BUILDING AN ENGINEER THROUGH A WORK-BASED EDUCATION PROGRAM

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Abstract – Every fall, most academic departments at the United States Military Academy at West Point, New York begin developing summer internships for cadets, which enable them to bridge the intellectual or cognitive gap between school and work. These opportunities are reserved for emerging junior and senior cadets who are otherwise not conducting military training during the summer. In the Department of Systems Engineering, we establish many opportunities with government and non-government affiliated agencies to help organizations solve Systems Engineering, Engineering Management, Operations Research and Information Systems Engineering related problems. This program is entitled “Academic Individual Advanced Development” (AIAD) and is vital to the educational development of cadets and provides them with an opportunity to participate in activities beyond our baseline requirements. These AIAD opportunities are designed to allow students to work with military and civilian organizations for a three-to-four week period and discover the “real world” applicability of their academic endeavors here at West Point.

These experiences broaden student perspectives; provide them with practical advanced education related to their professional responsibilities as student leaders and future commissioned officers. Participating agencies gain by having additional personnel to work on engineering projects, and by having the opportunity to expose future Army leaders to the important functions performed by their organization. Some AIAD opportunities extend beyond the summer into the academic year as CAPSTONE projects. These projects continue to allow a cadet the opportunity to discover the “real world” applicability of their academic endeavors.

This paper explores the uniqueness and nature of our program, its purpose, our process for matching skills with a participating agency and follow-up feedback from cadets. This feedback is used to assess the viability of the program for future students and participating agencies. This paper provides practical guidelines for implementing such a program in any engineering curriculum to enhance a student’s engineering education and learning.

Introduction

Global economic competitiveness is built upon the foundation of an educated and skilled workforce. In the early 1980s, reformers became increasingly preoccupied with the effects of inadequate education of U.S. workers on the nation’s economy. This development coincided with increasingly competitive economic challenges from Japan, Germany, and other European countries. Reformers reviewed the education system of America’s competitors and found that in
Germany and Japan, the workplace played a crucial role in the education system. A close look at America’s education system revealed that U.S. schools were not teaching the skills needed for work and that the transition from school to a stable career-oriented job was a haphazard and disorganized process.

The reformers identified many problems with U.S. schools. Essentially, they were failing to prepare the nation’s workforce. U.S. schools were not doing their job because 1) they provided no incentive for students to work hard; 2) did little to help students find good jobs; 3) did not teach the attitudes and maturity needed on the job; 4) isolated young people from adults who could act as models and mentors; 5) did a poor job of teaching the so-called advanced generic skills or workplace basics such as problem solving and teamwork, and the job-specific skills that are taught atrophy as young people spend a few years churning through unskilled youth jobs; and 6) provided a form of schooling that was ineffective in its pedagogic strategy. John Dewey, considered the Father of Education, viewed education as a continuous growth and demanded schools to present studies in relation to one another; however more specifically to link available knowledge with the live context beyond the classroom. Dewey felt that what is learned in the classroom must become meaningful and real. Otherwise, learning becomes a tedious memorization of data without a meaning immediately clear to the pupil. Learning in the classroom must be as close as possible to the world outside it. Work-based education evolved as a solution to these immediate problems.

The objective of the work-based education program emphasizes problem solving, teamwork, learning in context, and more active participation of students in their own learning. The teaching occurs in the classroom while students are later provided an opportunity to use skills learned in the classroom in a well-designed work experience. Since traditional schooling alone hinders the full development of each student’s cognitive abilities, incorporating education into real-world situations in which what is being learned will be used, work-based education has become the bridge to the intellectual or cognitive gap between school and work.

This paper explores the uniqueness and nature of the U.S. Military Academy’s work-based education program, its purpose, our process for matching cadets with a participating agency, and follow-up feedback from cadets. This feedback is used to assess the viability of the program for future cadets and increase the value gained from the program for participating agencies. This paper provides practical guidelines for implementing such a program in any engineering curriculum to enhance a student’s engineering education and learning.

