International Journal of Aviation, Aeronautics, and Aerospace

Volume 2 | Issue 4 Article 7

10-29-2015

# Recommendations For Improvement Of Collegiate Flight Training Operational Efficiency Through Guided-Inquiry Inductive Learning

John H. Mott
*Purdue University - Main Campus*, jhmott@purdue.edu
Darcy M. Bullock
*Purdue*, darcy@purdue.edu

Higher education and the value it provides to its customers has recently received considerable attention in both the popular press and in academic circles. There have been increasing calls from all sides for institutions to quantify this added value, but the mechanism which might provide that clarity remains elusive. At least one Midwestern university (Ray & Kafka, 2014) has worked with a national polling organization to create an index that attempts to examine the level of satisfaction of graduates. The inaugural Purdue-Gallup report of findings revealed that, while there is no significant difference in job satisfaction across college graduates as a result of individual choice of college, there are significant differences in engagement and job satisfaction that result from how particular students engage throughout their college residencies, with those who were primarily enrolled in experiential and internship programs that provided deep learning opportunities ranking higher in subsequent workplace satisfaction than those who were not (Daniels, 2015b). The report defines engagement as “employees being intellectually and emotionally connected with their organizations and work teams because they are able to do what they’re best at, they like what they do at work, and they have someone who cares about their development at work.” (p. 3) It is evident, then, that programs providing experiential learning opportunities to students will be viewed favorably relative to programs that do not do so.

At the same time, affordability is a primary issue, with the Gallup-Purdue report indicating that those students who graduated from college with $20,000 or more in student debt are three times less likely to be satisfied with respect to five key elements of personal well-being (purpose, social, financial, community, and physical) than those who graduated with little or no debt (Ray & Kafka, 2014). Clearly, the path forward is for academic institutions to provide students with opportunities for real-world experiences combining academic foundations with industry engagement, all at a cost that is more affordable than many such programs today. This challenge is being articulated at all levels from internal university communications to the national press (Belkin, 2014; Daniels, 2015a, 2015c)

The professional flight program at Purdue University provides operational experience that is designed to prepare graduates to operate the high-performance aircraft that many will be employed to fly soon after graduation.

*Figure 1*. Purdue flight training aircraft fleet.

In terms of cost, the program is near the median when compared with similar collegiate flight training programs. The question arises, however, whether program affordability can be improved, a question that is consistent with recent comminications from President Daniels (Daniels, 2015c) to the Purdue community. In addition to tuition, professional flight students at Purdue pay substantial fees for each flight-related course in which they enroll (Table 1).

Table 1
*Purdue Flight Program Costs*

| Total Four-year Flight Program Costs | Resident Students | Nonresident Students |
|---|---|---|
| Tuition | $36,832 | $112,039 |
| General student fees | 3,177 | 3,177 |
| Flight Program Fees | 53,439 | 53,439 |

Fees are determined during the preparation for the biennial budgeting process; consequently, fee reductions have a lagged effect relative to impact on students, as they cannot be imposed until final approval by the institution's board of trustees has been given.

The efficiency of collegiate flight training operations can have a substantial effect on the overall cost of those programs. At Purdue, a state-supported institution, state appropriations constitute a relatively small 16.1% of the total flight program operating budget. State support for higher education institutions is decreasing; Purdue received only 19% of its total revenue from state appropriations in 2012 (Purdue University, 2012), and that percentage is expected to decrease to 11% by 2020 (IU, Purdue expect state aid to continue falling, 2011). It is therefore clear that, absent any additional sources of revenue, gains in operational efficiency will be the principal source of improvements in program affordability. Mott and Bullock (2015) examined the professional flight training program at Purdue, identified critical path constraints that adversely impact program efficiency, and suggested solutions for mitigation of those constraints. The focus of the present research is integrating the implementation of suggested program efficiency improvements into the Aviation Technology educational experience.

