AC 2009-468: ENGINEERING INTERNSHIPS FOR FIRST-YEAR ENGINEERING AND UNDECLARED MAJORS

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Impacts of an Early Research Experience on Recruiting and Retention in Engineering

Abstract

One of the premier events in an engineering curriculum is participation in a summer internship program. The United States Military Academy (USMA) has developed a program to promote academic activities beyond the basic engineering requirements. This program has recently been opened to students that have yet to declare their major. One intent of the original program was to enhance the students' learning and problem solving experience in a real world environment and perhaps give them a start on their capstone project. The summer internship program allows them to conduct research and solve engineering problems with scientists and engineers in some of the nation's finest facilities. The Academic Individual Advanced Development (AIAD) program is purely voluntary, but nearly all of the civil and mechanical engineering majors forfeit some of their free time to participate in the program every summer. These internships are usually four weeks in duration due to other institutional requirements that can only be accomplished during the summer. This, however, is sufficient time to allow the students to be exposed to, work on, and sometimes solve an engineering problem. The Army Material Command (AMC) and United States Army Corps of Engineers (USACE) sponsor most of the AIADs, but there are sponsors from private engineering organizations, NASA, the national labs, and other Department of Defense activities. This paper describes the AIAD program and discusses how it attracts and retains engineering majors. Additionally, feedback from the project sponsors can be used to measure student progress and assess the curriculum.

Introduction

> "My sponsor and others at the Laboratory took time to talk with me not just about math and science but also the politics and struggles of research. The experience of working in classified and sensitive environments taught me discipline and procedure that I would not have learned elsewhere. Taking part in a long term planning meeting expanded my view on how engineers address problems and choose directions for research"[1].

The above quotation speaks to the invaluable experience students obtain from AIAD experiences that cannot be taught in academia. Other advantages and benefits, similar to those outlined here, to both individual students and outside organizations are well documented[2-5]. Internships, regardless of length, provide an opportunity for students to get their feet in the doors of various outside organizations. They give the student the best of both worlds: theory and example in the classroom and hands-on experience in the real world. Additionally, it is great chance for an organization to see the student's performance, as well as, for the student to experience the culture of the organization.

Educating students at USMA is rewarding and challenging. With many mandatory activities and required classes in the humanities and basic sciences, finding more time for academics is not an easy task. Moreover, the Academy is an undergraduate teaching institution, so some students

may lack the exposure to graduate students and faculty advisors solving real world, detailed engineering problems.

Some of the goals of the civil and mechanical engineering majors are for the students to understand better the complexities of engineering and design and how to solve an engineering problem with application of engineering fundamentals and principles. Detailed and extended engineer problems are usually not experienced until the students encounter their capstone project, typically in their senior year. The limitations of delaying this exposure to a comprehensive problem are obvious.

Additionally, the internal support required for faculty to manage extensive engineering research opportunities cannot be met. With the institution primarily a teaching and not a research organization, the time constraints imposed by faculty course load would be exceeded. The existing infrastructure (test and fabrication equipment, computer resources, and technicians) would require much upgrade to accommodate project needs. As a result, we must look outside the institution to promote practical experience in engineering.

One solution to the problem of increasing student exposure to engineering is to send students to a summer Academic Individual Advanced Development (AIAD). While many universities and college students participate in cooperative programs and internships during summer months, students at USMA can participate in a parallel program of shorter duration. They spend the bulk of their summers in other mandatory events, but with proper scheduling of all these events, there are usually several weeks of free or leave time that students are willing to trade for the opportunity to participate in an AIAD. Prior to 2008, AIAD participation had been planned before the senior year when most of the graduation requirements had been completed, and the student had taken more engineering courses (Figure 1). If possible, the AIAD project generated enough interest with the student that he or she continued to work on it and progressed it into a capstone project during the senior year.

