COLLABORATIVE LEARNING: ENGAGING INDUSTRY AND STUDENTS

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1. INTRODUCTION

Technical education specialists working in the aerospace and air transport industries are bound by certain government-regulated curriculum requirements for certification of portions of the work force. These regulations make it necessary to expend significant time and energy on the technical training required to "pass" the certification tests. The validity of the technical education provided under these regulations is based primarily on successful exam completion rates. Additional measures by which the value of such training is judged include the number of job opportunities available to program graduates, and the success of new hires in industry training programs. Although the value of the knowledge and skills mandated under these regulations is not in question, industry advisory boards to the university have lately modified their view of academic success as well as their expectations of the overall skills considered necessary for success in today's market place. This has been specifically the case for Purdue University as it has worked closely with industrial advisory members to develop a better understanding of knowledge, skills, and abilities (KSAs) critical to the success of students entering the aviation and aerospace industries. Through discussions and interactions with industrial advisory participants, additional KSAs have been identified and a new technical education experience that embraces these is coalescing for students of aviation.

Effective technology education requires that the students and the faculty members be actively engaged with the industry. This is particularly true when the environment is fast-paced and changing, as is the case with the aviation and aerospace industries. The need for engagement arises from the fact that technology education is focused on the interface between people and changing technology. In order to understand one component of this interface, students must be technically competent. Input from industry advisors made it clear, however, that other skills were just as, if not more, important to the industry. Advisory boards represent one element of the ongoing interface with industry by which feedback is obtained relative to specific curricula issues and overall program success. When used properly, information obtained in this manner is a critical component of the continuous improvement process.

The feedback provided by the Industrial Advisory Council (IAC) to the aviation program was consistently complimentary of the KSA's taught for entry level employment opportunities, particularly for those requiring government certification. The feedback relating to the abilities

desired for future leaders and managers in the industry, however, was less favorable. The skills where students fell short of expectations were in the areas of teamwork, critical thinking, creative problem solving, and communication skills. This information served as the primary motivation to develop an educational concept based on collaborative learning experiences and exercises with industry partners. By engaging industry with a team of students on joint research projects, a collaborative learning opportunity that focused on a specific industry issue was created. These research projects demanded that students bring to bear the very skills that the advisory councils reported were lacking among program graduates.

"Collaborative learning may be defined as an instructional method in which students work in groups toward a common academic goal" (Gokhale, 1995). In this case the common academic goals were the application and demonstration of skills requiring analysis, synthesis and evaluation in unstructured industrial settings to solve actual industry problems or issues. The critical thinking and group interaction that took place with student teams and employee groups further cultivated this learning experience. The distinction between collaboration and cooperation is important for these efforts. "Cooperative work … is accomplished by the division of labor among participants, as an activity where each person is responsible for a portion of the problem solving…", whereas collaboration involves the "…mutual engagement of participants in a coordinate effort to solve the problem together" (Dillenbourg, *et al*, 1996). Collaborative efforts demand that the participants utilize teamwork, critical thinking, and communication skills. The environment provided by industry has been very successful in forcing students into the collaborative mode necessary to produce meaningful product in a short timeframe.

While collaboration became the model for the group effort employed by these teams, action learning became part of the student industry research project methodology. "Action learning is learning from concrete experience and critical reflection on that experience – through group discussion, trial and error, discovery and learning from each other. It is a process by which groups of people address actual workplace issues or problems, in complex situations and conditions." (Zuber-Skerritt, 2002) Action learning creates the opportunity for rapid development of improved observational skills, and enables advanced mentoring by faculty members participating side-by-side with the student and industry teams.

These collaborative and action learning project efforts have supported rapid growth of the overall graduate and research programs in aviation at Purdue University. Furthermore, it was apparent after eight years of industry-based student research projects with numerous aviation industry partners that the strategy was having the desired results. Student learning experience had been greatly enhanced by these efforts and the results were evident in the accelerated careers graduates were enjoying in the industry. Anecdotal evidence from numerous former students revealed that the experience gained on industry research team projects led to more rapid acclimation in aviation careers and, subsequently, accelerated advancements. The breadth and depth of knowledge and experience resulting from these activities distinguished them among their peers and generated considerable respect from their superiors.