## Background

### Aviation Technology at Purdue

The Purdue Department of Aviation Technology houses Purdue's professional flight program, and is also home to an aviation management program. The flight program at Purdue consists of approximately 220 undergraduate students who train under a combination of full-time instructors and part-time students who have achieved their flight instructor certifications. With a strong emphasis on the implementation of project-based, hands-on educational methodologies that are relevant to industry needs within the University, the Department has developed a concept called the Industry-Purdue Opportunity Pipeline, or iPOP. iPOP is an innovative academic model that capitalizes on synergies with closely associated industry partners to maximize educational and financial benefits for both academia and industry, and provides a transformative, affordable, and accessible educational experience, leadership in the STEM disciplines, and world-changing engagement and research. The model was conceptualized in response to the Purdue College of Technology's move to transform the learning experience with the creation of the Purdue Polytechnic Institute (PPI), which itself is a values-driven effort to create an exemplar undergraduate technology education model. The vision, mission, and goals of iPOP align closely with those of the PPI, and "focus on the dual mission of addressing operational challenges within the aviation industry and facilitating positive educational outcomes for students by actively involving both graduate and undergraduate student researchers working closely with faculty mentors in a highly collaborative multidisciplinary environment." (Mott, 2014, p. 27)

The desire of the department to improve flight program operational efficiency, combined with the mission to implement the associated iPOP and Polytechnic concepts, naturally lends itself to combination of both goals into a course-based inductive learning activity in which aviation management students analyze the operational efficiency of the Purdue flight program, recommend potential solutions, and work with administration on the implementation of those solutions. That experience is the focus of this paper.

## An Inductive Learning Approach to Systems Thinking

Inductive teaching and learning is an umbrella term that encompasses a range of instructional methods, including both problem-based learning and project-based learning. These methods have at least two common features, first among which is the concept of learner centricity, meaning that the bulk of the responsibility for instruction is placed upon the student. In addition, they have in common the concept of constructivism, or the enabling of students to develop their own versions of reality, as opposed to accepting the framework presented by an instructor. Generally, active learning is an important component of constructivist learning methodologies. Freeman et al. (Freeman et al., 2014), attempted to create a working definition of active learning by collecting written definitions of the concept from 338 audience members in attendance at college-level active learning seminars. They developed a consensus definition of active learning through qualitative analysis. According to the consensus, active learning "engages students in the process of learning through activities and/or discussion in class, as opposed to passively listening to an expert. It emphasizes higher-order thinking and often involves group work" (p. 8413).

The benefits of these inductive learning methodologies, according to Frank and Barzilai (2004, p. 55), include "gaining interdisciplinary knowledge, acquiring that knowledge through active and experiential learning, taking responsibility for the learning, acquiring communication skills and methods of decision-making within a team, and enhancing of one's self-esteem." It should be noted that, with increasing frequency, an uncomfortable number of graduates of higher education institutions are unable to find employment upon graduation, while employers have difficulty assembling a properly qualified workforce. This dichotomy has at least two related causes. From a political perspective, suboptimal policies and procedures fail to connect competencies of university graduates with employer expectations. From a methodological standpoint, according to Cao and Braun 2014), this is due to a lack of communication and misalignment of the expectations between education and workplaces. According to Mott (2014), the benefits outlined by Frank and Barzilai (2004) are those which industry is seeking in its employees. It therefore should be readily apparent that incorporation of inductive learning methodologies has the potential to produce positive outcomes for both students and prospective employers.

Richmond (1993) argues that a primary reason for the intractability of many large-scale problems is a "tightening of the links between the various physical and social subsystems" (p. 113) that comprise our reality, and postulates that systems thinking, the process of understanding how system components (or subsystems) influence one another within the context of the overall system, is a promising approach for "augmenting our solution generation capacity." In terms of transferring the systems thinking process to the rest of the world, Richmond suggests that two elements are necessary to effect such a transfer: an understanding of the evolution of the education system, and an understanding of the process itself. According to Richmond, the emerging culture of learner-directed learning, as distinguished from the teacher-directed learning culture that has been entrenched for the past 200-plus years, is essential for the effective transfer of the systems thinking process.

The concept of systems thinking is particularly important to the problem under study. The overall system that comprises flight operations at Purdue University consists of subsystems that include a course scheduling component that places students into flight training slots in their respective flight courses, a dispatch component that manages the actual flight operations process, and a maintenance component responsible for ensuring that both scheduled and discretionary maintenance is properly performed on the training fleet. For the almost 60 years during which the academically connected flight training program has been in existence (roughly 1956 to the present time), there was little consideration given to the interdependence of these components with regard to the efficient operation of the system as a whole. It has become apparent, though, that a systems thinking approach will be essential to the improvement of overall system operational efficiency.