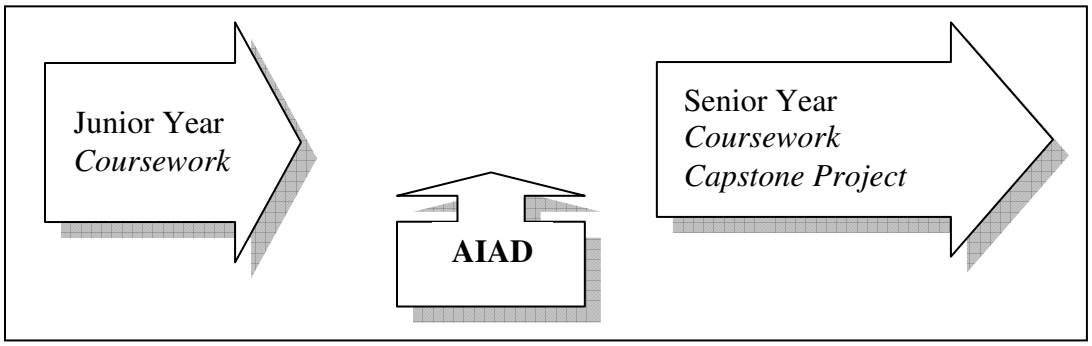

Figure 1. Original (Pre-2008) AIAD Planning Model

A three to four week AIAD offers 120-160 hours of exposure and work on a current engineering problem. This is equal to or exceeds the time a student spends in a semester course of 40 class meetings in a three credit course. Although most students do not receive academic credit for participation in an engineering AIAD, they gain considerable knowledge on a particular problem,

learn some new skills, usually function in a multidisciplinary team, and exercise some creative problem solving.

Other engineering departments at USMA use the AIAD model for projects and research. For instance, the civil engineers work with the U.S. Army Corps of Engineers for project sponsors. Mechanical and electrical engineers work with the Army Research Laboratory for sponsorship. Many departments seek projects from private organizations such as Boeing, Raytheon, Honeywell, and others with alumni contacts. Recently, a mandatory schedule change at the institution has limited the number of senior students participating in the AIADs, but has opened up many more possibilities for the juniors and some sophomores (Figure 2). Under the previous model, the student was well prepared to work on an engineering project, bringing the knowledge of many semesters of engineering courses to AIAD partners providing projects of reasonable scope. Under the new model, coursework and preparedness quickly become potential shortcomings of participating students. This paper focuses on the mechanical and civil engineering experience with AIADs, specifically the benefits of recruiting and retention by allowing underclassmen to participate in the AIADs, as well as noting the disadvantages of some students not being well prepared for their engineering requirements on the AIAD. Assessments from both students and project sponsors will be included.

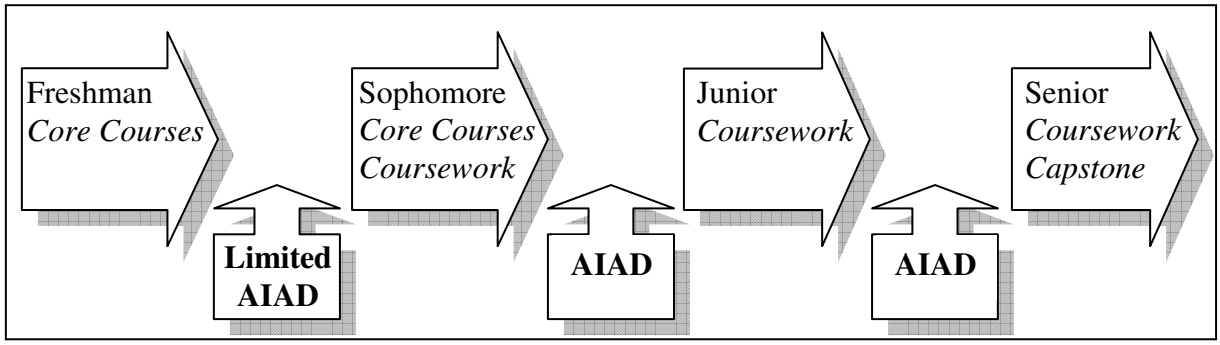

Figure 2. New AIAD Planning Model

Student Selections of Major and AIADs

At USMA students do not select a major until the beginning of their sophomore year. With many required courses in the curriculum, the freshman year seldom has the opportunity for an engineering class unless the student has had prior college and has validated many of the core courses. During the second semester of the sophomore year, an engineering major typically sees one or two basic engineering classes such as statics and computer aided design. This means the average student enters his junior year with very little exposure to other engineering courses. As the opportunities for them to participate in the AIADs increase due to fewer seniors participating in the program, there will be more students with little or no engineering coursework interacting with our project sponsors and solving real world problems (Figure 2).