Recognizing that anecdotal evidence is not by itself sufficient to garner internal funding and faculty support, the program mentors set about gathering data to determine the desirability of continuing the student research program. The study sought to capture the perceptions of

participants concerning the merits and effectiveness of the industry research program. The research question the study attempted to answer was "What are the benefits to students of participating in a structured program of industry-based research?" It was critical to the mentors to gain an understanding of the program's benefits for three populations; the students, the industry partners, and the faculty members. A series of focus groups were held with members of each population in order to capture the perspectives of the various benefits they felt were engendered by participation in the program.

2. BENEFITS TO INDUSTRY

The focus groups were very revealing, and provided strong evidence that the opportunity for research efforts of this type will only grow as the industry changes. Industry representatives reported that participation in research project partnerships had many advantages for their companies. Foremost among these was the unique opportunity to receive the unbiased truth about their research problem. Former industry research partners reported that often when they engaged consultants to evaluate and propose solutions for troublesome or persistent problems the consultants would "tell the companies what they want to hear", rather than the sometimes unpalatable truth about the nature and causes of the problem. Industry representatives also reported that they felt the consultants were often constrained in their assessments and findings to areas for which they had packaged solutions or expertise. Industry partners related that when they entered into projects with the student research program they often got "the unvarnished and enabling truth". They also reported that students often were able to obtain better, more insightful information from their employees concerning the problem under study than could consultants employed for the same reason. They attributed that fact to the non-threatening posture and persona of students and the fact that their employees often feel the need to "take the students under their wing and tell them how it really is."

Industry partners often find themselves inadequately and improperly staffed to address all of the problems confronted in today's dynamic aviation work settings. Clearly, the student research teams represent a resource pool from which to draw the necessary talent to address many problems that might otherwise remain unsolved. In the competitive and lean environment that exists in aviation and aerospace today, waste and inefficiency caused by unresolved problems simply cannot be afforded. The interdisciplinary nature of the applied research team also provides a rich diversity of knowledge and skills often unmatched by resources within the partner's workforce or from most consultants. Because of the nature of the student/faculty mentor relationship, industry partners can often avail themselves of subject specific expertise beyond those found within their workforce. The involvement of an unbiased "third party" coupled with student perspectives untainted by traditional barriers in thinking often result in innovative and effective approaches and solutions. The combination of these factors often results in highly innovative and effective solutions that would have been difficult to match utilizing only the industry partner's limited and constrained resources.

An additional advantage realized through cooperative applied research efforts is that of organizational learning. Partners in applied research projects frequently report that their employees often learn and adopt more effective techniques for dealing with difficult and

persistent problems as a result of their participation in these initiatives. The impact of these activities has, in some cases, reached down to the very core of the organization, leading to a cultural shift in organizational thinking. The team's strategy of working with partner representatives leaves the industry partner with the knowledge and skills necessary to continue to address the issues salient to the project long after the student research effort is concluded (Sterkenburg, *et al*, 2001).

As was further reported by Professor Ronald Sterkenburg and others in related study, industry partners also benefit from the fact that they are able to evaluate student researchers for potential future employment, and develop a pipeline to skilled, knowledgeable, and trained employees. Once the industry partners have identified students that have potential future value for them in the workplace, they are able to maintain contact with and provide additional training for those students through internships and fellowships. This extended contact and involvement with the student allows companies the opportunity to thoroughly assess the student's strengths and opportunities for improvement while building the student's loyalty and commitment to the company. Clearly, all of these activities serve to build relationships that are of mutual benefit to students and employers, alike. The industry partner also has a much better idea of the types of positions and opportunities that best match the individual student's talents, skills, and abilities.

3. BENEFITS TO STUDENTS

From the perspective of the student, the industry-based research program offered many unique educational opportunities. For projects of a global scale, perhaps the most important experience for students came about as a result of cultural and diversity issues. In order to successfully interact with others with different ethnic and experiential backgrounds, a great deal of preparation was required, and attentiveness to attitudes became a part of the prevailing philosophy (Thompson & Sterkenburg, 2001). Students reported that participation on applied research projects enabled them to study and practice team-centered work concepts. They also felt that these activities gave them a much better understanding of company policies and the overall workplace environment. The experience further enabled them to develop improved organization and planning skills, while they honed verbal communication and presentation skills. Clearly, as a result of these activities, students demonstrated increased self-confidence in personal abilities and developed an appreciation for the value of one's contribution to communal efforts (Sterkenburg, *et al*, 2001). On projects involving structured research methods, student team members learn how to select and utilize appropriate research techniques, such as questionnaires, focus groups, and observations, to clarify problem parameters, and to identify forces driving undesirable outcomes. Student researchers also learn how to develop and utilize various analysis techniques to isolate and delineate variables contributing to unwanted outcomes and to design intervention strategies to mitigate their effects.

