasm for STEM.

In addition to participating in the scientific process through research and analysis of data, students experience other important aspects of a scientist's work

by working as a team, sharing information and ideas and collaborating with peers across the country. Student participation has shown to be valuable for science team members as well, for example students were involved in the pilot test of the JCAT software for use with Mars spectroscopy data.

Participants gain real world experience successfully communicating their research both orally and in writing. After presenting via online technologies, many students have been invited to present their research findings at various professional conferences and scientific meetings including: Lunar Planetary Science Conference, Astronomy Society of the Pacific Conference, National Science Teachers Association's regional and national conferences, and the USGS Planetary Mappers Meeting.



Students analyzing spectral data

Educational Impact: Third party formal evaluation as well as informal assessments conducted through quantitative and qualitative surveys of participants show that involvement with in depth authentic student research programs has lasting impact. The executive summary of the 2014 evaluation conducted by Cornerstone Evaluation Associates, LLC, states, *“In short, the MESDT program captures students’ interest, generates excitement, offers unique opportunities to research ‘real world’ science, encourages teamwork and develops skill sets that serve students well in STEM careers. It offers students intensive, meaningful and repeated exposure to NASA mission-related science over an entire school year. This intensity and the diversity of experiences have resulted in lasting effects on student participants including “changing the course of their lives.”*

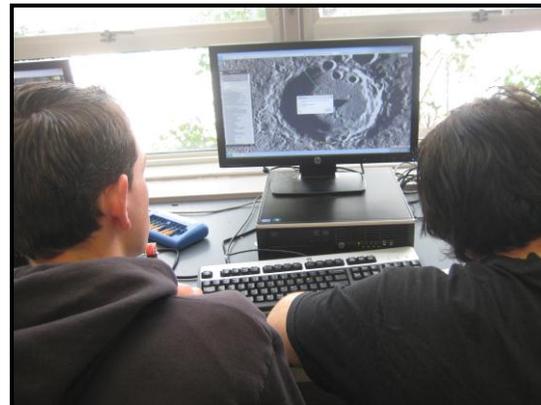
Participating teachers have also noted that their students have had STEM experiences and opportunities

they wouldn't otherwise have had if it weren't for their involvement in these programs.

- “My expectations are always surpassed as year after year, I get more students wanting to participate in this program. This program has also resulted in more students taking more of my Earth and Space Science courses and has promoted them going into science-related careers. Of the 65 students I have had participate ... over the last few years, 57 of them are currently pursuing science-related fields of employment or study.” (Rick Snyder, teacher, 2014).

- “This program provided amazing opportunities for my students. It was high interest material that allowed students to have access to some of the newest planetary information that has been released. Students were mirroring what “real scientists” do as they worked collaboratively to solve problems and do research.” (Annette Pearson, teacher, 2014.)

Collaboration and mentorship opportunities between peers and science team experts, with a shared goal of in depth exploration and discovery, have provided an effective vehicle for students to experience the excitement STEM research through NASA.



Students conducting research using QuickMap

Future Outcomes: This program prepares and inspires learners through problem based learning using NASA resources across data sets. It directly addresses and meets many of NASA's Education and Co-STEM goals. With continued funding of the Student PI programs, increased reach and student participation in STEM related fields is predicted. By continuing to expand the Student PI program through the incorporation of diverse data sets, additional learners will begin to see themselves in the role of a STEM professional while experiencing the joy of authentic research and the excitement of making authentic discoveries through the use NASA data.