Nomination Packet for Amy Pritchett for CETL's Curriculum Innovation Award

Table of Contents:

The faculty of the School of Aerospace Engineering nominate Dr. Amy Pritchett for the CETL Curriculum Innovation award for her tireless work to introduce Problem Based Learning (PBL) to the School. Amy has single handedly demonstrated the utility of the approach for both lower (Intro to AE) and upper level courses (System Dynamics and Automatic Control). She has proven to be a tireless and data-driven advocate of using the PBL approach to empower our students to take control of their learning and in so doing introduced many students to talents and capabilities they never knew they had. Similarly she has shown the faculty that PBL is an effective way to teach our students skills we routinely complain they do not possess. Amy has gone above and beyond to evaluate the effectiveness, advantages and challenges of the PBL method for AE courses by conducting both immediate and longitudinal studies of its impact on student performance. She has shared what she has learned in numerous venues across campus and at national conferences, thereby helping to proliferate understanding and use of the approach among engineering faculty.

Description: Problem-Based Learning in Aerospace Engineering Education

Problem based learning (PBL) is an instructional method which requires teams of students to solve a tough, authentic problem as a means to an end: the problem is carefully crafted by the instructor to require students to:

- identify what knowledge they need to acquire;
- reflect on this informations applicability to the problem and their depth of understanding;
- develop the skills essential to problem solving within the domain;
- stay active in learning activities spanning gathering information, assessing and applying knowledge as it is gained, and problem solving; and
- assume ownership and responsibility for their learning.

Thus, PBL fits within the broader construct of instructional methods focusing on active learning. Such methods can include simple interventions within lecture-based instruction such think-pair-share activities to promote active reflection and discussion on specific elements of content, while leaving the instructor to determine which knowledge is presented to the students. PBL, however, further emphasizes that the students should also learn the skills inherent to solving problems, including identifying which information they need to find, reflecting upon their knowledge as it is developed relative to its contribution towards solving the problem, and learning how to break down the problem itself. Further, PBL generally expects students to work within teams for two main reasons: first, to develop team skills in the common context of a problem too large for any one engineer to solve; and second, to promote the benefits of near-peer instruction between students as they individually master concepts and then find they need to also teach these to their team mates.

The intended benefits of PBL may be framed in terms of the intended student outcomes associated with accreditation of engineering programs as defined by the Accreditation Board for Engineering and Technology (ABET): a) an ability to apply knowledge of mathematics, science, and engineering; b) an ability to design and conduct experiments, as well as to analyze and interpret data; c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability; d) an ability to function on multidisciplinary teams; e) an ability to identify, formulate, and solve engineering problems; f) an understanding of professional and ethical responsibility; g) an ability to communicate effectively; h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context; i) a recognition of the need for, and an ability to engage in life-long learning; j) a knowledge of contemporary issues; k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

First, the active learning aspects of PBL are generally held to foster students' knowledge development beyond the passive learning endemic to traditional lecturing, thus contributing to ABET student outcome (a). Second, PBL further has a unique capability to also potentially address the other student outcomes (b) through (k) when the problem is carefully designed to require students to demonstrate (and, perhaps, acquire) their associated abilities. PBL problems inherently focus on teams (outcome (d)) and problem solving (outcome (e)). Students are required to learn on their own, providing them with the inquiry and research skills fostering life-long learning (outcome (i)). Students are required to apply techniques, skills and modern engineering tools involved in engineering practice (outcome (k)), and to design something (outcome (c)). PBL problems can also be designed to require some experimentation (outcome (b)), to consider some aspects of professional and ethical responsibility (outcome (f)), to understand the impact of their solution in context (outcome (h)) and relative to contemporary issues (outcome (j)). Finally, PBL is commonly constructed to require final presentations and written submissions graded relative to standards for effective communication (outcome (g)).

Throughout, PBL requires students to assume responsibility for their own learning and the ultimate solution to their team problem. However, PBL should not be implemented as simply handing students a problem and then standing back to see what they do with it. Instead, the problems should be carefully designed to implicitly require the desired learning activities by the students; and, the course should be carefully implemented such that the student teams are carefully facilitated such that the students properly reflect on their activities and recognize the knowledge and skills they need to attain, and such that the students are properly pushed to attain the desired level of understanding and capability.