**Effectiveness of Inductive Learning**

Significant evidence that demonstrates that inductive learning methods result in improvement of student learning outcomes is extant. Freeman et al. (2014) hypothesized that the use of active learning methodologies maximizes learning and course performance by metaanalyzing 225 studies that reported data on examination scores or failure rates when comparing student performance in undergraduate science, technology, engineering, and mathematics (STEM) courses under traditional lecturing versus active learning. The effect sizes in that particular study indicated that, on average, student performance on examinations and concept inventories increased by 0.47 standard deviations under active learning (n = 158 studies. These results suggested that average examination scores improved by about 6% in active learning sections, and that students in classes employing traditional lecturing were 1.5 times more likely to fail than were students in classes with active learning.

According to Olson and Riordan (2012), teaching and learning strategies that involve active learning “improve retention of information and critical thinking skills, compared with a sole reliance on lecturing, and increase persistence of students in STEM majors” (p. 11).

In a British study (Boaler, 1999), students inculcated in project-based learning methodology were found to be able to answer procedural questions involving formulas, but to be superior to traditionally educated students in their abilities to address applied and conceptual problems. This study indicated that three times the number of students exposed to project-based learning in a mathematics course received the highest possible score on a national exam than students who were not. This implies a need for alternative assessment approaches that can effectively assess students’ abilities to resolve open-ended, ill-defined problems that are encountered outside of academia, but also reinforces the belief that project-based educational methodologies continue to address successfully the learning outcomes that are evaluated by traditional assessment methods.

## Differences Between Project-based and Problem-based Instructional Methodologies

The two approaches to inductive learning that are particularly applicable to analysis and resolution of the problem at hand are problem-based learning and project-based learning. These approaches have several similarities and differences. Both generally involve one or more teams of students who are presented with challenges that are timely and relevant, open-ended in nature, and which call for solutions that can be formulated, implemented, and then adjusted based on outcomes.

The differences between the methods are related primarily to their respective end goals. Problem-based learning may be considered a subset of project-based learning, in that projects are typically broader in scope and may include multiple problems. Project-based methods tend to be focused on the application or integration of knowledge, as opposed to problem-based methods, which focus more on the process of acquiring knowledge. As Prince and Felder

(2007) note, the end-product of project-based learning "is the central focus of the assignment and the completion of the project primarily requires application of previously acquired knowledge, while solving a problem requires the acquisition of new knowledge and the solution may be less important than the knowledge gained in obtaining it" (p. 130).

Mills and Treagust (2003) suggest that project tasks are closer to professional reality and generally require a longer period for completion than problem-based learning problems. Those researchers note that time management and student role differentiation are especially important relative to project-based learning. In addition, they note that learning is more self-directed with the project approach than with the problem construct, since "the learning process is less directed by the problem" (p. 9).

Donnelly et al. (2005) note that, in practice, "it is likely that the line between project- and problem-based learning is frequently blurred and that the two are used in combination and play complementary roles." Clearly, then the two approaches may be successfully combined into a hybrid methodology, which is customarily how inductive learning is actually implemented. The key to doing so is to ensure that the deliverables or problem statement are clearly defined and adjusted so as to fit within the scope of the course in which the methodology is implemented with regard to learning outcomes and time and resource constraints.

**Importance of Real-world Experiences in Inductive Learning**

If maximum educational benefits are to be achieved from a course incorporating project- or problem-based inductive learning, it is essential that the problems selected for resolution be such that real inquiry is required for their solution. According to Larmer and Mergendoller (2010), real inquiry means that students "follow a trail that begins with their own questions, leads to a search for resources and the discovery of answers, and often ultimately leads to generating new questions, testing ideas, and drawing their own conclusions." The concept of real inquiry is ideally suited for application to project- or problem-based learning, since those two methodologies involve a developing series of questions that are initiated by the instructor and expanded and ultimately resolved by the students.

As noted by Bransford, Brown, and Cocking (2000, p. 61), "learners of all ages are more motivated when they can see the usefulness of what they are learning and when they can use that information to do something that has an impact on others." The efficiency problem herein is clearly well-suited for this sort of inquiry, as it is apparent that the work of the students in the course will have an impact on their peers in the professional flight program.

### Use of the Flipped Classroom

A suitable format for conducting courses in which active learning methodology plays a primary role as a delivery mechanism is the blended learning environment. Blended learning may be defined as “the thoughtful integration of classroom face-to-face learning experiences with online learning experiences” (Garrison & Kanuka, 2004, p. 96). The goal of the blended learning approach is to “create a synchronous set of learning activities where classroom based face-to-face interaction with instructors and peers is complemented asynchronously by work performed outside of class” (Hussey, Fleck, & Richmond, 2014, p. 25).

