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A Case Study Reflecting Successful Industry Engagement: Utilizing Industry Projects as a Mechanism for Discovery and STEM Education in Aviation Technology

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Abstract

Higher education is under increasing scrutiny, as evidenced by widely publicized concerns regarding the amount of student debt, new metrics for assessing the benefits of higher education such as the Gallup-Purdue poll, and competition between traditional learning and online resources, including on-line courses and degree programs, and massive open online courses (MOOC).Although there are many perspectives on higher education, there is also common ground. A goal shared by many stakeholders, including educators, students, parents, and industry is that education will lead to skill sets that are valuable to industry, which will benefit not only industry and individuals, but also society. One way to assure that education is relevant to industry is to involve industry in the education process. This is undertaken in a variety of ways, from industry advisory boards to cooperative education and internship programs at universities. Another avenue for collaboration between industry and academics is the inclusion of industry projects into academic courses. This paper provides a case study regarding how industry projects can be successfully integrated into an aviation technology curriculum to benefit both industry and education.

Keywords: STEM education, aviation education, industry engagement, practical based learning

1. Introduction

Higher education is under increasing scrutiny, as evidenced by increasing concern regarding the magnitude of student loans, which have prompted "best value" and educational return on investment calculations for both academic majors and for institutions (Hout, 2012; Psacharopoulos, G., 1994; and Psacharopoulos and Patrinos, 2004). The initiation of the Gallup-Purdue poll provides a different perspective and a new way to assess the impact of higher education (Ray and Kafka, 2014). Moreover, the benefits of attending college in residence have been closely examined since the advent of a wide range of online resources, including on-line courses and degree programs, as well as massive open online courses (MOOC), which have all broadened the options for higher education (e.g., Noble, 1998; Gikandi, Morrow and Davis, 2011; Yuan and Powell, 2013). One important consideration for higher education that many stakeholders can agree upon regardless of the assessment metric is the importance of higher education to future career success. Educators, students, parents, industry leaders and the public that fund our public institutions and back our publicly funded loan programs all share one common objective and expectation that an investment in education will lead to future personal and societal benefits in terms of contributions to industry and society, with commensurate tangible benefits to the individual in terms of career success. The importance of interaction with industry in higher education has prompted academic institutions to include industry engagement in their mission statements, develop industry advisory boards to provide a formal connection with academic departments, and develop cooperative education and internship programs to provide "real world" industry experience for their students.

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Another avenue for collaboration between industry and academics is the incorporation of industry projects into academic courses. There are many ways to accomplish this, and the value of project and problem based learning has been well documented in the literature (e.g., Mills and Treagust, 2003; Donnelly and Fitzmaurice, 2005; Savery, 2006), however, a review of the literature in aviation education indicates that there is very little documentation regarding the details of how this kind of collaboration can be successfully accomplished in an aviation technology curriculum. This paper provides an overview of one way to successfully manage industry projects in academic courses. The framework described has proven successful in the Aviation Technology Department at Purdue University, where it has been used in over 35 industry projects, reflecting participation by 16 different companies and 324 students.

2. Philosophical Framework for Industry Based Projects

A fundamental concept for industry projects is that students learn by doing. This concept is embraced and demonstrated in traditional education through laboratory exercises and vocational training. This concept is also a foundational one for industry based projects in an academic curriculum. Project based learning bridges the gap between academics and industry. Without project based learning, students who excel in a traditional academic framework of lectures and textbook problem solving through organization, discipline, and hard work may be disappointed to find that these important skills may not provide everything they need to allow them to meet their career objectives upon graduation. In industry, soft skills and innovative approaches may more relevant to navigate the complex environment in industry, with a wide variety of personalities, workplace politics, and challenges that require not just solutions, but also clear identification of the problems. In industry, it may not be enough to be able to solve a problem. It may also be necessary to identify the problem, successfully market the need to solve the problem to senior managers, garner cooperation with colleagues to solve the problem, and communicate your success to upper management once the problem has been solved. These are challenging concepts to teach in the abstract, and may be most effectively learned through practice. By utilizing industry projects, students have the opportunity to apply the technical skills they have learned, such as project management, process analysis, applied research techniques, and empirical observations, into the context of the actual industry environment. In some ways, the importance of project based learning may be especially critical in aviation. Aviation is an environment in which many areas are tightly regulated by the FAA. As a result, there is a strong emphasis on certification and the attainment of specific technical skills. While these technical skills are very important for success, they are just one component that is needed for lifetime success in a career in aviation. A second important element of industry projects in academics is progressive learning. In theframework of industry based project learning in aviation, the role of an individual student changes and grows as they gain experience. Students begin participation “on the ground floor”, typically as a freshman or sophomore, working on one segment of a project under the supervision of more experienced senior students. In subsequent semesters and on subsequent projects, their role changes to include supervision of other students, an increased role in decision making, a broader exposure to project progress, and increased interaction with industry representatives. This is analogous to most companies, in which recent hires complete internal tasks, and as they gain experience, they have additional opportunities in decision making and increased opportunities to interact with senior management and external stakeholders.