However, there is a selection process that helps screen the students and ensure they are the best match possible for a particular project. All students must take an extensive number of required math and science courses. We try to match a student's desire to participate in an engineering

AIAD with their level of success in the aforementioned courses. After students return for the spring semester, the student selection process begins. We advise them to prioritize their top four choices, and we use an order of merit system. For instance, the highest ranked student majoring in mechanical engineering gets the first choice of all the mechanical engineering related AIADs. The second highest-ranking student gets the second choice, and so forth. The same process is used for the civil engineering students. More details for student selection can be found in other literature[6]. Again, we must ensure AIADs with specific background requirements (coursework) are matched to appropriate students. Project descriptions are usually specific enough to identify any requirements or are stated in a prerequisites section. When a sophomore or junior selects a project rather than a senior, we usually inform the project sponsor and seek approval that a student with less than a senior level ability has shown strong interest in their project. Some face to face coordination is necessary, especially if the student is not one of our majors and project location becomes a strong variable in the student's selection. We have matched physics and electrical engineering majors to some of the projects designated for mechanical engineering majors with outstanding results.

When students have been approved for their AIAD projects, we send notification to the students and the project sponsors. Also, in instances where there was no student interest in a project, we inform the project sponsor and invite them to submit projects again next year.

Recruiting and Retention in the Civil and Mechanical Engineering Majors

One of the advantages of allowing juniors to participate in the AIADs is it allows them to verify their selection of major. Almost all students can change their majors at the beginning of the junior year since the first two years of classes are primarily core courses. Depending on the major, some will have to take minimal additional coursework to change their focus. In the case of sophomores attending, AIADs may help them decide on their major. As stated earlier, students select their majors at the beginning of their sophomore year.

Perhaps one of the largest advantages of the AIAD program is the feedback we collect from students and project sponsors alike. Soliciting information from both provides us with unique perspectives. Student feedback relates the relevancy of the project to engineering coursework. This information tells us whether or not we should keep the project available to the students if offered again. Their feedback also gives us personal information about the project sponsor and whether or not we should ask the sponsor for additional AIAD projects.

A short survey was sent to the sophomores and juniors who participated in one of the department AIADs in 2008. The feedback collected was one indicator of the positive impact the AIADs have on recruiting and retention of majors in the department (Figure 3). The following scale (Table 1) was used for the students' survey:

Table 1: Assessment Scale

1	2	3	4	5
strongly disagree	disagree	neutral	agree	strongly agree

Student comments and discussion on the student surveys reinforce their overall ratings. Additionally, the rating scale is a normal set of responses used at USMA for student surveys.