**An Integrative Experience**

The academic program at the U.S. Military Academy (USMA) at West Point has evolved in response to the needs of the Army and trends in higher education. The Academy’s balanced offering of courses in the arts and sciences leads to a Bachelor of Science degree and builds a solid foundation for future graduate study. Most academic courses are taught much the same as they are at a civilian institution, with some exceptions. There is usually between 14 to 18 students per class. Small classes ensure cadets receive personal and individual attention. Tutoring and additional instruction is also available. The core curriculum incorporates 26 courses equally balanced between the arts and sciences. The core curriculum provides the
foundation for the academic program and the broad knowledge necessary for achieving success as a commissioned military officer. The core curriculum also provides an opportunity for academic specialization. There are currently 22 optional majors and 25 fields of study. They cover virtually all the liberal arts, science and engineering disciplines one would expect to find in highly selective colleges.

A field of study requires a cadet to devote 9 electives to courses specified by the academic discipline. More than 75 percent of the Corps of Cadets elect to major and must devote additional electives to courses prescribed by the disciplinary field, follow a more structured elective sequence, and complete a senior thesis or Capstone Design project. The Capstone Design project falls under the Capstone Design Program, a one to two semester program designed to provide our majors with an opportunity to work on a real-world problem for a real-world client.

West Point’s academic program as well as its military program encourages learning beyond the classroom through the Academic Individual Advanced Development (AIAD) and Military Individual Advanced Development (MIAD) programs. These programs are considered work-based education programs that have been skillfully engineered to link specific aspects of a cadet’s knowledge base, both militarily and academically, with the live context beyond the classroom. Between spring and fall academic terms, cadets may participate in one or both programs; however MIADs and other military programs are mandatory for cadets and are given priority over AIADs. Once the cadets have completed required military training opportunities, they can complete an AIAD. These programs emphasize a planned and structured work experience that has productive educational value and is carefully coordinated with the military and academic learning that occurs in the classroom. Both programs are structured to produce cognitive benefits, forge institutional linkages, motivate cadets, and teach maturity and appropriate workplace behavior; however only a description of the AIAD program will be addressed.

**AIAD Opportunities**

West Point provides a stellar academic experience to cadets within the classroom; however a cadet’s cognitive development is incomplete absent the opportunity to apply concepts learned in the classroom in a well-designed work environment. Each summer, most academic departments at the Academy develop intern-like opportunities for cadets. These opportunities are reserved for emerging junior and senior cadets who are otherwise not conducting military training during the summer. In the Department of Systems Engineering, we establish many such opportunities with various government and non-government affiliated agencies to allow the cadets to work on engineering problems supporting the disciplines we offer in the Department. Specifically, these are Systems Engineering, Engineering Management, Operations Research and Information Systems Engineering. This program, known as “AIAD,” is vital to the educational development of cadets and provides them with an opportunity to participate in activities beyond our baseline requirements. The AIAD program facilitates a cadets’ acquaintance with an ever-changing world. Opportunities inherent to the AIAD program are designed to allow the cadets to work with military and civilian organizations for a three-to-four week period and discover the “real world” applicability of their academic endeavors here at West Point.
Unlike the focus of internships at civilian universities, the AIAD program is not intended to enable cadets to explore potential careers since cadets have to devote a minimum of five years to serving their country through military service; however in some cases, the AIAD experience may influence selection of a military specialty. Instead the objective is that these experiences broaden student perspectives and provide them with practical advanced education related to their professional responsibilities as future commissioned officers. Participating agencies gain by having additional personnel to work on engineering projects, and by having the opportunity to expose future Army leaders to the important functions performed by their organization.