3. Organizational Framework for Application of Industry Based Projects

The framework for industry projects in aviation is tailored to engage both industry and academic participants in every project stage, and to assure that participants can bring their strengths to the process, as well as realize personal and professional benefits. One organizational structure for industry-based projects in an academic setting that has been successful isa functional organizational structure as shown in Figure 1.In this model, the industry personnel typically function in the client role, and the academic team members function as consultants on the industry project.

3.1 Roles and Responsibilities

The roles and responsibilities for the industry and academic partners mirror typical roles for clients and consultants in industry, as described in greater detail below.

Executive Level. Typically, the faculty member responsible for the project course has an on-going relationship with executives in industry, and they work together as partners to identify projects that are appropriate for student teams to address.

Once a project is identified, the executive will typically identify personnel within the organization to provide project support, including data that is required, information about operations, and coordination. The industry executive provides high level support within the organization, and may provide feedback to the student team at the capstone presentation at the end of the semester.

Project Management.A graduate student typically takes the lead on project management, and serves as the point of contact with the industry managers and the student team leaders. The graduate student project managers assure that an appropriate schedule is developed and adhered to, and that technical teams meet their project goals, assuring the larger project can stay on schedule.

Industry Manager. The industry manager provides on-going information and feedback to the project team. After working with the academic team to provide approval of the overall scope and schedule, the industry manager provides interim feedback and coordination to the project team. In many cases, the industry manager serves as a facilitator, providing access for students to observe operations, or to obtain need data from the company.

Team Leaders. Team leaders are typically upper level undergraduate students who provide direction and oversight for the completion of technical components of the project. Team leaders report to the project manager, and may coordinate directly with other team leaders, as necessary.

Undergraduate Students. Undergraduate students invest the time and effort to complete technical modules to support the technical objectives. Work may include data reduction, technical drawings and other more time intensive activities. Undergraduate students work with one another and with their team leader to conduct technical analysis, which ensures that all work can be crosschecked for accuracy.

3.2 Activities and Coordination

A critical component for successful industry projects in coordination and communication, both within the project team, and with the industry sponsor. Although there may be differences due to project variations and the preferences of industry sponsors, there are standard practices that have evolved as the recommended best practice.

Team meetings. Each team is responsible for timely progress and successful completion of their technical analysis and documentation. In order to accomplish this, each team has team meetings scheduled on a weekly basis, to review progress, identify challenges and solutions, and share and document progress. Undergraduate workers complete work independently and in coordination with other team members throughout the week, and can consult with the team leader to request input and to address problems encountered, as needed. The team leaders are responsible for the agendas for the team meetings, as well as for documentation of meeting notes and action items, which are available for review by the project manager and faculty member.

Project management meetings. Each week the graduate students serving as project managers attend a 1.5 hour discussion session with the sponsoring faculty members. Discussion centers on a new management topic each week, and topics are selected to support the project activities. Reading material, including exploration of the topic and related case studies, provide a framework for the discussion. The faculty member serves as a facilitator, introducing topics and ensuring that the discussion focuses on practical solutions that each group can consider as it relates to their own project involvement.

Team leader meetings.A structure similar to the project management meeting structure isused for the team leader meetings. Team leaders attend a 1.5 hour discussion session with the sponsoring faculty members. Team leaders for different projects met separately, which provided candidness for discussion of major issues that could be occurring between team members, team leaders, or with project managers. Although these scheduled 1.5 hour course sessions center on assigned reading material and on current mentoring issues that the leaders were experiencing, one faculty member observed,“the sessions symbolized weekly staff meetings that commonly occur in industry”.

Bi-weekly meetings are scheduled for all student team members. Topics covered typically concentrate on a predetermined set of issues, as identified by faculty, however, the topic can be adjusted to address the immediate needs as requested by students and team leaders. Examples topics for discussion include observational research techniques, focus and interviewing research techniques, and measurement programs for the field. These work sessions provided foundational information needed for the projects and assured that appropriate skills were addressed in a timely manner to meet the immediate needs of the project.