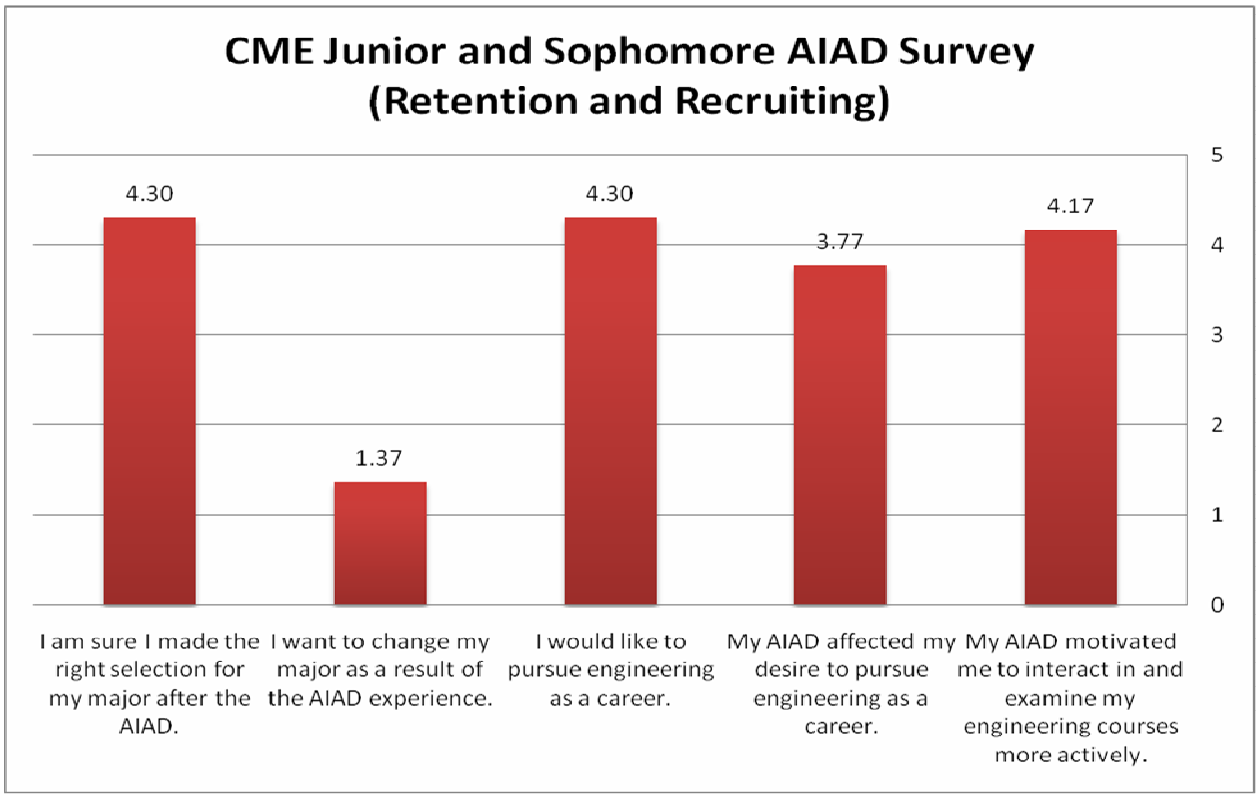

Figure 3. Junior and Sophomore Retention and Recruiting

It can be seen that students participating in the department's AIAD were satisfied with their selection of major and had little inclination to change their major once they had the opportunity. Additionally, they agreed that the AIAD heightened their interest in engineering courses and desire to pursue an engineering career.

Student Experience

The educational benefits to the students are varied, and experiences are unique to each AIAD project and student pairing. However, all students receive hands-on experience working on a real world project that usually has practical application. The relevancy of the problem to the students' future cannot be overstated: the students may help solve a problem that impacts their future. Additionally, the AIAD will probably be the first time the students function in a multidisciplinary team. Many capstone projects tend to be focused, discipline specific projects. The nature of these capstone projects reduces the number of multidisciplinary design experiences available to students. AIADs also reinforce the knowledge and theory learned in typical engineering classes with practical applications to a real world problem.

Upon arrival at the AIAD project site, the project sponsor quickly orients the student to the project. Work begins almost immediately. The AIAD projects are well defined by the time the

students arrive having most of the customer requirements, engineering targets, and timelines determined. The project sponsors have had extensive communication with the customers, so students are primarily involved with conceptual and product development and some testing and evaluation of the product. The bulk of student AIAD experience is in evaluation of concepts, actual product design through simulation or testing, and evaluation of a final product. Students also have secondary tasks of ordering materials for constructing a product, running computer programs and writing subroutines, constructing CAD models, and delivering information briefings. With these larger scale projects, students can personally experience a thorough, longer engineering process. Even though they may only see a limited portion of the overall project, students gain an understanding and appreciation of the time frame and requirements for a major project. With prior in-class projects limited to several weeks, they quickly change their first impression of the scope of work for typical engineering projects (Figure 4).

