BLENDING RESEARCH AND TEACHING THROUGH NEAR-EARTH ASTEROID RESOURCE ASSESSMENT. R. A. Fevig[1], J. Casler[2] and J. Straub[3], [1]Department of Space Studies, University of North Dakota (Clifford Hall Room 512; 4149 University Ave Stop 9008; Grand Forks, ND 58202; rfevig@space.edu), [2]Department of Space Studies, University of North Dakota (Clifford Hall Room 512; 4149 University Ave Stop 9008; Grand Forks, ND 58202; rfevig@space.edu), [3]Department of Computer Science, University of North Dakota (Streibel Hall Room 201; 3950 Campus Road Stop 9015; Grand Forks, ND 58202-9015; jeremy.straub@my.und.edu)

Introduction: The development of technologies for the assessment of near-Earth asteroids serves several highly valuable purposes. Assessment activities advance our knowledge of the formation of the solar system, are a required step in preparing for an Earth impator intervention mission, and serve as a first step towards resource extraction and utilization.

Space missions are, by themselves, highly inspirational for students. The current buzz surrounding the launch of Planetary Resources, a private corporation with plans and funding to mine asteroids, which is already cash-flow positive [1] makes the topic all the more exciting. Given that resource extraction from asteroids has never been done on the scale required for sustaining human presence in space or justifying the costs from returning minerals to the Earth for sale, it also presents a blank slate for students to explore.

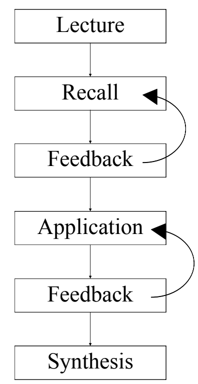
Curicullum Incorporation: Course-integrated, student-driven, team-based research efforts are a key component of the graduate-level courses that comprise the University of North Dakota's Space Studies Masters and Aerospace Sciences Ph.D. programs. The UND Space Studies Department offers students an interdisciplinary perspective which spans engineering, science, policy, business, management and history. Team projects are regularly included in several courses including SPST 502-Survey of Space Studies II, SPST 405-Space Mission Design, SPST 505-Spacecraft Systems Engineering, and SPST 506-Advanced Orbital Mechanics.

In each case, a real-world research problem is presented to students. However, they are left free to frame the problem as they saw fit and derive an appropriate solution that is responsive to the way they have framed the problem.

Learning Model: A six step learning model is used to engage students in project-driven courses. This model combines traditional education material delivery and assessment techniques such as lectures and assigned reading with innovative project and team-based learning techniques and assessment activities. The culmination of this process is the synthesis activity, where students apply the learned material to a new challenge. This multi-level learning approach is responsive to all of the levels of the revised Bloom's Taxonomy [2]. Figure 1 depicts the iterative engineering learning model.

The first step, conventional lecturing combined with assigned reading, imparts basic foundational subject-knowledge to the students. This step prepares them to gain additional knowledge through a guided

Figure 1: Iterative Engineering Learning Model



discovery process in later steps. Conventional recall testing mechanisms including written and oral quizzes and exams are utilized to test retention and understanding of this knowledge; appropriate feedback is given.

The second step, application, involves students utilizing the material learned during the preceding step in response to guided problem solving, application questions and scenario-based responses. These application exercises can take the form of in class discussion or individual or group homework assignments. Again, appropriate feedback is given.

The final step of this model, synthesis, which is alligned with the 'create' level of the revised Bloom's Taxonomy [2], causes students to utilize the imparted knowledge and to seek out other required knowledge in order to solve a larger-scale challenge. This workforce analog activity requires students to choose leaders, subdivide their team, identify key tasks and assign them in order to achieve the desired results.

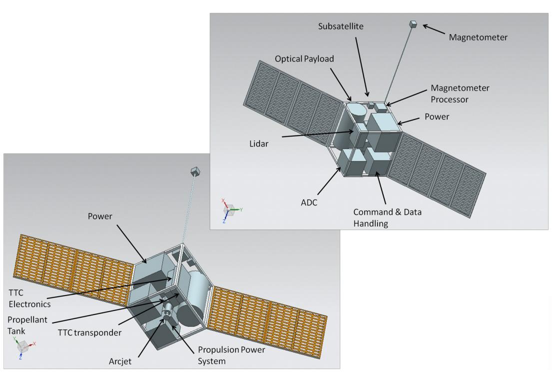
SPST 405: In Space Mission Design, students had a hands-on experience with designing, developing and operating a spacecraft through a high altitude balloon (HAB) near-space project. Each team devised a payload concept and progressed it through the various design phases. Several completed payloads were subsequently launched (as shown in figure 2). Work in the Spring 2011 iteration of SPST 405 lead to the creation of the mission concept that was further developed in the Fall 2011 SPST 505 instance, described below.

Figure 2: Preparing for the HAB launch

SPST 502: In Survey of Space Studies II, students prepare an individual paper on a NEA assessment-aligned topic. A group paper and presentation related to NEA assessment and the required in-situ characterization is also created. This group assignment requires students to place themselves in the role of a NASA panel reviewer making a case for a program go/no-go decision. The 2012 iteration of this course will focus on the Keck Asteroid Retrieval Feasibility Study [3].

SPST 505: In Spacecraft Systems Engineering, students developed a mission architecture and high-level design for a SmallSat-class spacecraft designed for Earth impactor assessment purposes as part of a multi-stage intervention architecture. The work performed in this class has served as the basis of three published works [4, 5, 6] and is being refined for submission to the USAF University Nanosat Program (UNP) for funding. Figure 3 shows student-produced CAD drawings of the spacecraft.

Figure 3: Spacecraft CAD Diagrams



SPST 506: In Advanced Orbital Mechanics, a student-lead, student-driven project focused on the ΔV requirements for tortile-style manuvers, which are used by electric propulsion, for an asteroid visit. The comparative payload mass available for a given launch weight was compared between various propulsion styles. This resulted in a poster presentation at an international conference [7]. An additional conference presentation [8] was generated from work performed partially in-class and partially as part of a student-centered research activity.

Student-Centered Research Activities: Extra-curricular research activities are also an integrated part of blending research and teaching. Many of the students that completed SPST 505 are still involved in spacecraft systems engineering work leading towards the aforementioned UNP proposal. Orbital mechanics design work is also ongoing.

Evaluation and Conclusions: Project- and team-based learning can provide a critical bridge between coursework, research or workforce entry. It causes students to internalize material in a way that conventional lecture-and-test techniques cannot approach. The blending approach has been extremely successful, generating several student conference papers [4-8] and a master's thesis [9]. Because of this, work is ongoing at UND on incorporating project- and team-based learning into other courses.

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