4. Integration of Project Based Learning within the Aviation Curriculum

The integration of the project courses into the aviation curriculum is shown in Figure 2. A student typically begins participation as a sophomore, registered in a 200 level project course. Upon successful completion of these requirements, the student may progress and participate through registration in a 300 level course, in which case they will begin to complete more complex and/or technical activities, or begin to take on components of the leadership role for the team. Subsequent participation allows the student to take on a designated leadership role through enrollment in the 400 level class, and a project management role through enrollment in the 500 level class. In this framework, completion of 200 and 300 level courses are considered prerequisites for the enrollment in the 400 level class, which is a prerequisite for enrollment in the 500 level class as a project manager.

Course requirements. The primary course requirements were attendance, participation, and satisfactory completion of deliverables on schedule. Students are provided with on-going feedback throughout the project by their team leader and project manager, as well as with feedback from the professor at academic milestones (e.g., halfway point of the semester). Constant feedback assured that the students understood project expectations, their role, and their current standing in the course. Students and team leaders were required to complete the interim and final deliverables of the learning project on-time per the schedule that was determined and approved by both the industry partner and Purdue. Sample deliverables include:

- Project management reports
- Team meetings: agenda, attendance, preparation and documentation of meeting activities
- On-site trips for data collection and industry collaboration: scheduling, completing, and appropriate follow up
- Supervision: selecting team members, assigning and overseeing duties to team members, creating and maintaining team morale,
- Final documentation: documentation of findings and delivering final presentations to higher level management

One key component of the industry projects is field observation. There is no substitute for direct observation, and opportunities for field trips to conduct direct observation studies are encouraged whenever possible. These field trips allow students to gain a holistic appreciate for the conditions in which work is completed, and to better understand how tangential conditions or activities may affect work outcome. Aviation projects are unique in that sometimes the industry sponsor can contribute to the project through transportation for students. Depending on the project, students may travel to different field locations to conduct portions of their study, and airlines are able to donate travel and utilize excess capacity on flights that are not fully booked. The flexibility of most students' schedules make this a practical alternative, and the practice is a win-win for both students and industry sponsors. Students obviously gain from the opportunity to travel and observe. Industry gains because the students can conduct more thorough analysis and the quality of their deliverables is enhanced by