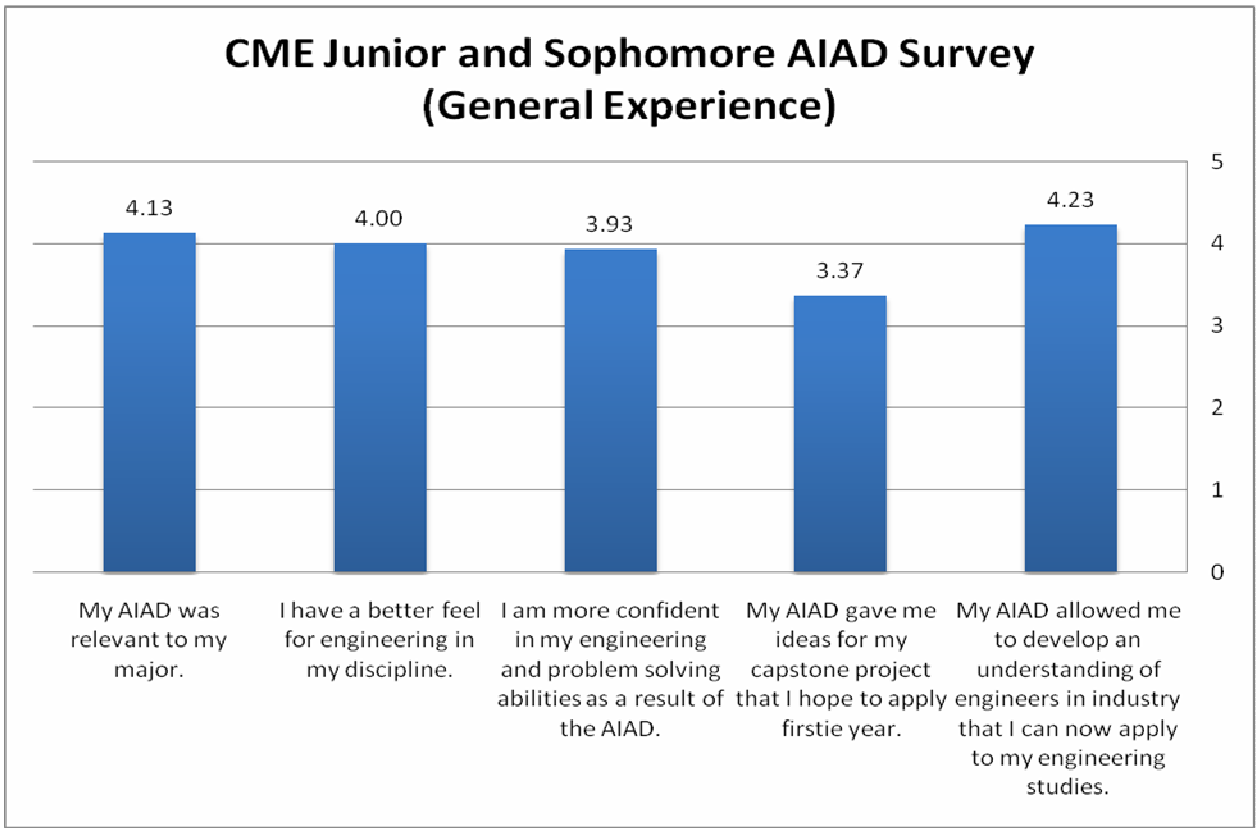

Figure 4. AIAD General Experience

The survey data shows that the AIADs gave students a better understanding of the engineering discipline as well as some confidence. However, one of the goals of the AIAD program is to stimulate ideas for a capstone project. The data showed they were fairly neutral in this area, not generating any potential projects for their senior year. Two reasons for this may be that students may not have the long term exposure in the department to gain an understanding of the capstone experience, or they have a strong desire to work on some of the larger competition-based projects.

One of the drawbacks identified in the survey of the sophomores was their lack of discipline specific knowledge. Most felt underprepared for their project (Figure 5). This deficiency has raised our awareness of the importance of matching the right student to the project. However, on a positive note, the data also shows that sophomores went in to their AIADs relatively neutral on their readiness to declare a major (3.33) and completed their AIAD ready to declare their major (4.33). This data speaks to the value of the AIAD/internship experience in helping students make informed decisions about their fields of interest. Sophomores selected for AIADs in the Civil and Mechanical Engineering Department all opted for one of our majors, and some have even asked for another AIAD for the upcoming summer; again this speaks to the success of the program motivating and educating students potentially interested in careers in engineering.