The AIAD program, strictly voluntary, grants cadets one to two opportunities to participate in the AIAD program as they emerge into their junior and senior year of study. To achieve success, the work-based education program must constitute a planned and structured work experience that has productive educational value and is carefully coordinated with the learning that occurs in the classroom. These criteria are used when recruiting organizations and agencies to participate in the AIAD program. Some cadets are granted academic credit for performing an AIAD. Usually these are cadets who will continue their summer work as a Capstone Design project in the upcoming academic term.

A Model to Import

The success of the AIAD program is due in large part to the manner in which the program is structured and coordinated. The fundamental basis of the success of the program is based on the efforts of an individual designated as the AIAD coordinator. This individual, in many respects, serves as the Project Manager and is responsible for linking all aspects of managing and planning the implementation and execution of the program for our department. The AIAD coordinator is provided a team of individuals from within the department to represent a group of cadets participating in the program. The planning for the AIAD program begins in the fall term and culminates with feedback from cadets. The program is described below with direct reference to the program in the summer of 2003. This model, with some minor changes, may be successfully imported into any academic department to enhance a student’s engineering education and learning.

Figure 1 graphically depicts the model used to successfully conduct the AIAD program. The model has six phases: 1) Identify Potential Organizations, 2) Recruit Organizations, 3) Cadet Notification, 4) Cadet-Agency Coordination, 5) Cadet Attendance, and 6) Follow-Up.
Phase 1: Identify Potential Organizations

The first of six phases is the phase in which potential organizations are identified that are able to provide cadets with intellectual, professional, and personal development experience in one or more of the four disciplines within our department – Systems Engineering, Engineering Management, Operations Research and Information Systems Engineering. Senior faculty members are chosen to serve as representatives for each discipline and are responsible for identifying organizations that will allow cadets to perform work related to that discipline.

The Department of Systems Engineering arranges AIAD opportunities with a variety of government agencies, such as government research centers, the Congressional Science and Technology Office, the Army Research Lab, the Communications and Electronics Command, and the National Aeronautics and Space Administration (NASA). We have also worked with civilian organizations such as Boeing, Raytheon, Enron, Sikorsky, AIG, United States Automobile Association (USAA) and others.

Phase 1 occurs in the fall term preceding the summer in which the AIAD occurs. The AIAD coordinator and senior faculty (department representatives) are involved in the identification of
participating agencies; however in some cases cadets refer agencies and agencies refer themselves.

Phase 2: Recruit Organizations

Phase 2 occurs upon identification of organizations that potentially qualify to participate in the AIAD program. Of special interest are organizations with projects that have the potential to be carried into the academic year as Capstone Projects. This, of course, does not preclude an organization from participating if their project has no Capstone potential. During this phase, organizations are contacted on whether they are willing to participate in the AIAD program. Consenting organizations are entered into a global database management system and later granted access to populate the database with information related to their project.

Information contained in the database includes 1) USMA point of contact information, 2) project title, 3) project location, 4) project description, 5) security clearance requirement, 6) available slots, 7) Capstone potential, 8) duration and 9) agency point of contact information. The information gathered is used by cadets to assist them in the selection of the appropriate AIAD opportunity that meets their individual goals. Of course, some are more interested in location than agency. Additionally, some cadets prefer to travel to overseas locations such as Australia, Hawaii, Honduras, and Germany while others are content on remaining stateside or at a location near family. As in Phase 1, the AIAD coordinator and department representatives coordinate the activities and events in this phase which occurs in October and November.

Phase 3: Cadet Notification

In Phase 3, cadets are granted access to the database and required to submit their AIAD choices in order of preference. This phase occurs from January until middle to late February. Once the database closes, the AIAD coordinator and department representatives screen cadet choices and match cadets with a participating agency based on the cadet’s major, interests, and talents. In the event a cadet is not satisfied with the match, they may reapply for another AIAD. Upon acceptance of a match, information is collected from the cadet for use in Phase 4; however cadets may ultimately elect not to participate. There is a high success rate in cadets receiving their first choice. In summer 2003, approximately eighty-nine percent (89%) of cadets received their first choice. Those agencies not requested by a cadet were sent correspondence indicating their agency was not chosen and were highly encouraged to reapply the following year.

