Developments in Business Simulation and Experiential Learning, Volume 29, 2002

PUTTING SERVICE LEARNING INTO ORBIT

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ABSTRACT

Service learning is a powerful pedagogical tool using community or public service experiences to enhance traditional course content's meaning and impact. This approach is valuable for two interrelated reasons: 1) it provides a form of practical experience enhancing learning in all potential curriculum areas and 2) the community service experience can reinforce civic and moral values desirable in society from serving others (Zlotkowski, 1996a, 1996b). This paper presents a brief description of service learning and describes a unique application of this pedagogy at a military service academy. A special offering senior capstone course involving engineering systems design and program management, where the final project (a small satellite) is actually placed in orbit, is used as a vehicle for service learning. Also experience-based insights into improving service learning implementation are presented with suggestions and demonstrations for making this approach part of the curriculum.

INTRODUCTION

Corporate America's perspective on the inter-relationship of profits and social responsibility has changed dramatically over the years increasing its involvement with community service. Volunteer or community service activities have shown to improve the acquisition and retention of skilled employees, the maintenance of morale and team skills, corporate reputations, and eventually profitability measures (McCarthy & Tucker, 1999). Likewise in our nation's global responsibilities, the views on the United States military's roles and missions are radically changing as well. With the fall of the Berlin Wall in 1991, Cold War posturing has ended with a renewed use of the United States military in peacekeeping and peacemaking deployments, humanitarian actions, and contingency actions such as drug interdiction in both global and domestic arenas (Air Force Magazine, 1999; Callander, 1998). This new direction is causing a radical change in military thinking and culture on how to train, organize, and use people, equipment, and tax dollars. This paper presents an example of how a United States military service academy embraces community/civic-based or service learning in much the same manner as the private sector and other universities have. But a major difference is this course's final project, a small satellite, is actually placed into earth's orbit.

Service learning is a vehicle where course curriculum or content can be reinforced as students perform valuable service to the community (McCarthy & Tucker, 1999). Possibly the most widely practiced form of experiential learning, service learning is a method where reasoning, leadership, interpersonal skills, academic content, values, and citizenship are taught through real-life community experiences (Katula & Threnhauser, 1999). As both universities and corporations meld community/civic service activities into their curriculums, events, and culture, it becomes important for students to develop increased awareness of social responsibility and commit to supporting this increasingly important aspect of business and education.

As the United States military's roles and missions evolve and change to new global responsibilities and citizenship, developing a service learning pedagogy at a service academy helps groom future officers and leaders for new global and domestic actions required of them. The military academy in this paper, United States Air Force Academy (USAFA), is an undergraduate institution located just north of Colorado Springs, Colorado. USAFA graduated its first class in 1959, and currently has just over 4000 students, selectively recruited nationwide. The Academy's mission is "to develop and inspire air and space leaders with vision for tomorrow." Consistent with this

mission, students (cadets) are commissioned upon graduation as Air Force officers with the daunting time-honored challenge of national service.

Evolving a service learning approach at USAFA is formally incorporated in at least two courses. Since the mid-seventies, Engineering 410 continues to serve as a core curriculum capstone experience addressing service to a wide variety of community stakeholders in three basic categories: Community Service, Assisting the Disabled and USAFA Improvement (Hornyak et al, 2000). But another course, Astro 433, is much more focused on servicing the Department of Defense (DOD), academic, and aerospace communities involving USAFA graduates. This course, referred to as, the Small Satellite Program, serves as the case scenario for this paper.

Over the last ten years, the Small Satellite Program has been administered and taught by the Department of Astronautics (DFAS), one of 22 Departments under the Academy's Dean of the Faculty. It was originally created as a dedicated systems analysis and decision-making process course for astronautics majors only. Since 1991, it has evolved into an interdisciplinary/community projects based course for students interested in synthesizing classroom learning from various disciplines to tackle "real world" engineering design challenges. Furthermore, the Small Satellite Program incorporates additional capabilities learned in the Academy's four academic divisions (Engineering, Basic Sciences, Social Sciences, and Humanities) and has become a prototypical capstone experience interchangeable with the required capstone course (Engr410).