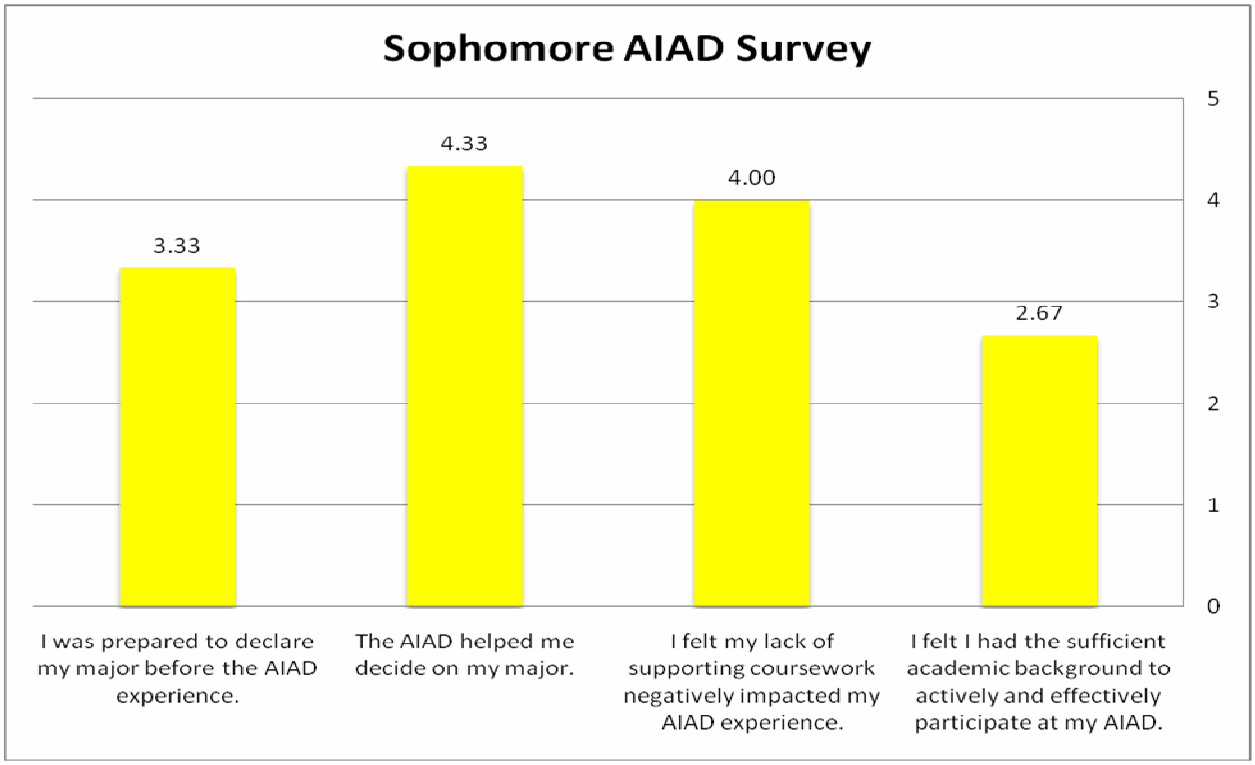

Figure 5. Sophomore AIAD Survey

Project Sponsor Experience

Project sponsor feedback is voluntary, and it provides us with an outside look at our academic program. We send students, who are products of our curriculum, out to an AIAD. We should know if we are preparing them for engineering in the real world. Sponsors are asked to assess the students' abilities and our program objectives. Their feedback helps in our internal assessment of the department's goals, the level of student competence, and the scope of certain subjects. Although the students can only participate for three to four weeks, the brevity does not seem to negatively affect the sponsors' perception. When students are matched well with their interests, sponsors often include free text responses on their surveys similar to the following:

"Although we only had Gabby for 3 weeks, her skills and ability to work were as strong as coops who had returned for a second summer"[7].

A project sponsor survey was sent to our mechanical engineering related AIADs. The same scale in Table 1 was used. This abbreviated chart shows that the institution's mechanical engineering program is meeting its program objectives. This information is valuable because it is an external look or independent view of the program and skills of the students. Since the AIADs occur early in the engineering sequence and the feedback is provided when the students are still in the program, we can address areas of concern before they graduate. Compare the timing of this feedback to the feedback of a capstone course where the student may graduate before areas of interest receive attention. Results from project sponsors are in Figure 6. All questions received very high marks. The lowest rated question (Familiarity with coursework to solve engineering problems) echoes the concern of sending students to AIADs early in their academic schedules.