Phase 4: Cadet-Agency Coordination

Department representatives coordinate AIAD dates and initial contact between cadets and their respective agency in Phase 4, which occurs between February and May. A cadet’s summer consists of many events, primarily military in nature. As a result, it is sometimes difficult to find a date that best serves the agency; however the assignment of dates is based on cadet availability and when the agency can accommodate them. The AIAD dates, once confirmed, are then passed to the department’s administrative secretary who coordinates travel arrangements and financial reimbursement to cadets for AIAD related expenses.
While performing an AIAD, cadets receive per diem rates based on the cost of living index for the area in which the agency is located. Cadets receive reimbursements for expenses incurred for lodging, airfare, and rental car expenses. Because cadets are employees of the federal government, they are prohibited from receiving income directly from the agency. Funding to cover per diem and additional expenses is sourced in one of several ways. The academic department sponsoring the AIAD, the United States Military Academy, or the participating agency funds the AIAD project. Since many agencies request cadets from our Department, we have the luxury of accepting those AIAD opportunities that provide funding or provide a sufficiently unique and applicable experience that would justify our funding of the opportunity.

A four-page document, containing administrative information, is used to provide initial information on the cadet to the participating organization and information on the participating organization to the cadet. The document contains 1) department representative information, 2) cadet information, 3) agency representative information, 4) schedule of events, 5) recommended work schedule and agenda, 6) logistical (meals, uniform, travel, intercity transportation and lodging) information, and 7) solicitation for feedback from the agency. In addition to this document, cadets are asked to draft a resume indicating academic intent and that resume is sent via email with the document to the participating agency prior to cadet arrival.

Phase 5: Cadet Attendance

The first two summers of a cadet’s time at West Point are earmarked for specific military training. The first summer, which occurs prior to a cadet’s freshman year, is Cadet Basic Training (CBT). In CBT, cadets learn the basics of being a soldier and a cadet. The second summer, which occurs after freshman year, is Cadet Field Training (CFT). In CFT, cadets learn more advanced soldier skills. In the remaining two summers, cadets must complete three programs lasting approximately four-to-five weeks in duration. The programs requirements are:

- Military Individual Advanced Development (MIAD): This is advanced military school, such as Airborne School or Air Assault School.
- Summer Detail: Cadets fill cadre positions for both CBT and CFT.
- Cadet Troop Leader Training (CTLT): Cadets fill platoon leader positions in actual Army units throughout the world.

Upon completion of the three required summer training programs, cadets may complete an AIAD if they have time remaining in their summer. Cadets are highly encouraged to consider some of their remaining time for leisure. If they do, only three-to-four weeks remain to fulfill an AIAD. We expect organizations to give them a project or tasks to support a project commensurate to the amount of time they will be on the AIAD.

Cadets are asked to maintain a journal while performing their AIAD as a follow-up measure and an aid in ensuring they are getting value from their AIAD experience. These journals are reviewed and used when assessing cadet and client feedback. Historically, cadets attending AIADs have worked on a specific project while at an agency. These projects are normally very well advanced, but are also scoped to match their three-to-four week programs. Two examples of actual projects are shown in Table 1.