When the class is small and the learning objectives are inherently "hands-on," PBL can be easy to implement and, indeed, has been widely applied. However, **the novel aspect is application of PBL to large engineering classes,** as is its application to the instruction of the theory underlying fundamental engineering classes such as system dynamics and controls. The innovation here, then, is two-fold: first, the general structure of creating a PBL offering of fundamental engineering classes at Georgia Tech in general and in aerospace engineering in particular; and, second, its specific implementation as a re-design of the pedagogy and instructional delivery of aerospace engineering courses, staying within their requirements for course content and student expectations (AE3515 Systems Dynamics and Control, and AE1350 Introduction to Aerospace Engineering).

GENERAL STRUCTURE OF THE INNOVATION

In designing a PBL course, the first crucial step is to detail the course objectives. Common curricula only specify high-level goals; these must be further broken down into detailed learning objectives spanning the ABET skill set (roughly 180 detailed objectives). Thus, this innovation started with the process of identifying learning objectives that may be either/both general to engineering or specific to the content objectives of engineering courses.

These learning objectives typically include both about 150 content-related objectives of a typical lecture-based class (ABET (a)), such as, for AE3515:

- ability to break dynamic systems down into component dynamics which can be modeled as first and second order systems,
- use toolset of fundamental modeling concepts to create useful models of system dynamics,
- use toolset of controller design concepts to create useful compensators,

but also about 30 skill-related objectives (ABET (b) through (k)), such as:

- model a physical system in a manner allowing for analysis of system dynamics and for controller design,
- present to a technical audience using proper terminology and mathematical models, and
- demonstrate an ability to sketch root locus and Bode diagrams to capture key attributes of a controller design.

For each course objective, detailed course content and criteria for mastery was then be identified. This identification spanned several months of brainstorming, consulting with experts in PBL and with other technical experts. Once these course objectives are identified, they were then grouped thematically as best as possible into a small number of significant problems, such as, for AE3515:

Problem 1: "Design of a Seismograph", where the students had to, among other things:

- design and build a prototype seismograph using cheap common materials, and
- develop the system's transfer function and identify experimentally its parameters.

Problem 2: "Structural Dynamic Model of a Bending Wing and Supporting Aerodynamic Analysis", where the students had to, among other things:

- create a structural dynamics model of a B787 wing using the panels method,
- evaluate the deflection and twist of the wing in response to constant loads, sudden turbulence, and deflections of the aileron, and
- simulate the complete model in Matlab.

Problem 3: "Design of a Heading Controller for an Air Transport Aircraft", where the students had to:

- develop a PID heading controller and implement and demonstrate it in a provided computer simulator of a Boeing 747-400 programmed in C++, and
- meet control performance requirements specified by the client.

Problem 4: "Design of a Guidance Controller for a Launch Vehicle", where the students had to, among other things:

- develop a pitch controller for a launch vehicle with unstable dynamics and a lightly damped flexible body mode,
- meet control performance requirements specified by the client, and
- make a trade-off analysis between SISO, MIMO, and full-state feedback control.

The wording of each problem statement is carefully tailored to steer the students towards the desired course objectives. For example, the statement of Problem 3 noted that, in questions following their final presentation, the presenter may be asked to hand-sketch a root locus illustrating the impact of any changes in the aircraft flight dynamics on the predicted performance of their proposed controller design; thus, the students were given a standard for learning that required sketching a root locus and understanding how to predict stability, transient response and frequency response from the location of closed-loop poles on the complex plane. Projects are generally cumulative; in other words, each project adds new content and supported prior content. A unique scoring rubric has been created for each project based on the course objectives planned for each project, based on a general template adapted as part of this innovation.

Further, the required deliverables of the problems are carefully detailed to include a presentation, a report and, in some problems, physical models or simulations conducted in Matlab. The student teams are provided with a detailed rubric that highlights the standards that the problems must attain, particularly emphasizing the use of underlying physics-based, mathematical models to drive their solutions rather than a design made by trial-and-error. They were provided with a report template based on that used by the American Institute of Aeronautics and Astronautics (AIAA) for professional publications, extended as part of this innovation to scaffold students' processes in outlining and authoring the report based on no assumption of any prior experience in technical communications.