The paper's intent is to extend the discussion of service learning and highlight this powerful experiential methodology's application in a unique learning environment, a military service academy. First, a quick review of the service learning concepts in management education is conducted. Next using USAFA's Small Satellite Program as a case scenario, its background, project histories and service learning pedagogy are highlighted while showcasing one current project, the building of FalconSat 2. Finally, reasons for program success are suggested and offered for consideration by other institutions as well as identifying what continued student service learning experience improvements are needed.

SERVICE LEARNING

Service learning is a method and philosophy of experiential learning where participants meet community needs while developing critical thinking talents, group problem solving abilities, and evolving their values and citizenship (Lamb, Swinth, Vinton, & Lee, 1998). The idea behind service learning is to use a community or public service experience to enhance the meaning and impact of academic course content. The connection of service to academic courses makes it quite different from community volunteer work or sending students into communities for additional course credit (Sax & Astin, 1997). Community service or service learning is valuable for two fundamental and interrelated reasons: 1) the practical experience of "service" can enhance learning in any area of a school's curriculum, and 2) by serving others, civic and moral values are reinforced by the experience (Zlotkowski, 1996a).

Service learning projects present another medium for students to learn and demonstrate knowledge in much the same manner as taking exams or writing papers. However, service learning also allows for different ways of knowing and learning to occur through action and experience (McCarthy & Tucker, 1999). Service learning activities can be implemented in various academic fields or disciplines using innumerable community-based projects. For example, a Psychology class could conduct counseling, mentoring or drug education for at-risk school children, an English course could design and implement adult literacy programs, and a strategic management course may develop business plans for needed services in low-income communities (McCarthy & Tucker, 1999; Sax & Astin, 1997). Reported student benefits from service learning activities include improved technical and problem-solving skills (Zlotkowski, 1996b) to increased academic development and civic responsibility (Sax & Astin, 1997).

After studying such compelling evidence, one may question why more schools are not willing to pursue this experiential pedagogy? First, it is not easy to develop and integrate a service learning agenda into a specific school curriculum. Kolenko, Porter, Wheatley, & Colby (1996) suggest barriers such as faculty and organizational resistance occurring due to a perceived increase in class responsibilities with service learning while already being burdened with high teaching loads (Gose, 1997). Another barrier is a lack of institutional infrastructure, people, and resources to coordinate internships and collect project contacts (Chapin, 1998; Lamb et. al., 1988). Finally schools shy away because the relevance of service learning in particular areas of study has not been convincingly demonstrated (Kolenko et al., 1996). Consequently, integrating service learning into a curriculum must be brought forward and advocated first as an institutionally sanction effort focusing on civic and moral concerns and not just various student-led volunteer activities. Also as a teaching pedagogy carefully crafted to specific disciplinary and interdisciplinary goals, service learning is not a one size fits all approach (Zlotkowski, 1996a). Service activity needs to mirror course content and not merely serve as an add-on experience requiring students to do something good for the community. It must be a planned experiential activity tied to not only course objectives but also linked institutionally through outcomes, curriculum, faculty roles, and rewards. The case scenario presented here integrates all of these requirements.

SERVICE LEARNING AT USAFA

Some find it unlikely for service learning to be a pedagogical approach used in course work at a military service academy. Normally, service academies are categorized as engineering schools with multiple engineering and science academic components. In fact the Air Force Academy undergraduate program is distinctive in that students are required to take a core curriculum of specific courses in engineering, basic sciences, humanities and social sciences. The heavy engineering and science course load means every graduate receives a Bachelor of Science degree—in over twenty disciplines such as Management, History and even in English.

However new United States military roles and missions involving new global responsibilities and citizenship have evolved since the end of the Cold War such as domestic and regional humanitarian aid, assisting the war on drugs, and peacekeeping. These new roles and missions involve closer contact with local communities, organizations, and the people therein. As a result new and different skills and abilities are being required of military members to better deal with a dynamic operational environment. An increased sensitivity to civic, local, and moral concerns may be an important ingredient in the growth, education, and nurturing of future soldiers. The USAFA curriculum has evolved over the years to best service the Air Force needs while satisfying each student's individual desires and academic goals. Responding to this environment, the evolving Small Satellite Program course (Astro433), introduces operational situations preparing students for their service after graduation.

