UNBOUNDED LEARNING ENVIRONMENTS AS AN APPROACH TO PRESERVING DESIGN FLEXIBILITY DEMONSTRATED WITH NASA STEM ENHANCEMENT IN EARTH SCIENCE (SEES) STUDENTS.

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Introduction: The Artemis Lunar program is providing opportunity for young scientists and engineers to contribute towards leading edge design concepts regarding early on-surface work areas that are aligned with major national initiatives[1]. Therefore, it is imperative in any discovery process that those young scientists and engineers be provided the bandwidth or operating in a 'greenfield' technology environment that encourages new ideas, and perhaps the discovery of ideas that would not be realized within typical structured engineering constraints. To facilitate this concept, the use of unbounded teaching methods was utilized to provide a low-constraint environment from which students can design and discover the requirements that are bounded by the natural environment of the lunar surface, and then build up design requirements un-hindered by budgetary and/or logistics realizations of the moment funding capabilities. Specifically, this design exercise provided the students to operate with unlimited budgets, and unlimited up-mass lifts to the lunar surface to develop a preliminary feasible process for establishing a working lunar research based upon the near-area permanently shadowed regions within the lunar surface [2]. In concept, working near PSRs will be advantageous as they receive near eternal shielding from solar radiation and may potentially host numerous volatile substances such as water ice, methane, hydrogen sulfide and helium-3 that will be the target of scientific investigation and in-situ resource utilization ISRU. The advantage of an upstream working area is that the quality of return materials could potentially be exponential when including an upstream analysis prior to earth-return missions. Furthermore, it's well known within the scientific and engineering community that working with the base materials in front of human eyes elucidates new features and observations that may not survive when stored and shipped to Earth. Finally, it is theorized that these methods and techniques developing on the lunar surface would be applicable to other planets or cometary surfaces.

Teaching Setup: Each student was set up to be both a section leader/coordinator, as well as a team-mate on other operators' sections [3]. The effort here is to have equal opportunity to experience both managing an effort, as well as participating as a teammate, with the hope to reduce or eliminate inner team conflicts and promote collaboration. Furthermore, with the enormous scale of the project for a summer analysis, one can realize that there is no time to conflict on small issues. Solve the design problem and move to the next. From a preliminary survey, this method seemed to resonate well with the students.

Preliminary Design Results: Our presentation relies on the mission assumptions that this is a post Artemis Mission, with SLS rockets being readily available and needed equipment such as the modules and transportation vehicles being an understood science. This lunar base will serve as Mars forward test facility, with mission durations lasting three months, a 628m^3 base required, and a power demand of 20 kilowatts per day. Our research modules reflect our scientific objectives. The support systems, Biology, Excursion, and Geology and Materials, modules will house the independent research that will be conducted in the modules.

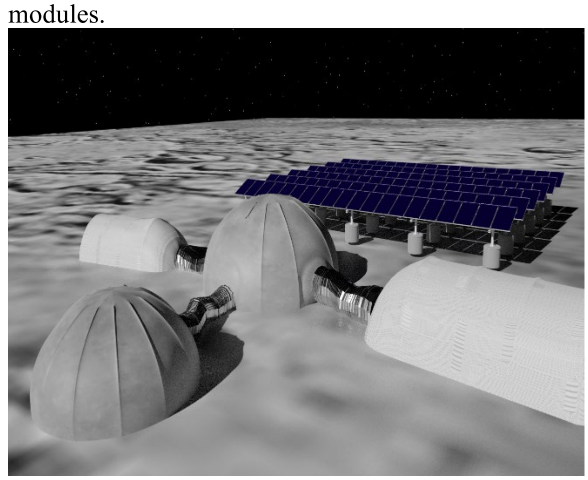
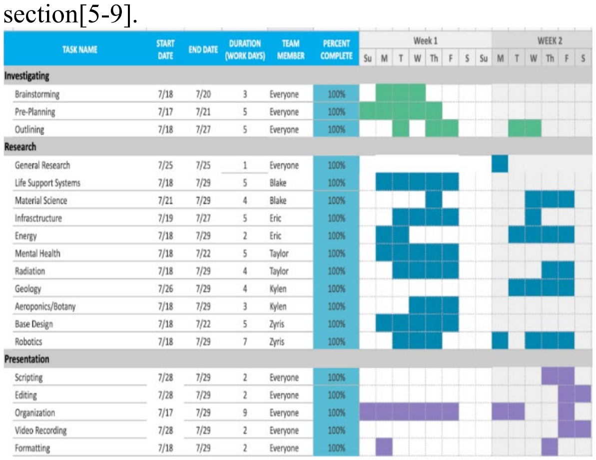


Figure 1: 3D render of the DELOS base made in the graphic design tool Blender. Shown are the solar arrays and the different base modules covered in a layer of lunar regolith for protection.