This structure was designed to 'flip the classroom' - almost all class time had undergraduates working together on teams to master these projects and provide the deliverables (notably, the report and presentations). Starting with the first day of the semester, in the syllabus and the introductory lecture, the 'ground rules' of PBL were given to the students. Whereas lectures were generally anticipated by the instructor, specific dates and topics were not built into the syllabus, with the exception of review/debrief lectures after every project. Lectures where only offered when students could articulate what they wanted to know and why, at a level illustrating genuine reflection on the recommended references. When individual groups could articulate their own isolated stopping points, they were provided with an impromptu focused tutorial. Finally, multiple office hours per week were established in the syllabus with the possibility of extra office hours per arrangement.

The explicit intent was for students to take responsibility for their own learning, and to master the corresponding skills in inquiry, knowledge development, problem solving, and teamwork and project management. For example, one of the goals of the PBL method is to teach the students how to search for relevant technical information on their own. Hence, while some references were provided to help the students complete the projects (notably a recommended textbook, and videos of past lectures and past homework with solutions), the students were also mentored as to search rigorous data sources for further research such as the library, and databases of peer-reviewed journal articles.

Thus, the course appeared, by design, to the students to be largely student-directed. However, the classroom time was carefully structured so the faculty instructor and a team of trained graduate student instructor 'facilitators' closely mentored each group. The difference from the normal class room was that the instructors did not frame their role as giving answers; instead, students were consistently challenged to describe their thought process and intention, particularly when the students appeared to be off course and needed external stimuli to reflect and correct on their process. Further, the instructors served to model the behavior of 'real' engineers leading a team project, such as emphasizing the types of questions that any engineer ought to ask as proof or justification of a statement of fact, and as part of the problem solving process. Thus, the instructors (faculty and graduate student facilitators) were actively mentoring the students not only, implicitly, on the content objectives of the course; they were also explicitly mentoring them on the learning and professional skills that transcend any one course.

This mentoring included detailed assessments made throughout the semester that were both summative and formative: Summative in that they were designed to assess learning at key points throughout the semester (particularly at the conclusion of each problem), and formative in that they were intended to direct the students to higher-performance behaviors. Examples of the summative assessments included: project scores, midterms after each project, and final peer evaluation of every project.

Examples of the formative assessments included:

- weekly inquiry/progress updates delivered by the students,
- comments by the facilitators on those inquiry/progress updates and on the performance of the group during group meetings (facilitator comments were based on the scoring rubric for each project to promote high standards and inter-rater reliability),
- interim self and peer evaluations provided to facilitator to guide an assessment session and also used to detect potential problems requiring direct intervention by the instructor,
- detailed written feedback on project presentations and reports.

The interim self and peer evaluations were based on an assessment rubric distributed to the students at the beginning of the semester. The rubric was divided in four areas: inquiry skills, knowledge building, problem solving, and team skills. For each area, the rubric established the prerequisites for an exceptional ("A"), proficient ("B"), fair ("C"), or poor ("D") grade in terms of specific observable behaviors typifying each level, such that the assessment did not appear to be completely subjective, and such that the rubric illustrated actions that the students were expected to take that themselves map to good skills. The students were asked to assess themselves and their group peers on these four areas based on this rubric. As an example, the prerequisites for an "A" in inquiry skills were:

- actively looks for and recognizes inadequacies of existing knowledge,
- consistently seeks and asks probing questions,
- identifies learning needs and sets learning objectives,
- utilizes advanced search strategies,
- always evaluates inquiry by assessing reliability and appropriateness of sources.

At the end of each project, in addition to delivering a complete project report, the groups had to present their work to a review panel formed by usually three or four persons, each reviewing two or three groups. The review panels were formed by one aerospace faculty, facilitators (not reviewing their own group), industry/operational experts when possible, other faculty, and experts on teaching and learning familiar with methods of questioning and challenging students. Each panelist was given a detailed scoring rubric. Feedback on the presentations was provided to the groups within 24 hours, often on the same business day. Groups were allowed a few days to finish their project reports after receiving this feedback. Detailed written feedback was also provided on the problem presentations and reports, to encourage and inform student performance on the subsequent problems. At the conclusion of each problem, a review session was held on the underlying technical content. The students then individually completed mid-term exams (and final exam after the last problem), providing the opportunity to assess them individually and the motivation for all students to thoroughly learn the requirement course material individually.