Table 1. AIAD Project Examples

<table>
<thead>
<tr>
<th>Project A</th>
<th>Project B</th>
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<tr>
<td>Parachute Modeling and Simulation</td>
<td>Support of Tactical Vehicle Systems</td>
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<td>Agency</td>
<td>Agency</td>
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<td>Army Materiel Command</td>
<td>Stewart &amp; Stevenson</td>
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<tr>
<td>Location</td>
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<tr>
<td>Yuma Proving Grounds, AZ</td>
<td>Houston, TX</td>
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<td>Project Description</td>
<td>Project Description</td>
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<td>One of Yuma Proving Ground’s missions is to certify a variety of materiel for air delivery. These efforts entail an initial design of parachute rigging requirements conducted by the Natick Soldier Center, a series of drop tests from a static-drop tower to validate/redesign the rigging, and the airdrop of these systems for final verification that the materiel can be airdropped without damage to the equipment or hazards to our soldiers. YPG has been investigating the application of modeling and simulation to supplement these test efforts. Continued work is required to assess the feasibility of introducing these capabilities into the test process.</td>
<td>Stewart &amp; Stevenson’s (S&amp;S) tactical vehicle systems division manufactures the Family of Medium Tactical Vehicles for the U.S. Army in Sealy, TX, just outside of Houston. As provider of the highest operationally available major weapons system in the U.S. Army inventory, we offer the opportunity to learn how we design and manufacture vehicles that exceed mission requirements and continually redefine the U.S. Army standard for equipment reliability. This internship with S&amp;S will be within the engineering department. In this capacity the intern will be assigned specific problem solving tasks in the areas of engineering design, failure analysis, and vehicle testing. The intern will have responsibility for fully defining the task, analyzing multiple solutions, and implementing the solution. The intern will use and gain experience without facilities and tools such as our rapid prototyping facility and our 1.3 mile on/off-road vehicle test tract. The intern will within a team of highly skilled and experienced engineers and be required to interface with other departments such as manufacturing, logistics, and purchasing. From this experience the intern will not only develop an understanding of the engineering design of military systems, but just as importantly, how all disciplines interact in a true systems environment to produce a product that is integral to the mission of every U.S. Army unit.</td>
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Upon completion, agencies and cadets are asked to complete an After Action Report (AAR) on the AIAD.

Phase 6: Follow-Up

In Phase 6, feedback on the AIAD program is solicited through an AAR that is developed by USMA for both the participating agency and cadet. Although we solicit and encourage feedback from agencies, we rarely receive it. Additionally, the level of feedback received from cadets is not to our satisfaction. We can obviously do a better job in canvassing feedback from cadets.

To improve client feedback potential, we have developed a web-based system that makes it easy for the client to input as well as the department to consolidate results. We expect that this system will make a difference in the amount of feedback received from agencies in the future so that we can effectively and adequately assess the program from the client perspective. Although we lack feedback from agencies, the vast majority continues to participate in the program.

The AARs we receive from cadets are reviewed to determine whether cadets are realizing the objectives outlined in a work-based education program. The benefits and lessons learned from cadets will be addressed later.

Connecting Activity

The School-to-Work Opportunities Act of 1994 called for a comprehensive reform work-based plan that includes school-based learning, work-based learning, and connecting activities. The third component, connecting activities, includes matching students with appropriate work-based learning opportunities and providing a school-site mentor to act as liaison between the employer...
and the student’s school, teacher, social administrator, and parent. A further activity is to provide technical assistance to employers in designing school-based learning components. The Capstone Design course is the Academy’s connecting activity for senior cadets and provides the basis for maintaining the link between the workplace and the classroom. The Capstone Design course is an activity which requires a senior cadet to apply a four-year comprehensive set of skills and concepts learned in the classroom to a real-work project for a real-world client. Additionally, the department works to develop problem topics of relevance to the Army and the Academy.

An objective of the AIAD program, as mentioned, is to identify focused AIADs that will lead to Capstone Design projects for the upcoming academic year that have specific deliverables for the client. The cadet may work a small project for the client while at the organization, but the focus for the cadet is to establish preliminary work and bring back to the Academy specific information that will allow his or her Capstone group to begin work immediately in the fall semester of their senior year. The cadet bringing back the work will serve as the nucleus of the Capstone Design team. A cadet receives one credit for the summer work performed, which is commensurate with the work involved in obtaining the required information for the Capstone Design project. The design experience provides cadets the opportunity to continue their development of cognitive problem solving skills, self discipline and to exercise creativity in a multi-disciplinary environment and integrate all of this into a useful product for the client.  