Blended learning typically employs what is colloquially referred to as a “flipped” or “inverted” classroom, which is a restructuring of the traditional classroom model in such a manner that the locations and times at which students complete required coursework and are exposed to lecture content are reversed. In an inverted class, students review lecture material online outside of schedule classtimes and participate in active learning activities during classtime. Reversing the delivery mechanism in this manner allows a maximization of interaction time between the instructor and students, since it allows the passive, one-way information flow associated with a lecture to occur at a time of the student’s choosing, reserving valuable time in class for instructor-student interaction.

## Methodology

### Class Structure

The lead author chose his undergraduate aviation managerial economics course as a platform through which to actively involve undergraduate students in analyzing opportunities and implementing solutions to increase the operational efficiency of their department’s flight training activities. The course was an ideal one in which to accomplish this goal; it was newly developed and had never before been taught, making it relatively easy to adjust the course structure to accommodate the incorporation of inductive learning instructional methodologies and the attendant inversion of the class. Furthermore, 13% of the enrolled students were Professional Flight majors and 7% were employed as dispatchers. In addition, the course title and learning outcomes were tightly aligned with an investigation of the efficiency of an operational process. Those outcomes are as follows:

- Articulate and define managerial economic decision-making terminology

- Illustrate the central decision problems that managers face,
- Provide appropriate solutions for those decision problems using tools introduced in the course, and
- Apply managerial economic decision-making concepts to solve an aviation industry problem.

By having students working to improve the efficiency of an internal operation critical to the overall success of the program, a significant degree of project relevance is ensured, thereby facilitating the achievement of outcomes through the active learning delivery mechanism, as noted previously.

The general learning methodology selected for delivery of the course was a combination of the two inductive methodologies described previously: problem-based learning and project-based learning. The integration of knowledge obtained by the students from their previous courses in both aviation and finance was a goal of the course project, as was the application of that knowledge to the development of a real-world deliverable (a more efficient scheduling process for both flight and maintenance operations). At the same time, though, the process of acquiring the knowledge in incremental steps was a primary focus of the course, as well. Those two objectives lend themselves well to a hybrid methodology.

More specifically, the instructional methodology utilized in the managerial economics course can be described as process-oriented guided-inquiry learning (POGIL), using a floating facilitator model, as suggested by Prince and Felder (2007). In this classroom model, students are formed into small groups of three to five students and work through the steps that constitute the research process. These steps are modularized, with additional information presented and leading questions, designed to guide the students toward formulation of their own conclusions, posed in each module. In the floating facilitator model, the instructor circulates among the groups during class, asking questions and probing for understanding. Different levels of external guidance may be provided by the instructor, with a great deal of the responsibility and accountability for the work devolving to the student groups. In this particular implementation, the instructor was assisted in the facilitation process by a graduate teaching assistant.

**Process**

The course began with an introduction to the general challenge of operational efficiency with regard to the flight program, with a call for an improvement in training fleet utilization rates and subsequent goal of admitting more students to the program in an effort to capitalize on the excess capacity. The class was shown a PowerPoint presentation with graphics supporting the argument that the excess capacity exists, and this was combined with a discussion among the students facilitated by the instructor. The students were then assigned to groups of six groups of three students each, which covered the 18 students enrolled in the class. Three of the students enrolled in the course later dropped it, resulting in three groups of two students and three groups of three students. Three of the groups were assigned to investigate the scheduling and dispatch opportunity; the other three were assigned to the maintenance opportunity. The groups were tasked with investigating their respective areas, developing recommendations in those areas that would lead to an improvement in overall operational efficiency, and implementing or assisting with the implementation of those recommendations.

The instructor scheduled information sessions with the faculty member and staff member assigned administrative responsibility for the scheduling and dispatch area and the maintenance area, respectively. Those sessions consisted of 30-minute presentations by each individual, with additional time for follow-up questions from the students, during two separate class periods. These individuals offered themselves as information resources for the students for the semester's work. Additional resources, such as the aviation technology business office and various college and university websites, were introduced, as well.

Informal presentations with follow-up discussion and guidance from the instructor were scheduled for the fifth week of the 16-week semester. A more formal presentation from each group was scheduled for the seventh week. Deliverables included a short presentation supported by the use of Microsoft PowerPoint that described the research topic and problem statement in the words of the individual groups, research questions, findings at that point, challenges, and future steps. Performance of the assignment was assessed on a completed/not completed basis and contributed to the overall participation grade for the course.

