PLANETARY SCIENCE SUMMER SEMINAR CAREER DEVELOPMENT TRAINING AND EDUCATION MODEL. C. J. Budney[1], L. L. Lowes[1], K. L. Mitchell[1], and A. S. Wessen[1], [1]NASA Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, California 91109. Charles.J.Budney@jpl.nasa.gov, Leslie.L.Lowes@jpl.nasa.gov, Karl.L.Mitchell@jpl.nasa.gov, Alice.S.Wessen@jpl.nasa.gov.

Introduction: Sponsored by NASA's Planetary Science Division, and managed by the Jet Propulsion Laboratory (JPL), the Planetary Science Summer Seminar (PSSS) prepares the next generation of engineers and scientists to participate in future solar system exploration missions. Ten years after its inception in 1989 in a lecture format, JPL evolved the experience to focus on the process of developing a robotic planetary exploration mission concept into reality through concurrent engineering, mentored by members of JPL's advance project design team "Team X". This model of PSSS provides "breakthrough" learning of concrete skills directly applicable to future careers in planetary exploration, providing a bridge from participants' knowledge gained in graduate school and PostDoc positions and a jumpstart into the world of planetary science missions. Participants report PSSS has near-term value and applicability which continues to hold later in their career.[1]

Course design of this immersive experience intentionally includes effective instructional design principles, authentic learning experiences, and design thinking. There is a good deal of commonality between the key components of these modern education and training design principles, bolstering the justification for their use. This paper describes the alignment of PSSS with effective learning principles.

The Planetary Science Summer Seminar Experience: PSSS is a 12-week long career development experience, culminating in an intensive one-week exercise at NASA Jet Propulsion Laboratory's Project Design Center, preceded by a series of 11 weekly preparatory webinars and assignments. Under the mentorship of a lead engineer and a lead scientist (most recently, Dr. Charles Budney and Dr. Karl Mitchell), students select, design, and develop a mission concept from the Planetary Science Decadal Survey, following the guidelines of the NASA New Frontiers Announcement of Opportunity.

Students select the mission and science goals from options based on high-priority missions as defined by the scientific community, and develop a preliminary suite of instrumentation and a science traceability matrix. Students have both a science team role and a mission development role.

Once at JPL, students participate in a series of Team X project design sessions — their mentors aid them in finalizing the design of their mission and instrument suite, and in making the necessary trade-offs to stay within the cost cap. At week's end, students present their Concept Study to a mock "proposal review board" of JPL scientists and engineers and NASA Headquarters executives, who feedback the strengths and weaknesses of their proposal and mission design.

Effective Instructional Design Principles: PSSS is based on the common principles of instruction that most promote learning[2]:

- Learners are engaged in solving real-world problems – that is, a whole task rather than only components of a task, and a task that is representative of what the learner will encounter in the world. PSSS participants choose to develop a mission concept aligned with planetary science community priorities and their specific interest.
- Knowledge is activated as a foundation for new knowledge – by stimulating mental models of experiences in grad school and beyond to be applied in the mission concept design.
- New knowledge is demonstrated to the learner – PSSS mentors guide students to sources of relevant background information, and provide specific examples from their vast repertoire of actual mission development experiences.
- New knowledge is applied by the learner – as students advance in the understanding of the chosen mission and their roles within it, they increasingly take ownership, while mentors shift from a teaching to a guiding role.
- New knowledge is integrated into the learner's world – students publicly demonstrate their knowledge to the "proposal review board" and in subsequent conference presentations and professional publications.

PSSS as Authentic Learning Experience: A key element of effective instructional design, authentic learning is an instructional approach characterized by real world projects that are relevant to the learner.[3]

- By its very nature, PSSS is an authentic activity in to mission-related careers of planetary exploration professionals. Most obviously, conceiving and designing a mission concept in response to a NASA AO mirrors the core reality of doing mission-based science. Throughout this experience, Team X tools are the same to design

and cost actual missions. While this is the most important of the nine elements of authentic learning, PSSS addresses all of them.

- By developing a mission in response to a recent NASA AO, PSSS provides an authentic context that reflects the way participants' knowledge will be used in real life.
- PSSS is infused with science, engineering, and training professionals serving as mentors, providing access to expert performances and modelling of processes. Mentors guide students in areas both inside and outside of their "comfort zone", sharing technical knowledge, experience, and valuable narratives and stories.
- Students assume multiple roles and learn other perspectives from the mentors representing different technical areas of mission design and hypothesis-based science research.
- Concurrent engineering design is by definition collaborative - PSSS utilizes students' backgrounds and specialized technical roles to collaboratively construct knowledge and develop a solution for their mission design.
- Between actual Team X sessions, students further refine the mission concept design and prepare their culminating presentation, promoting reflection and articulation - enabling abstractions to be formed and tacit knowledge to be made explicit.
- Given the fast-track nature of mission concept development during PSSS, coaching and scaffolding are provided at critical times to guide students away from "road blocks" and stay on track towards a closure of a mission design.
- An integrated authentic assessment of learning is the preparation and presentation of their concept with feedback from the "proposal review board".

Design Thinking in Instructional Design and Mission Concept Development: Design Thinking is necessary in effective solutions to mission concept development, as well as in instructional design. Key stages include: empathy (research needs), define (state needs and problems), ideate (brainstorm), protoype (start to create solutions), and test (try out solutions)[4]. PSSS aligns with design thinking features[5] by:

- Starting from abstract specifications: Student teams respond to a largely unconstrained opportunity to design their mission.
- Involving a process that is iterative, concurrent, exploratory, and sometimes chaotic: Unexpected problems arise within a concurrent design environment, requiring iterative design, multiple brainstorming sessions, and specifications and solutions evolving in response to challenges.
- Follows cycles of mutual adjustment between specifications and solutions until a final solution is reached: JPL tools allow prototyping and testing of ideas within a concurrent environment. Mission design and trades are tracked and negotiated within a coherent framework.

Participants: To provide a jumpstart at a crucial point in the early development of planetary scientists and engineers, applicants are science and engineering post-docs, recent PhDs, doctoral or graduate students, and faculty teaching such students. Disciplines include planetary science, geoscience, geophysics, environmental science, aerospace engineering, mechanical engineering, and materials science.

To ensure the students have the necessary background to benefit from PSSS, participants are selected through a competitive review process, with selections based on the strength of the application and advisor's recommendation letter.

The majority of students come from US universities with planetary science or aerospace-related engineering programs, representing over 50 different universities. 654 individuals have participated in the Team X-based PSSS sessions since 1999. The majority are now employed or conducting postdoctoral research at NASA Centers; are employed at Federally-Funded Research and Development Centers, science research organizations and aerospace companies; or they are university faculty, staff, or postdocs.

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References:

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