In each project, a student team leader is identified to coordinate activities with the industry partner, manage the project, and recruit, develop, and manage the students on the team. Research team leaders develop higher-level skills by assuming responsibility for a research team's activity. In this capacity, they are responsible for developing the research design for the project, initiating and fostering industry partner relations, scheduling team and research

activities, developing team member skills, providing necessary training, promoting team cohesiveness, and keeping the project performance on-track and productive. This requires that student team leaders refine and optimize their organizational, interpersonal, communication, problem solving and project management skills. Students who had been team leaders reported that this was the most valuable aspect of their participation in terms of career success.

Students often related that improving their presentation and written communication skills through preparation of the project deliverables for industry partner upper managers was a critical advantage of the program. Many students also had the opportunity to co-author journal articles and conference papers. Several students reported that these publication efforts resulted in name recognition within the industry and often gave them credibility with their peers and superiors, a fact that often "opened doors" for them in their career pursuits.

According to the data from the students studied, establishing applied industry research partnership opportunities has been a tremendous success. The exposure and experience gained by students through these opportunities has proven invaluable in preparing the respondents for their future careers in the aerospace and air transport industries. Although student participants were often not paid for their participation on the research team, students reported that the rewards for their efforts were invaluable; furthermore, as students began their working careers, higher starting salaries were correlated to participation in these activities (Thompson & Morton, 2001). All of the students studied felt that the practical experience gained through the research program gave them a competitive edge over their peers.

4. BENEFITS TO THE FACULTY AND DEPARTMENT

Benefits to faculty and university academic units participating in the applied research partnerships with industry have gone well beyond the obvious benefit of experiential education opportunities for its students. From the faculty perspective, participation in the assessment and solution of current and emerging industry problems has allowed faculty members to maintain a level of currency with the state of technology, while also putting them in a position to observe the developing opportunities and challenges of the aviation/space industry. This has resulted in course and curriculum contributions which foster a much more effective educational foundation for preparing tomorrow's aerospace professionals. Faculty members have also enjoyed the opportunity to attend many industry-training courses and be the benefactor of educational material from research partners. In one particular case, a recurrent industry partner formed a strong bond with the department that resulted in the donation of significant aviation materials, parts, systems and financial support for educational activities. This included support for faculty and student travel to national and international conferences, aircraft and components for laboratory coursework, and financial gifting to support program development and to fund a graduate assistant position for the department.

A recent addition to the joint research team experience has been the inclusion of an international component to the projects. Faculty-led student teams have conducted trips to foreign operations to gather data to support the project objectives. Faculty reflection on this portion of the team experience indicated a unanimous opinion that cultural ideologies and language barriers were the

most challenging of the obstacles encountered. The opportunity to work with foreign managers was considered extremely beneficial due to the new perspectives brought to bear on issues or problems. A very promising foray into collaborative research teamwork is linking faculty as well as students in the United States with faculty and students from an aviation university in the Peoples' Republic of China (PRC) on joint research projects. An industrial partner is sponsoring the program by offering access to facilities and identifying research themes and issues that have arisen as a result of rapid expansion in the aviation industry. Given the explosive rate of economic growth and aviation expansion occurring in the PRC today, significant infrastructure and readiness issues will demand attention if the industry is expected to maintain a level of safety and reliability. These initial research efforts are important not only for the information gathered and subsequent solutions put forward, but also for the long term relationship and future research opportunities forecast to develop as the aviation industry grows in that part of the world.

5. CHALLENGES

Despite the resounding successes of the industry-based collaborative research program, the strategy has not been without its challenges. One significant challenge was that of administratively supporting the needs of the program. As with most universities, Purdue University was accustomed to funding research trips and other program needs through traditional research grants. University policies and procedures reflected years of working within the structure of receiving burdened grant funding to provide for faculty and graduate student research and travel needs in support of the funded project or study. Many of the collaborative research projects utilized "in-kind" donations or monetary gifts as the principle means for funding the projects. The university was unaccustomed to receiving and processing funds in support of research activities in this way and many exceptions and policy changes had to be worked through in order to facilitate the project activities. While the process of working through these issues was often frustrating for the research faculty, administration, and business offices involved, the benefits of the collaborative-learning activity were obvious and significant such that all involved recognized the importance of resolving the problems.