At this point in the process, the expectation was that solutions would begin to emerge from the respective groups. Those solutions were refined by the groups after the midterm exam with guidance from the instructor and teaching assistant, and that refinement, with an emphasis on feasibility of implementation, continued until week 14 of the semester, at which point the solutions were finalized and guidelines for implementation were presented. Planning for the implementation of the most feasible solutions, as determined by the instructor through group discussion and consensus, was initiated over the remaining two weeks of the semester.

## Strategies to Facilitate Stakeholder Engagement

Various stakeholder groups participate in the operation and oversight of the department's flight training program. Acceptance by these stakeholder groups of the modifications that will be required to improve the program's overall efficiency is seen as essential to the success of the implementation of those modifications. Certainly the most critical of these groups is that of the professional flight students. Several of the students in the managerial economics course are majors in professional flight, and are viewed as potential liaisons between the class and the flight students. These flight students in the course will serve a dual role as class participants and as facilitators of acceptance of change among the flight students at large.

A second stakeholder group is that of departmental and college administration. Meetings were held early on in the process with the department head, the department's business manager, and the college's director of financial affairs to present the overall goals and strategy and solicit feedback in an effort to obtain acceptance for the requisite modifications. A strong level of support was obtained from all three of those individuals.

The Department of Aviation Technology's Industry Advisory Board is a third stakeholder group whose involvement is a critical element of the plan's success. The overall goal of the Board is twofold. First, the department must maintain relevancy in its curriculum due to the changing dynamics of the aviation industry; it is therefore essential that individuals from a wide variety of aviation career paths interact with the department on a regular basis in order to keep curricula and related programs current with regard to industry practice. Secondly, the Board provides a mechanism for both faculty and students to maintain currency with respect to these changing industry dynamics so that neither is artificially insulated from the other. The Board, the constitution of which is a professional accreditation requirement, also provides additional insight into the skills successful graduates might require in the future, including important non-technical skills such as interpersonal communication and cross-cultural interactions.

The department's Industry Advisory Board met in early February, 2015. The lead author made a brief presentation to that group consisting of a PowerPoint deck very similar to the one used in the course introduction. The industry group were very appreciative of the initiative by the department to improve affordability, as well as the effort to keep them informed of the progress of that initiative.

The fourth significant stakeholder group is that of faculty. Accordingly, faculty members from both the aviation technology department and other schools within the university were solicited to be available to students as those students moved through the research process, and also to serve as evaluators for the final project presentation. Faculty were joined in that presentation by industry members, as well.

**Description of the Assessment Process**

The necessity of integrating instruction, learning, and assessment is essential (Van den Bergh et al., 2006). While it is clear that assessment methods should be congruent with the methodology used in instruction and suitable to what students should be learning, there are challenges associated with traditional methods of assessment that make such integration difficult in practice. Frank and Barzilai (2004) demonstrated that formative assessment, consisting of continuous assessment throughout the course conducted in a variety of alternative formats, is found to be more suitable than traditional methods. The alternative assessment methods applied to the managerial economics course included semi-structured student interviews, peer evaluations, a student survey, instructor assessment of group project reports, and faculty and industry evaluation of final project presentations.

A traditional mid-term exam was scheduled for the eighth week of the semester. The semi-structured student interviews were begun shortly thereafter. These were conducted in a group setting, using questions prepared in advance, with each group interviewed at the end of class on a different date. Once those interviews were complete, the student survey, which was distributed electronically through the use of Qualtrics software, was distributed. Students were given one week to access the survey, after which it was closed. A sample of the questions asked on the survey is shown below (Figure 2).

Peer evaluations were conducted during the week prior to the final presentations; these were paper-based. Each student was asked to complete an evaluation of the other members of his or her group. These evaluations were aggregated for each student and scaled and mapped to three levels of output such that the factor thereby created would either raise or lower each student's class participation score by a predetermined amount, or would have no effect.

Finally, project reports were evaluated by the instructor through the use of a standard rubric that considered such items as problem definition, review of existing research, research methodology, veracity of data collected, analysis, recommendations, and plan for implementation. Presentation evaluations by the instructor and invited guests consisted of evaluation of content, clarity of expression, validity of proposed solutions and feasibility of implementation, and general communication skills of the presenters.

Do you believe that taking this course will help you develop the skills you will need to be successful as an aviation manager?