THE SMALL SATELLITE PROGRAM LEGACY

Critics of higher education often complain educators focus more on teaching only their discipline (e.g. management) instead of "how to manage" with students becoming competent in the needed good management action skills (Wexley & Baldwin, 1986). For decades USAFA has pursued the challenge of doing a better job of enhancing not only student's cognitive skills but also their interpersonal and behavioral management skills. The Small Satellite Program successfully addresses the past criticism of being "discipline focused" since 1991.

The Department of Astronautics created the Small Satellite Program as a way to enhance the Astronautical Engineering curriculum. From 1991 through 1997, astronautical engineering students designed, fabricated, and operated satellites flown from high altitude balloons. However later in 1997, the Small Satellite Program paradigm shifted from complex satellites with multiple payloads to a modular, scalable approach. As such the FalconSat program was born. FalconSat modules enabled students to apply what they have learned in various technical and non-technical courses to find design solutions to real world problems. All of the FalconSat projects have a service learning orientation benefiting multiple facets of the Air Force, education, and space community at large. FalconSat teams are given minimal direction other than background on how technical systems are developed and produced within the systems acquisition process. In fact, this sink or swim approach is identical to what students will experience as new officers designing, developing, and procuring major Air Force weapon systems.

The Air Force systems acquisition process is an essential part of a successful application of engineering technology. It consists of five phases: concept exploration and definition, concept demonstration and validation, engineering and production development, production and deployment, and operations and support. FalconSats "live" through each phase of the acquisition process completing a "whole" life cycle. However one institutional stumbling block almost made the experience unachievable. Since FalconSat projects usually last more than one year from concept exploration through final production, it was necessary to constantly rotate student program management teams due to graduation. To generate continuity and maximize the learning experience, the Small Satellite Program enrolls interested third year students (juniors) into the program giving them an opportunity to work with fourth year students (seniors) and instructors over a two-year period. The class operates like any company under government contract or a government agency charged with a specific task. The project team selects a program manager who is singularly responsibility for successful task completion. Other team members perform functional duties such as finance, production, test, logistics and documentation depending how the team decides to organize itself. This parallels how a major weapon system program office is organized and operates.

The groups are assessed, measured and evaluated using specific acquisition milestones marked by graded briefings, demonstrations, and written reports. There are no examinations since milestone briefings are the vehicle for information transfer and assessment. As in the real world, a successfully completed project is a time-proven benchmark of excellence. The course emphasizes the economic and managerial aspects of the acquisition process, as well as technical performance. Unprecedented degrees of freedom are allowed in the course. Students decide on the schedule, perform all planning and accomplish all coordination within the milestone schedule serving as a key constraint. Each FalconSat project receives funds from customers and government organizations interested in the project's payload. Also significant USAFA resources are available such as lab supplies, machine and electrical shop support and expertise.

PROJECT DESCRIPTIONS

FalconSat projects differ significantly from its predecessors, in that the modular approach allows for a

single primary payload with interchangeable subsystems to be supported by a common "bus". Simplicity and continuous growth drive the current FalconSat program philosophy giving students the opportunity to design and build from previous project's successes/failures while contributing to future FalconSat projects success. Unlike previous projects, highly ambitious goals are replaced by more realistic, increasingly complex goals for subsequent FalconSat projects. To facilitate continuous growth from each FalconSat project, students in management and systems engineering roles must ensure progress in design and fabrication in one semester is continued to the next. Moreover, students must ensure design and fabrication information is transferred from one project to the next despite more complex payloads and subsystem requirements mirroring the "real" acquisition process (SmallSat WWW).

FalconSat projects transcend typical engineering courses by their unique capacity to connect to the community they serve. The current FalconSat project, FalconSat 2, recruits students, instructors, consultants, engineers, physicists and scientists from a broad spectrum of organizations around the world. Within USAFA, FalconSat 2 allows students and instructors from various academic majors address issues ranging from scheduling and budgeting to designing, fabricating, and testing the satellite structure. In addition, FalconSat 2 enables students to coordinate with external government and for-profit organizations to focus on addressing critical project issues and needs. This external community interaction makes FalconSat 2 a unique service learning experience.

