Aerospace Living Learning Community (Aerospace LLC) for First-Year Students

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Abstract

Living and Learning Communities (LLC) at New Mexico Institute of Mining and Technology (New Mexico Tech) were originally developed through the Student Engagement and Success (SES) Title V Grant, a United States Department of Education-funded grant, awarded in 2010. The LLC project-based program offers a range of focused research and design themes to first-year students including sustainability, aerospace, mobile computing, watershed management, and robotics. This paper discusses the New Mexico Tech Aerospace LLC program.

Overview and Mission of the Aerospace LLC program

The 2015-2016 Aerospace LLC project is the third iteration of an applied research and design course developed to introduce first-year students to the basics of aerodynamics, engineering principles, and experimental testing. Innovating LLC curriculum requires flexibility and continuous collaboration by faculty mentors to modify successful LLC courses as they evolve over the course of the project and in future years. The primary goal of the 2015-2016 Aerospace LLC is to introduce incoming students to the fundamentals of Aerospace Engineering. The Aerospace LLC project curriculum provides in-depth, hands-on, group-oriented learning experiences to first-year students at New Mexico Tech. The restructured Aerospace LLC curriculum now introduces students to the basic concepts of aircraft construction and design, while retaining the best practices determined from a previous focus on rocket nose cone prototyping. Aerospace LLC students will first learn the fundamentals of aerospace engineering including aerodynamics, aircraft layout, and aircraft control. In assigned groups, teams design and fabricate remote controlled aircraft capable of carrying and dropping student-designed payloads onto a designated target. Teams then compete for the best performance, evaluated on their ability to model and predict the flight path of their projectile. Emphasizing communication skills and higher-level thinking, teams evaluate their performance and discuss their results in final oral presentations.

Learning Communities at NMT

Retaining more students seeking degrees in science, technology, engineering, and mathematics (STEM) is an effective way to meet the increasing national needs for an estimated 1 million

STEM professionals over the next decade (PCAST, 2012). Statistical analyses of national data for students seeking bachelor degrees in STEM fields found that "participation and performance in undergraduate STEM coursework are associated with STEM attrition;" students who take a heavier load of STEM courses while maintaining a high GPA in their first year are less likely to leave school or change to a non-STEM major (Chen, 2013).

The American Society for Engineering Education (ASEE, 2012) cites learning communities, collaborative projects, and undergraduate research as some of the high-impact educational practices that increase retention in engineering disciplines. Learning communities effectively increase the level of academic challenge, encourage active and collaborative learning, and provide a medium for student-faculty interaction (Kuh, 2008; ASEE, 2012). Learning communities are not only effective in retaining students in STEM majors (ASEE, 2012; Palm IV & Dunn, 2015), high-impact project learning helps students build necessary academic and professional skills (Kuh, 2008; Moening & Weber, 2012) and creates a sense of identity for incoming students as part of the STEM community (Ciston et al., 2011). At New Mexico Tech, LLCs center on collaborative research and design projects that create applied learning experiences, foster community, and facilitate interaction between faculty, learning coaches, and first-year students.

New Mexico Tech developed the LLC program through the Student Engagement and Success (SES) Title V Grant, a United States Department of Education-funded grant, awarded in 2010. Research- and design-themed project coursework, direct interaction with research faculty, tutoring and mentoring by peer learning coaches (successful upper-level undergraduate science and engineering students), and a greater sense of community within the institution have created a successful model for increasing engagement and retention in STEM disciplines for undergraduates. Students involved in an LLC are more likely to have higher grades, a higher GPA, higher satisfaction, and higher graduation rates. Because of this success, NMT institutionalized the LLC program in 2015, operating under the Office for Student Learning (OSL). To persist at New Mexico Tech, incoming students need to develop computational and technical skills, early, to achieve academic success in STEM and to keep motivated on the path towards accomplishing their individual educational goals. LLC faculty mentors recognize the importance of building community. Mentors are willing to take a more participatory role in first-year education by developing integrated curriculum that helps students apply introductory concepts to hands-on projects. Coursework centered on a hands-on design and build project gives relevance to introductory courses and concepts through applied learning. The LLC projects help students transition to university life by encouraging them to become actively involved with their own learning. Team-based design projects (typically 20 students divided into teams of 3-4 students), led by faculty and peer learning coaches, give first-year students immediate access to a support network, as well as, the ability to problem-solve by connecting ideas from different disciplines to a themed design project. Project-based learning facilitates building closer social

and intellectual relationships between research faculty and new students as they work together to solve real world problems.