Another challenge came from the faculty's interest in expanding these industry-based research activities beyond the traditional boundaries of graduate student involvement. Participation by graduate students was easily accommodated in both the areas of academic curriculum integration and research trip scheduling due to the greater flexibility of the graduate program to these important facets of the strategy. Providing a means for including the projects within a graduate student's plan of study was easily accommodated through a research practicum course which offered students credit for participating in the research activities. Given that most graduate students have fewer class contact hours which are generally grouped in such a way that large blocks of time are available for research trip activities, it is much easier for graduate students to participate in industry-based activities involving travel to partner locations. The inclusion of undergraduate students in these research projects represented a considerable challenge since they have more classroom contact hours and their academic curriculum is less flexible. In each case involving travel for research purposes, undergraduate students had to seek approval with their instructors to be absent from lecture and laboratory meetings. Often times, these were complex issues that forced students to make compromises and difficult decisions with respect to other

courses in which they were concurrently enrolled. These considerations often limited the involvement and participation of undergraduate participants, particularly when travel was required to industry locations where the actual research was being performed. In many cases, undergraduate students found they could only participate in data-rendering or research strategy activities which took place at the University. These limiting issues meant that the educational experience of the undergraduate students involved in these projects was less robust and narrower in scope.

While all of the industry-based research projects have proven to be exceptional learning experiences for students, a few have resulted in some level of disappointment and frustration. In most cases, student driven projects have led to highly effective and cost-saving solutions to troublesome and persistent problems confronting the partnering company. Implementation of the developed strategy led to measurable improvements over extended periods of time. However, once the project was completed and the research team ceased their visits to the company, some industry partners abandoned the solutions for various reasons ranging from corporate inertia, to changes in management, to failing to support the solution because it was "not invented here." As an example, a research team working with a major airline was asked to help them improve their "on-time performance" at one particular station. The student research team utilized a combination of process mapping to analyze the problem and "performance shaping" to effect new behaviors for workers which resulted in dramatic improvements. The strategy improved on-time performance for the carrier by 70% over a six-month period. When the team did a follow-up visit four months after the completion of the project, they found that a new station manager had discontinued the use of the new strategies and on-time performance was, once again, very low.

6. CONCLUSION

It has become clear to the faculty involved that collaborative learning through research projects of the type described heretofore is of singular importance for students in the aviation program. Engagement with industry on real-time projects that address the interface between people and changing technology should become a fundamental part of technology education. The key component, experience has revealed, is the collaborative effort that draws together the elements of teamwork, critical thinking, creative problem solving, and communication skills. Not all students are ready or equipped for these experiences; nonetheless, it is the feeling of the faculty members involved that most of the technology students in aviation can benefit, in some manner and at some level, from such activities. Successful mentoring of students enables them to initially contribute in a way that enhances learning, while also allowing them to grow within themselves. As students develop, their responsibilities within research projects may evolve to include leadership and advanced communication roles. Development of these skills and abilities gives students a strong competitive advantage as they enter the workforce.

Technology education should be responsive to the needs and the changing face of the industry, and research engagement provides the vehicle for this to occur. The aviation and aerospace industry, in particular, is rapidly changing, and requires strong leadership now and for the future. Through these research efforts, students are developing leadership qualities and other

knowledge, skills and abilities of critical importance to the industry. Coupled with the strong technical skills these students already possess, these experiences prepare graduates to compete for the best jobs and help the industry meet the challenges of the future.

The problem, and it is one, has to do with managing the growth of these research initiatives. The aviation industry is in dire need of effective research, and requests for research help are outstripping the capacity of the program, both in terms of faculty mentors and student numbers. Industry research partners have observed the return on investment possible through collaborative efforts of the type described herein, and generally are willing to invest accordingly. Students are also recognizing the importance of these activities and are participating in increasing numbers. Faculty support obviously is a function of available resources, and these are currently stretched to the limit in higher education. Expansion of the program must be predicated on the ability to support the initiatives at a level that is beneficial to all parties involved. This is a significant challenge facing technology education today.

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