The external interaction with the DOD, academic, and aerospace communities and the FalconSat 2 project is greatly enhanced for three reasons. First, FalconSat 2 is set to travel aboard a manned space flight tentatively scheduled for a first quarter 2003 launch. Due to extensive National Aeronautics and Space Administration (NASA) requirements and specifications, FalconSat 2 students communicate frequently with NASA engineers to ensure proper completion and documentation of various technical issues. In fact, FalconSat 2 specifically tasks one student to act as the NASA liaison responsible for ensuring all NASA-required documentation is maintained (SmallSat WWW).

Second, the FalconSat 2 project relies on components from the University of Surrey, England, for its modular power source. These FalconSat 2 components are critical to its design with students relying heavily on technical (e.g. engineering specifications and testing) and non-technical (i.e. scheduling) communication of issues between institutions. University of Surrey engineers travel to the USAFA to lecture FalconSat 2 students, providing valuable training and interchange concerning various engineering topics. Also, FalconSat 2 students and instructors travel to England and visit the University of Surrey to stage formal FalconSat 2 power module acceptance testing.

Finally, FalconSat 2 works closely with various Air Force and DOD-level organizations ranking 21 of 34 essential programs by the DOD Space Experiments and Review Board (SmallSat WWW). At the Air Force level, the Air Force Office of Space Research partly funds the FalconSat 2 project, and expresses much interest in the payload designed to measure and record plasma depletions in the ionosphere. At USAFA, FalconSat 2 relies on the Association of Graduates (AOG), USAFA's official alumni organization, providing invaluable support to the project as it provides service to the organizations tied to its success. (SmallSat WWW)

The FalconSat 2 program is a benchmark for unique service learning projects nationwide. With worldwide organizational connections needing payload and launch assistance, FalconSat 2 allows students to learn engineering, management and acquisition processes through hands-on experience. Regardless of their future career specialty selection, students on the FalconSat 2 team learn essential components of the Air Force systems acquisition process while assisting outside organizations. From contracting officers to pilots, many will eventually hold positions designing and procuring major weapon systems, and the FalconSat 2 program prepares them well through service learning.

WHY DOES THIS SERVICE LEARNING PROGRAM WORK?

USAFA's service learning oriented courses (Engr 410, Astro 433) have been in operation since the mid-seventies and completing one or the other is a graduation requirement. The reaction in recent surveys targeting Academy graduates at the 6-8 year point of active duty service overwhelmingly favor keeping Engr410 in the core curriculum (Bruno, 1999) matching the views of the Air Force and Academy leadership. Also, this course was lauded by the North Central Accreditation (NCA) body as well as the Association for Advancement of Collegiate Schools of Business (AACSB) during recent accreditation visits. Why is a service learning approach at this engineering school working? What lessons can other institutions learn about developing their own service learning projects?

Earlier Kolenko et al. (1996) identified major barriers to making service learning a viable part of students' education. However, the Small Satellite Program course philosophy and implementation appears to address each of those barriers promoting its likelihood of success. First, engineering department faculty members, as well as the social sciences departments are invited, encouraged, and used as instructors/mentors for the projects. Participation is highly recognized, valued, and rewarded by the Dean and Department Heads. Besides the obvious appeal and "status" of launching the final project into orbit, the course's overall significance to the core curriculum minimizes faculty and organizational resistance.

Second, the infrastructure for service activities is already in place. USAFA has an established machine and electrical shop with works areas and skilled personnel available for advice on design, and construction. Most

impressive, the Small Satellite Research Center (SSRC) has been created and endowed with an impressive laboratory, fabrication site, permanent staff, and office area solely dedicated to the FalconSats. Thus many of the "infrastructure" concerns associated with viable service learning activities have been mitigated.

Third, the relevancy barrier is addressed by tying FalconSat to the Air Force's and outside organization's systems acquisition process in completing design projects. Like Engr 410, Astro 433 requires attention to engineering technical details of systems design as well as the economics, management, and social aspects of the process (Param & Shilkitus, 1999). This is the identical process students' experience once graduated. Also the realism of managing group dynamics is apparent with teams involving students of a variety of academic majors many of which are not engineering-related.

Finally, the significance of service learning is directly linked to the Air Force core value of "service before self." This core value tells students and faculty performing one's professional duty takes precedence over personal desires (United States Air Force Core Values, 1997).