- Yes
- No

Please select from the list below the item that most closely reflects your goal for taking this course.

- To fulfill a graduation requirement
- I plan to work as an aviation manager and believe the course will help me develop important management skills
- I do not plan to work as an aviation manager, but believe the course will help me develop important management skills
- I am just curious about the topic

During this class, did you:

| | Frequently | Occasionally | Not At All |
|---|---|---|---|
| Have an opportunity to work on an assignment in teams? | | | |
| Communicate with others to coordinate and complete tasks? | | | |
| Seek help from team members to complete tasks? | | | |
| Manage problems so as to meet deadlines? | | | |
| Coordinate with other classmates to make a group presentation? | | | |

Did the problem-based learning approach provide opportunities for you to develop the following skills?

| | Frequently | Occasionally | Not At All |
|---|---|---|---|
| Problem-solving skills (gather information, research similar problems, analyze findings, identify possible solutions, justify a decision) | | | |
| Group communication / teamwork skills | | | |
| Group presentation skills (explain things to team members, present to the class) | | | |
| Leadership for a team conducting a complex task | | | |

*Figure 2.* Sample student survey questions.

# Results

## Recommendations

Each of the six student groups in the class arrived at innovative solutions to the efficiency problem. As noted previously, three of the groups approached their solutions from a maintenance perspective, while three did so from a scheduling and dispatch perspective.

The first maintenance group observed that the mean times for aircraft phase inspections in the Purdue operation exceed those of similar operations, and proposed both that the inspection program be replaced with a simple 100-hour inspection cycle, and that an incentive pay structure be established for maintenance personnel. The second maintenance group addressed what appears to be an excess of time spent by aircraft in pre- and post-maintenance queues, proposing the incorporation of RFID tags to provide accurate information on both aircraft positions and technician task completion. The third maintenance group proposed the addressing of an apparent need for additional technician-hours by adding a training course to allow aviation students to learn maintenance fundamentals to allow them to perform routine maintenance tasks that do not require completion by a certificated mechanic.

The first scheduling and dispatch group proposed the development of an integrated software application by a restructured dispatch operation that would efficiently assign aircraft to scheduled students based on availability and upcoming maintenance needs. The second group created a mandatory flight slot assignment system that assigns students to unused slots based on knowledge of students' schedules and ancillary factors such as whether they have slots at adjacent times. Finally, the third group examined the implementation of financial incentives for underutilized slots, collecting useful elasticity data in the process.

The instructor and lead author determined that the most feasible of these solutions for rapid implementation and significant impact were the fleet assignment algorithm and the slot incentivization approach. Consequently, those solutions were slated for implementation for the Fall 2015 semester. Additional solutions will be evaluated and considered for implementation on a continuing basis.

## Implementation

The fleet assignment algorithm can be formulated as a linear programming application that will allow the efficient assignment of aircraft to student flights. By so doing, it is anticipated that cumulative ground time between training flights can be reduced.

The slot incentivization solution presents some challenges with respect to implementation, since there is no readily accessible mechanism for reimbursing enrolled students with fixed amounts, and limited available funding for doing so. Due to the difficulty of accounting for slots actually flown, it was decided to base the incentivization on scheduled slots as a reimbursement to be given to students in the form of a predetermined number of fixed scholarships. The scholarships will be distributed to students who voluntarily enroll in traditionally undersubscribed flight slots during the University's open registration period for the Fall 2015 semester. The slots that will be eligible for incentivization will be determined just prior to the open registration period, and will be based on the existing level of subscription at that point. It was agreed by multiple stakeholders that the proposed solution is an effective and equitable means of incentivizing students to enroll in undersubscribed flight slots.

**Assessment of Learning Outcomes**

The results of the semi-structured student interviews were aggregated and analyzed to determine the effectiveness of the delivery method with respect to student learning outcomes. The 14 students interviewed consisted of two Professional Flight and 12 Aviation Management majors; nine were juniors and five were seniors. Their reasons for taking the course ranged from believing it would benefit them in their careers, to being interested in learning more about economics and decision-making, to having a convenient course to fill a schedule opening.

The students noted that the manner in which the course was taught forced them to become more independent in their actions and in taking responsibility for their own learning, as opposed to standard courses in which they were "spoon fed." While they missed being able to ask questions during the online lecture, they did appreciate the degree of interaction during the scheduled classes. They believed that the instructor-guided classroom activities assisted in their learning, as these were based on realistic situations. They mentioned in particular that the fleet efficiency improvement project was very beneficial in helping them make the connection between the concepts covered in class and the application of those concepts in an actual aviation environment, noting that they considered the work important because the result would improve the program and help the department. Some students said that they were frustrated with the project because it was somewhat open-ended and the expectations of the instructor were unclear, but many suggested that they realized that such projects are the norm in industry.