Capstone Design projects are supervised by senior faculty members, all of whom hold a PhD.

Benefits and Lessons Learned

AARs are our primary source for enhancing the AIAD program. We request AARs from both agencies and cadets. Only forty-seven percent (47%) of the cadets participating in the AIAD summer program in 2003 provided an AAR. Due to the low response from cadets and an even lower response from participating organizations, we are unable to adequately assess the program; however we were able to obtain valuable information from the cadet AARs. Cadet comments have been summarized and are indicated below.

- Work performed had a direct relationship to skills learned in academic discipline.
- Work performed extended classroom learning.
- Academic skills were used to improve military readiness.
- Received social education on pending role as a military professional.
- Gained an appreciation for other cultures.
- Exposure to a myriad of real-world complex issues encountered in work environments.
- Learned value in teamwork.
- Realized the collaborative role civilians (commercial companies and academic institutions) play in military readiness.
- Gained personal respect for work performed by civilians in support of armed forces.
- Learned the value of good leadership.
- Gained a sense of how the Army works at different levels.
- The AIAD experience assisted in determining military career specialty.
Lessons learned were primarily administrative in nature. The following lessons learned were noted.

- Cadets expressed a concern in being able to contact their department representative while attending the AIAD. Some cadets experienced administrative and logistical problems upon arrival to their AIAD location and were not able to make contact with anyone at the Academy when problems surfaced.
- Although cadets were reimbursed for legitimate expenses upon their return, some cadets felt they did not receive adequate advanced funding. Some cadets expected to be given more than the 80%, of estimated expenses, received prior to attending the AIAD. No specific difficulties were communicated in the AAR; therefore it is unclear whether cadets required more than 80% of estimated expenses. Only a few cadets indicated they would have liked more than 80% but again no substantial reasons were given.

The feedback obtained from the cadet AARs reveals that the AIAD program is a very rewarding experience for cadets. The evidence is noted in the direct correlation between work-based educational program objectives and comments received from cadets.

Conclusion

The work-based education program, entitled AIAD, described herein provides several clear enhancements to a university work-based education program. Aside from becoming experienced in problem solving, learning how to work in teams, learning in context, and an observation of appropriate workplace behavior, cadets are given the opportunity to actively participate in their own learning. The greatest benefit for the cadets was the opportunity to encounter a real-world work environment that granted 1) usage of academic skills, and 2) a knowledge of their role as future military officers.

Under the Capstone Design program, cadets continue to discover the “real world” applicability of their academic endeavors. The integration of the year long Capstone Design project into the curriculum allows cadets to further gain “hands on” experience using system design tools and processes on meaningful problems. The concepts discussed in this paper may be readily imported into any academic department’s yearly activities. However, the specific details may need to be adjusted to accommodate each program, as USMA is not your traditional academic institution.

To launch such a program, there is a clear need for an academic department first to appoint someone as an AIAD coordinator and provide department representatives to help institute the program. The AIAD coordinator must be 1) knowledgeable enough to coordinate the events and activities in each of the six phases of the AIAD process, 2) have the time, in addition to routine academic duties, to handle the enormous amount of planning and coordination, and 3) possess excellent interpersonal skills. It is readily apparent that without such a structure, the objectives and goals of a work-based education program will not be reached.

The positive feedback received from cadets is encouraging. We conclude that the AIAD program is a successful approach to building engineers and military leaders in the 21st century;
however a larger response is needed from cadets and organizations to make specific objective findings or to accurately assess the program.

References


Biography

LIEUTENANT COLONEL ROBERT A. POWELL is an Assistant Professor in the Department of Systems Engineering at the United States Military Academy. He received a BS in Industrial Engineering, Texas A&M University, a MS in Operations Research/Management Science, George Mason University, a Master of Military Art and Science, US Army Command and General Staff College, and a PhD in Systems Engineering, Stevens Institute of Technology. He is married with three children and a bulldog.