SERVICE LEARNING AND USAFA EDUCATIONAL OUTCOMES

But most impressive in the Small Satellite Program's success is the linkage between service learning and USAFA Educational Outcomes. The lesson for institutions beginning this type of approach is to start with the outcomes you want to achieve. The direct links between the service learning pedagogy used in Small Satellite Program to USAFA's Educational Outcomes establishes to describe the institution's qualities desired in its graduates:

- *Officers who possess a breadth of integrated, fundamental knowledge in basic sciences, engineering, the humanities, and social sciences, and depth of knowledge in an area of concentration of their choice.*

As complex as designing a satellite may sound, the students do not require knowledge above what they have achieved in their core classes. Even though some basic core skills have not been used or forgotten, they are re-emphasized in this capstone educational experience. Students should graduate recognizing where to get help, how to teach themselves again, and that people from every discipline can make meaningful project contributions.

- *Officers who are intellectually curious.*

When presented with a problem, or a seemingly unachievable obstacle, students are expected to apply appropriate models to assess the situation and solve the problem. When dealing with small satellites, there are no solutions manuals. Students are expected to address problems using intellectual curiosity as their compass and all their means available.

- *Officers who can communicate effectively.*

The students involved in the Small Satellite Program are not just communicating with peers and instructors. They must communicate ideas to outside organizations and users paying for the service. Students need to understand the immediate project needs/impact and be able to articulate and "sell" what is being done for multiple clients and customers.

- *Officers who can frame and resolve ill-defined problems.*

By their very nature, the construction of a small satellite is an ill-defined problem. A Statement of Work attempts to qualify and quantify what the user needs. As a team, they need to further clarify requirements and identify constraints in order to develop a solid understanding for application in design solution. The process may seem ambiguous but if time is taken to understand complexities, ask questions, understand the project requirements, and laying out a useful schedule, it can be done.

- *Officers who can work effectively with others.*

It would be difficult to construct a better opportunity uniting a team of people to work toward a common goal. While this course offering is only one of many courses taken, the time, dedication and tenacity required of individuals would be futile if not for the cohesiveness of the team. Simply put, this is not a one-person job, so survival is predicated on teamwork, leadership and followership.

- *Officers who are independent learners.*

One of the true course benefits is it challenges the students to teach themselves about their project. For the students, the FalconSats are the "first of their kind" items meeting the peculiar needs of individuals or organizations. Answers to questions need to be discovered and independently applied to the solutions because there is literally no single source to rely upon.

- *Officers who can apply their knowledge and skills to the unique tasks of the military profession.*

Regardless of what Air Force career a students is assigned, there will always be some aspect of the systems acquisition process involved no matter if the job is in supply, acquisitions, maintenance, personnel, space operations, or flying. At some point, all Air Force members will be called on to head a major project team with all of its ambiguities (Bruno, 1999). As military service roles/missions change having an appreciation for civic/moral considerations are an important new skill set as experienced in the private sector.

The above Educational Outcomes are crafted toward USAFA graduates becoming military officers. However, other institutions can develop their own particular Educational Outcomes and mold service learning opportunities to help accomplish those desired results. USAFA as an institution has committed to service learning as the key vehicle to culminate its undergraduate education and meet its educational outcomes. The Small Satellite Program transitions students from a primarily academic environment to experiencing reality-based situations encountered as Air Force project officers. By continuing to add new elements associated with the technologically dynamic space environment to its service learning pedagogy, the Small Satellite Program continues to make huge strides in developing good students, good officers, and

good citizens. The Small Satellite Program uses elements of true service learning and to fully capitalize on this opportunity, some improvement can be made.

WHAT DOES FALCONSAT STILL NEED TO DO?

As Zlotkowski (1996a, 1996b) suggests, the civic and moral concerns are the "equal partners" in enhancing learning through practical experience as schools apply a service learning approach in courses or curriculum. However, this connection needs to be consistently reinforced for FalconSat. In beginning each year, much excitement and enthusiasm is exhibited by the team as meeting to discuss the "client and customer's" needs and issues. Also, having a project actually launched into space has its own positive motivation and organizational inertia. However as the process moves into the design and fabrication stages, the team focus turns to production and meeting critical project milestones. The reality of the project's scope and significance becomes apparent, and depending on the progress, may become disheartening. Instead of just focusing on the deliverable, what may get lost is the sense of the value being added to the community, customers or individuals through the team's work and effort.