Aerospace LLC (2015-2016)

Fall semester

In the fall semester, twenty first-year engineering students focused on building a knowledge base including the fundamentals of aircraft design and the basics of aerodynamics. The students applied this knowledge to the construction and modification of model aircraft capable of transporting and dropping a payload on a specified target. Initial lectures overviewed propulsion systems and several components of aircraft design. Because the Aerospace LLC is open to students from multiple majors and who differ in pre-college preparation for STEM, students practiced using units to relate different physical quantities and were introduced to numerical computational methods used to model systems. Throughout the introductory coursework, we exposed students to programming concepts by showing examples of MATLAB code for calculating different flight-related variables. We divided the cohort into five teams of four students. Each team was tasked with ordering a model airplane kit based on the project requirements, ease of construction, and ease of modification to accommodate a payload and drop mechanism. The learning outcomes of the first semester curriculum were for students to one, have a conceptual idea of how their drop mechanism will function and two, have completed an initial design of their payload. One crucial design consideration teams need to evaluate is the mounting scheme of the payload. An internal mount will require a larger fuselage to accommodate the payload and dropping mechanism. External mounting will require a higher ground clearance to allow for takeoff and landing.

The weight of the payload largely affects the wing, motor, and propeller selections. Students researched different wing-loading conditions and determined the most effective aircraft design as part of their solution. After selecting wing and fuselage geometries, student teams determined the appropriate propeller geometry for their aircraft. With these decisions made, stall speed and thrust requirements can be calculated to select the appropriate motor. Students will need to apply these concepts, taught during the first quarter of the course by both Dr. Yilmaz and the learning coaches, as part of the design process. Throughout the design process, quad chart presentations and written and oral progress reports were assigned to keep track of student progress and build communication skills. We set checkpoints and requirements in the syllabus, reflecting the Mechanical Engineering department junior and senior design clinic requirements, to better prepare the students for their future capstone projects. We assessed students by evaluating the design and analysis of their aircraft system and on their progress throughout the semester.

Spring semester

In the spring semester, teams will focus on designing the payload and drop mechanism for their aircraft. Students will design a payload that has the proper shape and weight distribution to accurately drop onto a designated target. Students will need to be aware how the weight distribution and shape of the payload affects the flight performance of their aircraft. Incorrectly calculating the weight distribution may lead to an unintended shift of the center of gravity after the drop, causing unstable flight. Teams choosing internally mounted payloads will be more limited by the volume of the aircraft. The drop mechanisms will need to be restored to their original positions after actuation to keep their outer mold line consistent. This poses a challenge for the design teams, to understand that a drop mechanism can be designed to be "use and forget" by allowing gravity to do most of the work. Students will need to consider different actuators that fit their budget, weight, power, and volume requirements. The course includes strict budget restrictions for each group, proposal presentations, midterm reports, final design reviews, and the flight competition.

Student teams will test their completed design in a competition at an airfield on campus, open to the general student body and the faculty. The students will be given the opportunity to answer questions about their design and defend design decisions they have made throughout the year to gain experience in technical communication.

Preliminary results

Construction of the aircraft in the fall semester has taken longer than expected. Teams will need to complete construction in the beginning of the spring semester. Spending only a few hours on construction a week has not provided adequate time, showing that the timeline will need to be modified in the future to incorporate more lab time outside of class or to begin construction earlier in the fall semester. The progress that teams have made on the design of the payload and drop mechanism, which is ahead of schedule, will counteract the construction delays in the spring semester. Students are excited to complete their aircraft and will have enough time in the beginning of the spring semester to complete the mission and be ready for the final competition in April 2016. Fall semester model aircraft construction is shown in Figures 1-4.

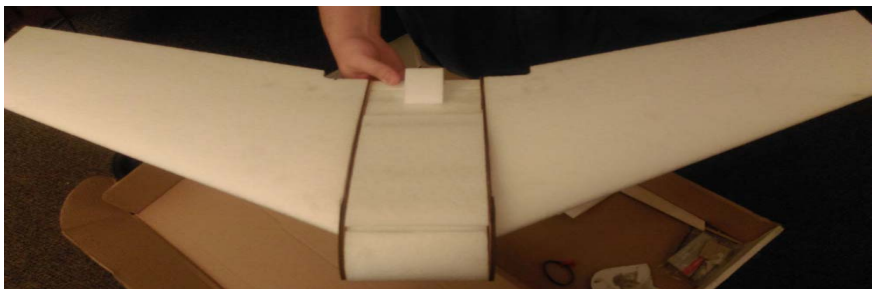

Figure 1. *Flying wing construction*

Figure 2. *Team-constructed wings for a high wing bush plane*

Figure 3. *Fully constructed foam high wing bush plane*

Figure 4. *Construction in progress of balsa and monocoat high wing L19*

The Aerospace LLC students have grown in their knowledge of aircraft design. They know the fundamentals of design, demonstrated by their selection of appropriate aircraft and preliminary payload designs. Students have also begun to incorporate their knowledge of physics into modeling the payload drop and have been experimenting with using MATLAB for drop simulations. These skills will give the first-year students a great advantage in future classes, having gained much engineering knowledge and experience from this one credit introductory class.

Summary

The Aerospace LLC provides incoming students at NMT with an opportunity to gain hands-on experience that many engineering students do not get until their junior or senior year design courses. As LLC faculty mentors and learning coaches guide students through the process of prototype design and experimental testing, students build important relationships while developing quantitative skills and a more comprehensive understanding of the principles of

aerodynamics. The ability to communicate, access to networking and resources, and a toolbox of engineering skills gained in this course give Aerospace LLC students a solid foundation on which to build their academic and professional careers.

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