Students most commonly mentioned problem-solving, marginal analysis, negotiating, systems engineering, project management, decision-making, and communications skills as those they had gained from the course. They also noted that the students who would most enjoy the course are those who are self-motivated, independent, prepared, interested in mathematics, able to master abstract concepts, and determined.

Ten of the fifteen students enrolled in the course responded to the student survey during the last week of class. 100% of the respondents believed that the course helped them to develop aviation managerial skills; six of the ten students plan to work in the industry as managers. The respondents confirmed that the course frequently enabled them to work in teams, communicate with others to coordinate and complete tasks, and manage problems so as to meet deadlines; the students sought help from other team members and coordinated with other classmates to make group presentations more occasionally. Respondents also verified that the problem-based learning approach provided either frequent or occasional opportunities for them to develop problem-solving, group communication and teamwork, and presentation skills, as well as leadership skills for teams conducting complex tasks. In addition, there was strong confirmation that the instructional methodology allowed students to either learn or master professional analytical approaches to problem-solving and analysis of information to determine its relevance, and more moderate confirmation or learning or mastery of technical concepts, terminology, knowledge of industry problems, and explanation or problems to others. Results were more mixed on feedback received through the POGIL methodology; roughly half of the students agreed that the feedback assisted them with monitoring their progress, determining areas of needed correction, and examining and choosing alternatives, so this suggests a potential area of improvement in future sections of the course.

80% of the students indicated that they would prefer taking the course as delivered, with 20% preferring a traditional lecture-based form of delivery. However, 90% indicated that they would recommend the course to a friend or colleague. 90% of respondents also indicated that they were more engaged in the course than in others they had taken, suggesting that they did extra work on their own, came early, stayed late, worked more with teammates or classmates, and discussed the project outside of school.

Survey respondents were given the opportunity to provide free text responses to two questions regarding the features they liked about the learning approach and changes that would have improved the experience for them. The features they liked included the fact that the project was interesting to them and relevant, in the sense that the results would be used to make positive changes to programs in the department. They also appreciated the practical experience they acquired through the course, much of which was done so independently, furthing their confidence in their abilities to complete projects successfully. Suggestions for improvement included clear project objectives, more feedback during the phases of the project, and additional connections between concepts in the textbook and the project. Other suggestions included providing additional time for the course, and incorporating recitation sessions guided by a teaching assistant.

The group presentations were conducted during the scheduled final exam period for the course and were made to an audience of project stakeholders that included faculty from multiple departments, flight instructors, dispatchers, and maintenance personnel. Each of the stakeholders was provided with a grading rubric and given the opportunity to evaluate the presentations. The presentation grades were averaged to determine a single grade for each group. The single group grade was then adjusted differentially based on peer evaluations conducted during the last week of class to arrive at an individual grade for each student. The resulting individual grades were normally distributed on a 0 to 100 scale with a mean of 91.9 and a standard deviation of 4.1. The overall course grades were likewise normally distributed with a mean of 84.8 and a standard deviation of 8.8.

## Conclusion

The process-oriented guided inquiry approach to inductive learning that was utilized in the research described herein appears to be both an effective means of determining promising practical methods to facilitate improvement of operational efficiency in the collegiate flight training program under study, and a successful classroom instructional methodology leading to increased student engagement and concept reinforcement and retention. The department plans to implement one or more of the student recommendations resulting from this process in the fall semester of 2015. Further research relative to the assessment of outcomes and improvement of related metrics is suggested. It is anticipated that the validation of one or more of the recommendations in this manner will lead to the improvement of the operational efficiency and subsequent improvement of student affordability of this particular flight training program, and will be extensible to other such programs, both domestic and international.

## References

Belkin, D. (2014). At Purdue, a case study in cost cuts; former Indiana Gov. Mitch Daniels, now school president, drives a rethinking on value of a degree. *Wall Street Journal (online).* Retrieved from http://online. wsj. com/articles/at-purdue-a-case-study-in-cost-cuts-1406326502

Boaler, J. (1999). Mathematics for the moment, or the millennium. *Education Week, 17*(29), 30-34. doi:10.1023/a:1003880012282

Bransford, J. D., Brown, A. L., & Cocking, R. R. (2000). How people learn: Brain, mind, experience, and school. Washington, DC: National Academies Press.