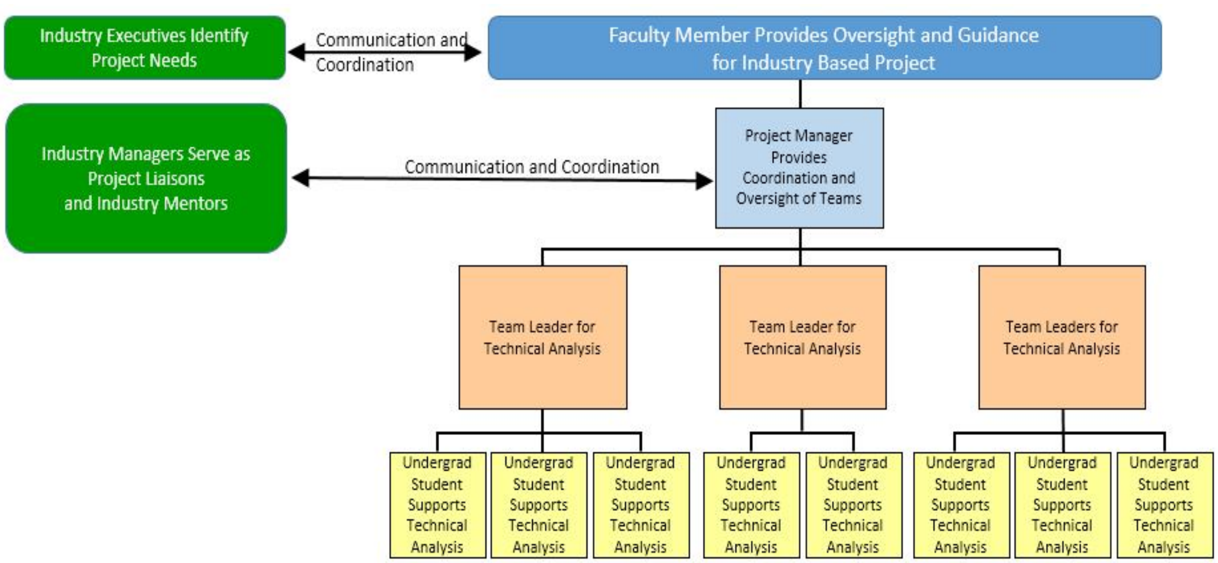

Figure 1: Functional Organization for Industry Based Projects

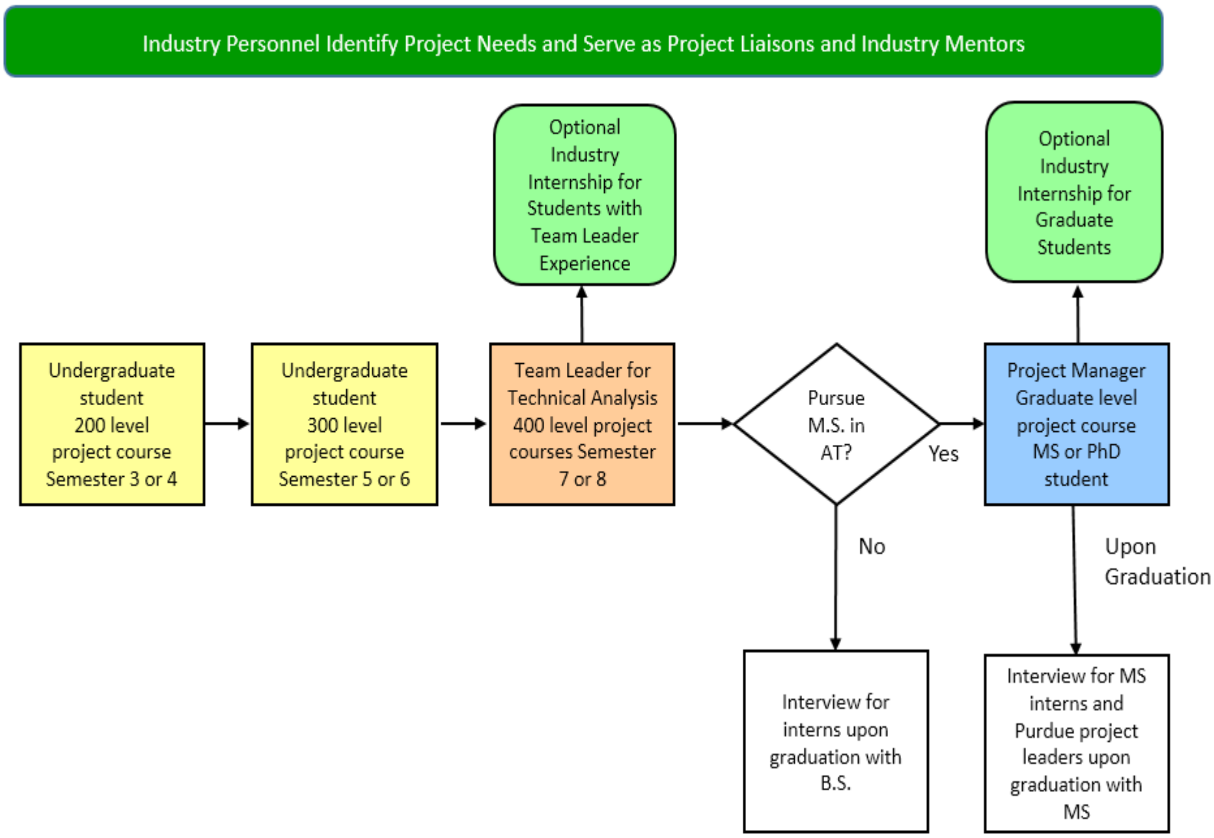

Figure 2: Integration of Project Courses within Academic Curriculum

The on-site experience. Although typically only a select group of students travel, travel can be used to reward high performing students. Other activities that were important included both written and oral communication, and networking opportunities. Coordination with industry provided a valuable opportunity to enhance professional communication and correspondence. Students participants at all levels learned communications protocol and vocabulary since project communication was shared whenever practical.

5. Benefits of Industry Based Projects in Aviation Education

There are numerous benefits that result from incorporating industry based projects into aviation education. These benefits are realized by the students, as well as by industry participants and even professors.

5.1 Benefits to Students

The industry based projects class is designed to benefit student educational goals and there is no question that this is the primary benefit. Participating students acquire a progressive skill set, and learn from their participation, regardless of whether they participate one semester or four semesters, or more. Due to the nature of the project courses, students benefit from progressive skill sets, as well as exposure to multiple projects, when participating for more than one semester. Sample projects and technical components are shown in Table 1.

