IMPACT EVALUATION: INVESTIGATING THE EXMASS PROGRAM’S IMPACT ON STUDENTS.

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**Introduction:** Since 2009, the LPI-JSC-led Center for Lunar Science and Exploration has managed a research program for secondary (high school) students across the United States. The Exploration of the Moon and Asteroids by Secondary Students (ExMASS) program provides secondary students with an opportunity to conduct authentic, inquiry-based research with the guidance of their teacher and a planetary scientist. In this context, “authentic” student research occurs when they utilize multiple processes of science, just as professional scientists would, during an investigation [1]. “Inquiry-based” student research occurs when students pursue a research question/topic that is of interest to them [2]. To date, over 600 students in 30 states and Puerto Rico have participated in the program. More than 40 planetary scientists have worked with those students.

**Why ExMASS?:** Similar student research programs pairing students with scientists to perform authentic science research exist [3]. However, these programs tend to place students in a position where they are assisting in a researcher’s investigation, rather than a researcher supporting student-defined research [4]. Consequently, students are generally not provided with an opportunity to engage in multiple science practices, including communicating their research, in a collaborative setting. Despite the Next Generation Science Standards [5] call for developing authentic scientific communities of practice for students, opportunities to do so remain sporadic.

**Evaluation:** The goals of the ExMASS program are to 1) provide an opportunity for secondary students to engage in multiple practices of science, 2) foster positive student attitudes toward science, and 3) enhance student lunar and asteroid science content knowledge. Evaluation data has been collected over the life of the program to assess the extent to which these goals have been met. Data is collected via online surveys and includes pre and post lunar and asteroid science content surveys, an attitude towards science inventory (survey), and a process of science survey. These data show that the program consistently meets its goals [6]:

- Students utilize multiple processes of science during their investigations.
- There are statistically significant increases in students’ attitudes towards science.
- Student knowledge specific to lunar and asteroid science also increases.

It is important to note that the requisite Internal Review Board (IRB) exemption was not obtained for data collected during the 2009–2012 program years. An IRB exemption was obtained for the 2014 program and all subsequent years. Consequently, the data presented here is from the 2014 and later program years. (Note: No data exists for the 2018 and 2019 programs as the ExMASS program was on hiatus due to funding pauses.)

**Goal 1: Processes of science.** A survey was created to determine how many, and which, science processes students engage in while participating in ExMASS. The instrument is a multiple-response survey in which students select indicators of the process(es) of science they engaged in while conducting their research. The content in each item is borrowed from the practice of science standards and indicators found in the Next Generation Science Standards [5]. The survey contains eight practices, each with five or six indicators. Survey data indicates that most students recognize their practice of science.

**Goal 2: Attitudes toward science.** In 2018 Shaner et al. [7] reported results of validity and reliability tests on a survey specifically designed to measure ExMASS students’ attitudes toward science. This study found the survey both valid and reliable in measuring student attitudes across two factors: personal importance of science and importance of science in society. Using paired t-tests, the study also found statistically significant increases in positive student attitudes toward science when measured pre- and post-ExMASS participation.

Data reported in the 2018 study was collected during the 2014, 2015, 2016, and 2017 ExMASS program years. In 2022 a new paired t-test analysis was performed integrating attitude survey data from the 2020 and 2021 programs with the earlier data. This analysis showed continued, statistically significant increases in positive student attitudes toward science across all years [6]. An updated analysis including survey data from the 2022 program will be presented.

**Goal 3: Lunar / asteroid content knowledge.** Students enter the ExMASS program with gaps in their lunar and asteroid science content knowledge. To help fill these gaps, they go through a series of readings and exercises called Moon 101 and Asteroid 101. These “101” activities supply a foundation of basic knowledge in lunar and asteroid science that is beneficial to students as they move into the research phase of the program. Stu-
Many students complete both a lunar content and an asteroid content survey before undertaking the “101s” then complete the same surveys following the Moon and Asteroid 101 experience, but before they begin the research phase. These surveys have a mix of multiple choice, multiple response, matching, and open-ended items.

Analysis of these survey data reveal that, in general, the percentage of students scoring better on each item increases in the post-lunar content survey compared to the pre-survey. There are a few items in which the post score is lower than or the same as the pre score. There are multiple reasons why this may be, including ambiguous language in the item stems and/or response options. Also, these content surveys were created for internal evaluation only and did not undergo validity and reliability testing.

Inquiry-based?: Is it possible to determine the extent to which ExMASS is inquiry-based? This question can be partially answered by data collected from program exit surveys given to students, teachers, and advisors. One item asks respondents to rate the extent to which students were responsible for completing various phases of their research. Ratings fall on a Likert-scale — from one (1), indicating the advisor was mostly responsible, to five (5), indicating the students were mostly responsible. The phases of research rated were selection of research topic, development of research question, developing research plan, analyzing and interpreting data, constructing an explanation, determining layout/content for poster, and writing the abstract.

Responses by students, teachers, and advisors suggest students take strong ownership of their research. However, with one exception (writing the abstract), no one group (students, teachers, or advisors) agreed 100% that student teams took full ownership of any phase of the research process. This is not surprising. For most ExMASS participants, this is their first experience conducting student-driven research. The data is positive but limited as it is self-reported. In the future, this data could be complemented with interviews of students, teachers, and advisors to better understand why members of each group chose the ratings they did.

Though preliminary, the student research ownership data also provides a first step to examining the relationships between advisors and students. Looking deeper, Williams-Duncan and Watson [8] analyzed email communications between ExMASS teachers, advisors, and students during the 2020-2021 program. Their reported findings outline the positive characteristics of advisor-student relationships as well as best practices for advisor-student relationships.

Other Indicators of Program Success: The ExMASS program’s success is also evident in students’ research products and their activities following their participation. For example, 30% of ExMASS student research presented at annual NASA forums have received student awards. One student project resulted in a peer-reviewed journal article and one team presented their research to their state legislature. Though not initially a goal of the program, two peer-reviewed publications [6], [7] have resulted describing the program and discussing its success in meeting its goals, particularly the increase in positive student attitudes toward science.

Conclusion: The ExMASS program was created with the guidance of research literature findings on the impact on students participating in authentic, inquiry-based experiences. Participation in authentic science activities improve learners’ perspectives of and involvement with science [9], promotes understanding of scientific processes [10], and contributes to the development of a science identity [11]. The program’s confirmation of earlier research findings, along with the dearth of such experiences, supports a need for similar programs. While it is hopeful students may be inspired to pursue a STEM career with NASA or academia, it is understood that a small subset of program participants will ultimately dedicate themselves to that path. Developing an appreciation for, and remaining excited about, science is also a worthwhile participant outcome.

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