Cao, L., & Braun, E. (2014). Addressing Ecological Validity in Modeling and Measuring Competencies in Higher Education (KoKoHs). *KoKoHs Working Papers No. 6*, 11. doi:10.1007/978-94-6091-867-4

Daniels, M. E. (2015a). How student debt harms the economy. *Wall Street Journal (online).* Retrieved from http://www.wsj.com/articles/mitchell-e-daniels-how-student-debt-harms-the-economy-1422401693

Daniels, M. E. (2015b). Measuring Great Jobs and Great Lives: The Gallup-Purdue Index. *Computer, 48*(1), 66-69. doi:10.1109/mc.2015.21

Daniels, M. E. (2015c). An Open Letter to the People of Purdue. Retrieved from http://www.purdue.edu/president/messages/1501-med-openletter.html

Donnelly, R., & Fitzmaurice, M. (2005). Collaborative project-based learning and problem-based learning in higher education: a consideration of tutor and student role in learner-focused strategies. In G. O'Neill, Moore, S., McMullin, B. (Ed.), *Emerging Issues in the Practice of University Learning and Teaching*. Dublin: AISHE.

Frank, M., & Barzilai, A. (2004). Integrating alternative assessment in a project-based learning course for pre-service science and technology teachers. *Assessment & Evaluation in Higher Education, 29*(1), 41-61. doi:10.1080/0260293042000160401

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences, 111*(23), 8410-8415. doi:10.1073/pnas.1319030111

Garrison, D. R., & Kanuka, H. (2004). Blended learning: Uncovering its transformative potential in higher education. *The Internet and Higher Education, 7*(2), 95-105. doi:10.1016/j.iheduc.2004.02.001

Hussey, H. D., Fleck, B. K. B., & Richmond, A. S. (2014). Promoting Active Learning through a Flipped Course Design. In J. Keengwe, Onchawari, G., & Oigara, J. (Ed.), *Promoting Active Learning through a Flipped Classroom Model* (pp. 23-46). Hershey, PA: IGI Global. doi:10.4018/978-1-4666-4987-3

IU, Purdue expect state aid to continue falling. (October 29, 2011). Retrieved from http://www.washtimesherald.com/news/iu-purdue-expect-state-aid-to-continue-falling/article_ca543c57-b37c-58bb-8ef4-d217c00075c8.html

Larmer, J., & Mergendoller, J. R. (2010). Seven essentials for project-based learning. *Educational leadership, 68*(1), 34-37.

Mills, J. E., & Treagust, D. F. (2003). Engineering education—Is problem-based or project-based learning the answer? *Australasian Journal of Engineering Education, 3*(2).

Mott, J. H. (2014). A$^3$IR-CORE at Purdue University: An Innovative Partnership Between Faculty, Students, and Industry. *Journal of Aviation/Aerospace Education & Research, 24*(1), 27-40.

Mott, J. H., & Bullock, D. M. (2015). Improving Training Aircraft Utilization in Collegiate Flight Programs: A Case Study at Purdue University. *Collegiate Aviation Review, 33*(1).

Olson, S., & Riordan, D. G. (2012). Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics. Report to the President. *Executive Office of the President*.

Prince, M. J., & Felder, R. M. (2006). Inductive Teaching and Learning Methods: Definitions, Comparisons, and Research Bases. *Journal of Engineering Education,* 95(2), 123–138. doi:10.1002/j.2168-9830.2006.tb00884.x

Ray, J., & Kafka, S. (2014). Life in college matters for life after college. Retrieved from http://www.gallup.com/poll/168848/life-college-matters-life-college.aspx

Richmond, B. (1993). Systems thinking: critical thinking skills for the 1990s and beyond. *System dynamics review, 9*(2), 113-133. doi:10.1002/sdr.4260090203

University, P. (2012). *2012 Financial Report*. Retrieved from http://www.purdue.edu/business/account/pdf/Annual%20Financial%20Report%202012.pdf

Van den Bergh, V., Mortelmans, D., Spooren, P., Van Petegem, P., Gijbels, D., & Vanthournout, G. (2006). New assessment modes within project-based education-the stakeholders. *Studies in Educational Evaluation, 32*(4), 345-368. doi:10.1016/j.stueduc.2006.10.005