Table 1: Sample Projects and Technical Components for Industry Based Projects in Aviation Education

Sample Projects and Technical Components
Assess human factors on ramp operations
Process map aircraft turns
Develop safety management system for commuter service at small hub airport
Analyze and develop operation standards for airline control centers
Analyze/ process flow major airline work functions and develop staffing models

Another significant benefit of the program is the hands on learning that occurs. Project based learning allows students to apply what they have learned in their technical classes, which lends credibility to this information, and provides a depth to their knowledge. One of the greatest benefits of the project class is the opportunity to interact with professionals in the aviation industry in a meaningful way. Interactions with aviation professionals provides a window to a future world, a preview of a corporate culture, and the opportunity to learn unwritten social norms. In a project based context, there are also very defined benefits, including enhanced technical knowledge of how a company does business, standard corporate practices, and examples of written and oral communication in the industry. These benefits, as well as the opportunity for networking, provide lasting value and give the student a "head start" for their career. Industry projects also provide a very non-threatening environment for student learning. Although all participants take the project very seriously and strive for the highest level of professional deliverable, if an error is made, the students will not lose their job, and all participants convert it into a learning experience. Specific comments by students regarding the class are shown in Table 2. Although most comments are overwhelmingly positive, some comments reflect the challenges that some students have with project based learning. "Assignments were sometimes unclear" reflects the ambiguity that is associated with defining and solving a problem in the real world of aviation. Real world problems are not presented following a chapter in a text with the relevant equations given. Real world problems require problem definition, reasonable assumptions and research to complete problem solving. The technical "problem solving" component may, in fact, be the easiest component of the process.

5.2 Benefits to Industry

The projects based learning courses resulted in significant benefits to industry. Industry realized tangible benefits as a result of the projects. Typically the analysis and project deliverables provided valuable information to the company at a very low cost. The risk to the company is minimal, and when necessary, all or part of the information provided is constrained by a non-disclosure agreement. One benefit that was not fully expected, was the benefits to the industry representatives who worked directly with the students. These experienced professionals typically report that they learn from the students, and are re-charged by the experience of sharing their knowledge with students who are respectful and eager to learn. Specific comments from industry regarding the benefits of the class are shown in Table 2. Industry comments reflect that participation in the industry sponsored projects are invariably an opportunity for employees to grow and develop. One recurrent comment by industry is the value in "previewing" future employees, as well as providing an opportunity to develop future employees, and even provide feedback regarding valuable skill sets while they are in school and have a chance to take courses to enhance these skills. Students are improving their skill sets not only for the specific company participating, but also for the good of the entire industry. A final benefit is that the industry project learning ensures that the curriculum stay relevant and fresh. Not only due students bring their new found knowledge with them to future jobs, but they also bring this information to other classes, sharing this information during classes and keeping education relevant and current. Faculty also benefit from this partnership, since it gives them a chance to stay abreast of the most current industry practices, and even a preview to the future needs of industry. Faculty with this kind of "hedge" can adapt their curriculum, as needed, to assure that education keeps current with the needs of industry.

Table 2: Sample Comments on Project Based Learning in Aviation

Student Comments	Industry Comments
• Makes you more proficient at researching and finding things on your own • Treats students like employees • Really lets people be creative • Allows everyone to participate • Assignments were sometimes unclear • Projects with companies get you some real world experience	• Quote from a Senior Vice President of an airline, "My employees obtain as much education value as the students." • The last student project model was installed into our operation and resulted in a $5M return the 1st year • When my employees visit Purdue as a working group with the students, employees' innovation and creativity abilities are set to a higher level • It makes me want to come back to college

6. Conclusions

Industry based project learning in aviation provides a unique opportunity to blend the best of both worlds – real life projects reflecting current conditions and challenges in the aviation industry, blended with academic resources and access to students with a variety of current technical skill sets. This paper outlines one framework that has proven successful from the perspective of the student, industry partner, and the academic institution. The resulting course provides a unique opportunity for hands on learning based on aviation problems, as well as opportunity for students and aviation professionals to work together to solve real world problems. Although many universities refer to project based learning, there is very little documentation as to the details of implementation in an aviation environment. This case study provides a detailed look at implementation, both throughout the semester, and over a period of years as project based learning becomes an important part of the curriculum. More widespread utilization will benefit industry and academics, and eventually the students that once served as team leaders and project managers, will become industry liaisons as they move forward in their careers.

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