Student Learning: The sequence of landing materials and sections upon the lunar surface for establishing an up-field lunar research base is non-trivial. Considering the CLPS program [4] could provide many tips by breaking the working sections to solve one component of the materials on site. Any assembly must be either simplified, and/or modular, so that the work time fits within the work time on the surface. Preliminary designs for a lunar base, along with scheduling of Gantt charts were obtained [5].

Feedback from Students: From the students, the response in general was initially questioning the project, methods, and goals. However, once the students dove into the details, and began to see the enormity of the scope of the project, for most the engagement of the project coupled with the opportunity to make their mark increased significantly. The method of hybrid leader/teammate seemed to provide a smoother group working process. Keeping in mind, this design session was during the global pandemic as well, and the students did a phenomenal job being flexible, working both online, with a variety of online project management systems, as well as converging in Austin and JSC to work and meet as best they could. This culminated with a final presentation into the NASA SEES summer seminar series where each student presented their section[5-9].



TASK NAME	START DATE	END DATE	DURATION (WORK DAYS)	TEAM MEMBER	PERCENT COMPLETE
Investigating					
Brainstorming	7/18	7/20	3	Everyone	100%
Pre-Planning	7/17	7/21	5	Everyone	100%
Outlining	7/18	7/27	5	Everyone	100%
Research					
General Research	7/25	7/25	1	Everyone	100%
Life Support Systems	7/18	7/29	5	Blake	100%
Material Science	7/21	7/29	4	Blake	100%
Infrasctructure	7/19	7/27	5	Eric	100%
Energy	7/18	7/29	2	Eric	100%
Mental Health	7/18	7/22	5	Taylor	100%
Radiation	7/18	7/29	4	Taylor	100%
Geology	7/26	7/29	4	Kylen	100%
Aeroponics/Botany	7/18	7/29	3	Kylen	100%
Base Design	7/18	7/22	5	Zyris	100%
Robotics	7/18	7/29	7	Zyris	100%
Presentation					
Scripting	7/28	7/29	2	Everyone	100%
Editing	7/28	7/29	2	Everyone	100%
Organization	7/17	7/29	9	Everyone	100%
Video Recording	7/28	7/29	2	Everyone	100%
Formatting	7/18	7/29	2	Everyone	100%

Figure 2: Work matrix developed and executed by team to facilitate the project, parsing out work tasks and deliverables.

Conclusions: For the learning pedagogy, SEES engages in Active Learning by immersing students in real research. This also supports Experiential Learning. The SEES students were highly motivated individuals to start. Their motivation only grew as the project progressed. They were given the Learning Goal and Learning Outcome and had the problem and were told to produce a product/ poster. The SEES students participated in Asynchronous Instruction, where students learned the same material, but were in different locations and time zones. This broadens their understanding of differences and allows them to learn to work with different people. Using Blooms, students were able to understand the problem, apply new information, analyze old data to organize their ideas, evaluate their designs, and create original work for a real project. Students used Collaborative Learning to work together and saw communication was important and it sharpened their skills. SEES is Culturally Responsive, and speakers and lecturers from across NASA were introduced to a variety of scientists and engineers from diverse cultural backgrounds. The PIs learned to navigate a Learning Management System to monitor student progress and keep connected to all students. SEES is like a Project-Based Learning or Problem-Based Learning. Some Scaffolding was used through the modules they had to complete.

From this learning structure, the students were able to explore and develop preliminary design concepts for a working lunar research and advanced curation environment upon the lunar surface upstream of the sample return presumably through the CLPS and/or Artemis programs in the future. All the information utilized during the development design exercise was found from the references from the internet.

Year-end evaluation results show that SEES is on track to achieving its stated objectives for increased number of students, particularly underrepresented and underserved who will major in STEM in college and/or become employed in STEM careers and increasing interactions among science experts, NASA researchers and SME's, secondary school teachers, and high school students.

Acknowledgments: Support for this work is acknowledged through the NASA SEES program. Furthermore, teaching through the Texas State / Texas-JETS program for Dr. Lewis is acknowledged. The NASA SEES program provides significant support and learning for students and teachers during this effort.

The SEES High School Summer Intern Program is in partnership with NASA Cooperative Agreement Notice NNH15ZDA004C Award NNX16AB89A. TSGC is funded through the NASA National Space Grant College and Fellowship Program (SPACE Grant) Training Grant 20152018.

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