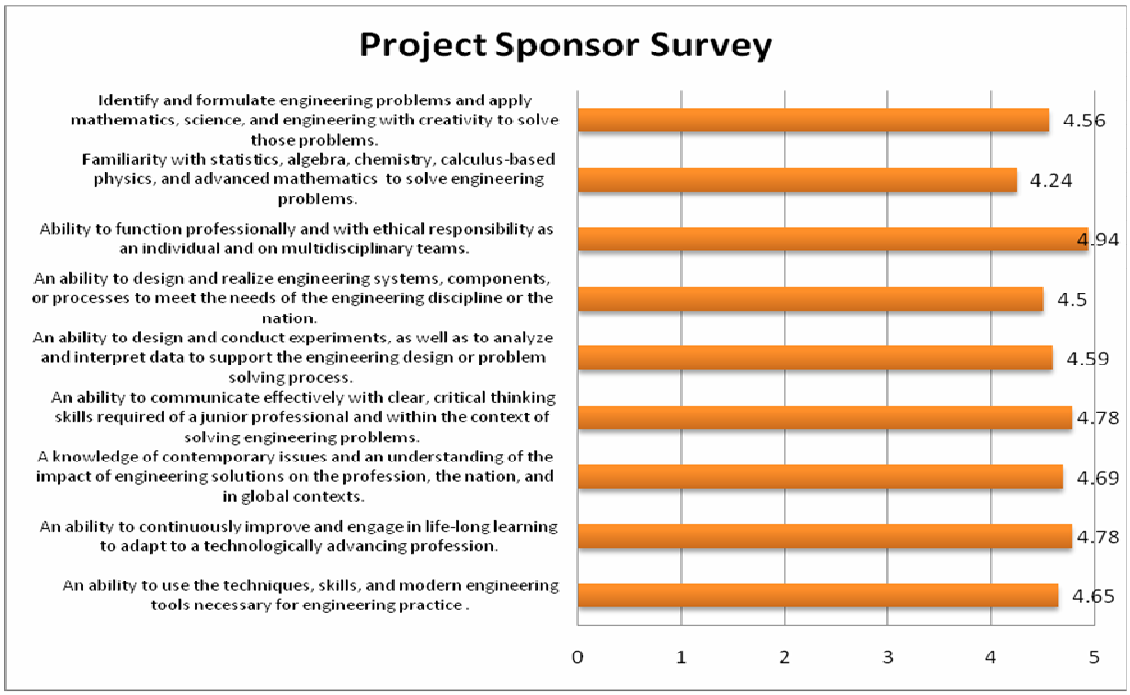

Figure 6. Project Sponsor Survey

This openness and communication through AIADs can strengthen the alliance between researchers and educators. There is a steady exchange of ideas and information about new technology between the institution and the project sponsors, and the engineering coursework becomes more relevant with actual engineering problems. The civil engineering students receive comparable praise and comments from their project sponsors as well.

Other Benefits of the AIAD Program

Some less tangible benefits of the AIAD program include the exposure students receive to different cultures in different parts of the U.S. or abroad. Students must travel, often for the first time, on their own in a business status. They learn to deal with the requirements of official travel as representatives of the institution.

All of these benefits, however, come at a cost. The AIAD program requires a great deal of administrative support. Each student's experience is a separate project to be planned and resourced. These activities can include coordinating summer schedules for several students participating in the same AIAD project or location. The administrative staff must develop official travel orders, submit changes to the travel orders, and check security clearances for over 64% of the majors in about a month every spring semester.

Conclusion

Incorporating more time for engineering education is difficult with a full curriculum, but the AIAD program at USMA offers some solution. There are many beneficiaries of the AIADs. The sponsors or customers receive an enthusiastic student to do work, conduct tests, and be part of an engineering team. Even though the project sponsor spends time mentoring the student initially, the student provides the organization some degree of expertise and most sponsors are surprised at the zeal and commitment to the project they receive from the student. The students work on real world projects. Some of them are small, and some are larger, involving complex test equipment and computer codes that the Academy does not have. Many of the mechanical engineering projects involve equipment that will be fielded in the next few years, so students are working on equipment that they will personally use in the future. Civil engineering AIADs deal with ongoing projects, so all students have the opportunity to see real-world applications of the engineering concepts they learn in class. Lastly, the department and the institution benefit from this experience. Project sponsors provide feedback to us concerning the level of academic knowledge of the students, our curriculum, and our department objectives. The students themselves have the opportunity to experience their chosen major while there is still time to change. Most importantly, they gain insight and experience they can use in the classroom and beyond.

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