Also, students are required to make self-evaluations and peer evaluations to be valued in the final grade. However, the evaluations rate individuals based on criteria important to the service learning exercise's "practical application". Job performance, attitude, leadership, management of resources, and communication categories are self- and peer-rated. These performance categories are defined toward project task accomplishment. What is missing is the opportunity for students to specifically reflect, assess, or balance what the participants have done from a community, civic and moral perspective. This could be accomplished by simply requiring students to submit a memo reflecting on the experience, both positive and negative. Students could then take a position and articulate why or why not the military should promote community/civic service and if the cost/benefits are worthwhile (Lamb, et al., 1998). Also their milestone reviews should include a discussion on personal and community project impact perspectives. If USAFA desires to advance the impact of service learning, the students need more time to reflect, analyze, and openly discuss their experiences.

Another opportunity may be emphasizing Small Satellite Program integration into USAFA's Ethics Across The Curriculum (EATC) program. Part of the Character Development Program, this activity ties the school curriculum to the Air Force's core values of "integrity, service before self, and excellence in all we do (United States Air Force Core Values, 1997). Program outcomes are developing officers who voluntarily decide to do the right thing; are selfless in service to country, Air Force and subordinates; are committed to performance excellence in personal and professional responsibilities; having the stamina, self-discipline, and courage to do their duty (Strategic Plan for Character Development at the Air Force Academy, 1997). The Dean and Department Heads highly encourage ethics-related discussion in all classes but implementation up to the Course Directors. However, the EATC program needs to formally include service learning related courses as key anchors or "checkpoint" courses especially since currently Engr 410 and Astro 433 are the core curriculum's capstone course already offering a service-learning component. By doing better balances the service learning effort between practical application and the participants in civic and moral actions. Also, the specific impact of ethical decision-making involving such tragedies as the Challenger "O-ring" decision, makes its significance to FalconSat even more apparent.

With the continuing nature of the FalconSat project, opportunities to have other organizations join this effort need to be pursued. For example academic institutions are joining future FalconSat projects and providing new technical and entrepreneurial aerospace ideas. The project's widening base of people and organizations increase the situation's complexity demanding more student development skills. In the years ahead, this initiative is expanding to include the University of Colorado, University of Utah, Naval Academy, West Point, University of Surrey, and University of Alabama in future launches.

Finally the Small Satellite Program needs to longitudinally survey past graduates as to particular personal and professional impacts seen after graduation. For example, does the course help understand the philosophy and reasoning behind the military's new roles and mission? Should these types of projects be started earlier in an academic program? By addressing these questions the course's future will be enhanced.

Final Thoughts

This presentation of service learning at USAFA suggests the planned, deliberate, interweaving of service learning experiences can be a very important element in helping meet institutional educational outcomes. It also supports service-learning arguments that this learning pedagogy is appropriate for a variety of disciplines (McCarthy & Tucker, 1999; Sax & Astin, 1997) including engineering and the military profession. The case also shows educators how easily learning by integrating coursework with practical application and experiential learning can be achieved through service learning. At the same time, the paper indicates the importance of the institutional commitment required for a successful service learning program and the need of balancing the course focus on both a practical and civic/moral side. Though the current Small Satellite Program needs continuous improvement to "re-reinforce" the social, civic and moral values inherent in serving others, course adjustments can be readily made and addressed.

The Small Satellite Program is an example scenario providing the most realistic learning application students have seen. Being assigned ambiguous problems involving "real" people and "real" issues and thrown into groups of students they have not met, and then told to solve the problem within time and budget constraints may be emotionally and mentally taxing. To have your final project go into orbit is inconceivable to many as the ultimate educational experience but it closely resembles what future careers can involve. As such service learning helps provide a real life course for real life people and USAFA is committed to continue putting service learning into orbit.

Opinions, conclusions and recommendations expressed or implied within are solely those of the authors and do not necessarily represent the views of USAFA, USAF, the DoD or any other government agency

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