Beyond the artifacts and structure generated above, the innovation also included establishment of a graduate teaching practicum each semester of a PBL offering. This teach practicum is designed to serve the needs of graduate students seek the CETL Tech-to-Teaching Intermediate Certificate by providing key aspects of both the foundational experience and CETL 8715 otherwise not available to most aerospace engineering graduate students. Further, the simultaneous offering of an undergraduate PBL course and the teaching practicum were crafted to work together synergistically: part of the graduate students' experience of student learning and teaching was direct and face-to-face in that they served as the PBL facilitators to the undergraduates. Each week, the faculty instructor and graduate students also met separately to compare observations of how students learn (or learning blocks), and to compare notes on 'best practices' on diverse areas ranging from providing feedback to students to develop their learning and professional skills, to working one-on-one with students who are experiencing learning blocks, to managing classroom time and providing tutoring sessions or lectures to PBL groups where warranted.

IMPLEMENTATION OF PBL IN AEROSPACE ENGINEERING

The instructional methods and pedagogy have been re-designed for two Aerospace Engineering courses: AE3515 System Dynamics and Control, and AE1350 Introduction to Aerospace Engineering. AE3515 was offered as a PBL course with Dr. Pritchett as instructor-of-record in spring 2012 to 125 students; AE1350 was offered as a PBL course in fall 2012 to two sections, i.e. 98 students (collaboratively with another instructor-of-record, Eric Johnson), and again in fall 2013 to a single section of 48 students. At the same time, Dr. Pritchett was also the instructor-of-record for AE8803 "Teaching Practicum" with 6, 14 and 9 graduate students in each offering, respectively; the latest offering also included students from Mechanical Engineering and Materials Science and Engineering who chose this version of the teaching practicum in seeking the CETL Intermediate Certificate.

The implementation of the course design described above started the first day of classes: groups were randomly formed and, for each, project sites were generated in the university's online learning management system. With this system, group members could share documents and collaborate with each other online. Group sizes ranged from 12-13 undergraduates per tea for the large offering of AE3515 to 5-6 in the smallest offering of AE1350.

Evaluation: Problem-Based Learning in Aerospace Engineering Education

Dr. Pritchett conducted substantial evaluation and documentation of the effectiveness of her approach. The evaluation of a PBL offering started the first day of class as part of the formative assessment enabling agile instruction, i.e., tailoring the instruction to the students, including one-on-one and group tutoring, interim feedback on presentations to guide their subsequent report, etc. The evaluation then continued, even to longitudinal studies that are continuing to monitor how the innovation of PBL offerings of engineering courses impacts their subsequent performance. Thus, the evaluation of this innovation is on-going. It is used to improve subsequent instruction and to support the school's improvement processes (including an upcoming ABET accreditation). Further, the evaluations are now bearing fruit in terms of research papers and presentations to the broader community. As an example of the evaluation, here is a recently published evaluation of the first PBL offering, in a large Fall 2012 section of AE3515 System Dynamics and Automatic Control. Being the first offering, its longitudinal study spans the greatest time and thus was chosen as the example here; subsequent offerings are also being similarly evaluated.

The first result worth noting is that an improvement of roughly half a letter grade in project scores over the semester. For example, the project scores of one of the groups from the first to the last project were 85%, 89%, 88%, and 90%. We attribute this improvement to two main factors: the adjustment of the students to the PBL method, which was new to all of them, and a higher level of understanding of dynamics and controls by the students as the semester progressed. To compare the PBL method with the lecture-based method in terms of final exam scores, four final exam questions were made nearly identical to previous offerings of the course by the same instructor (Amy Pritchett). The scores obtained by the students on these four questions are compared with the previous scores in Table 1. The data shows that the students obtained nearly identical scores with both methods; statistical analysis found no significant difference.

Table 1. Comparison of average scores with the PBL method and with the lecture-based method on near-identical final exam questions.

Question Topic	PBL	Lecture-Based
Definition/application of transfer functions	96.7%	91.8%
Creating a dynamic model	61.0%	55.9%
Root locus methods for controller design	83.2%	84.9%
Frequency responses and Bode plots	71.7%	73.3%

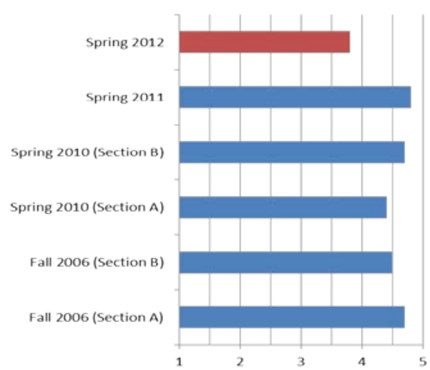

Figure 1. Comparison of Student Responses to the CIOS Question "Considering everything, this was an effective course", ranging from 0 (strongly disagree) to 5 (strongly agree)

Further, subsequent longitudinal analysis tracked the students' final grades in two subsequent classes: both "AE3521 Introduction to Flight Mechanics" and "AE4525 Controls Lab" require this course as a pre-requisite, and build upon its material. Students in this PBL offering of AE3515 were found to later perform significantly better in the subsequent controls lab: the numerical average score in this later class was higher by 0.35 amongst the students who had taken AE3515 as PBL (roughly 1/3 of a letter grade), a significant difference with 95% confidence. Students in this PBL offering of this class were also found to later to perform slightly better in the flight mechanics course: the numerical average score improved by 0.16 which, however, is not statistically significant. Indeed, the score of the students in the PBL section were found to correlate significantly with (i.e. statistically predict) their performance in the subsequent courses; in contrast, student scores in the traditional offering of AE3515 was found to have a weak correlation with subsequent scores in AE3521 and no correlation with subsequent scores in AE4525.

As a separate method of analysis of the efficacy and impact of PBL on teaching system dynamics and automatic control, two different surveys were sent out to the students to gather their opinion on the PBL class. The first one was the standard Course/Instructor Opinion Survey (CIOS) administered Georgia Tech, asking the students to evaluate the class and its instructors. Georgia Tech uses the same survey for every class on campus. It is important to note that this survey was designed with the lecture-based method in mind and, hence, many of its questions are not adequate to gather the opinion of the students on the PBL method. Hence, a second voluntary web-based survey was sent out to the students by the instructor, more pinpointed to analyze their opinion on specific aspects of the PBL method.

The survey revealed a wider spread in the PBL class's ratings than in previous offerings, suggesting that the students' opinion about the class was less homogeneous than before. Examining

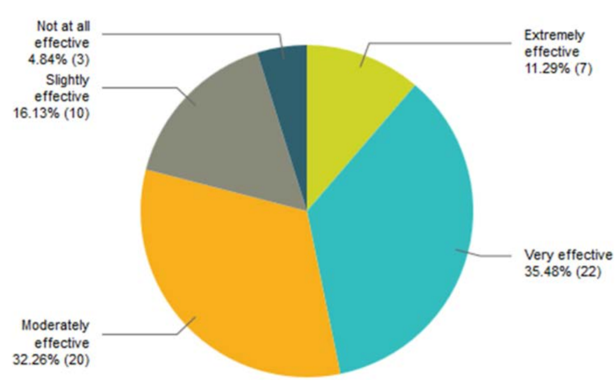

Figure 2: Student responses to the question: "How effective was this course in helping you learn the course content?"

students' ratings relative to the statement: "Considering everything, this was an effective course," they varied from 0 ("strongly disagree") to 5 ("strongly agree"). Thus, this innovation dropped the course/instructor's rating almost 1.0 compared to her previous (lecture-based) offering, as shown in Figure 1. (Note: the instructor's CIOS scores in PBL have increased since then, to a 4.25 in the latest PBL offering; this is still significantly lower than in her lecture-based courses.) Several questions received ratings above 4 (out of 5) by the students including "instructor's enthusiasm" and "instructor's respect and concern for the students." The CIOS also allowed students to provide anonymous free-text responses. The main complaint of the students about the PBL was that it was too hard and required too much work. On previous lecture-based offerings of the same class, that was also the main complaint. With the PBL offering, students also offered free-text comments on PBL. These ranged from the 'for' (paraphrased examples include "I became an engineer with the hope I could learn to solve real-world problems like this " and "This course pushed me in a good way") to the 'against' (paraphrased examples include "I spent a lot of time figuring out what I was supposed to do" and "It's the instructor's job to teach me.")

Figure 3: Student responses to the question: "How effective was this course in helping you attain each of the ABET learning objectives?"

Out of 124 students, 62 answered a second, voluntary, web-based survey administered after one semester by the instructor via SurveyMonkey. The students were asked seven questions. The results of three of those questions are shown in Figures 2, 3 and 4. They reveal that a majority of the students believed that the PBL class was very effective in helping them learn the contents of the class and that, if given a choice in the future between the PBL method and the lecture-based method, they would prefer the PBL method. Further, as shown in Figure 3, the students also noted specific areas not only in the course content (largely ABET objective (a)), but also in several other ABET objectives traditionally described as 'soft-skills' and not listed as learning objectives in the fundamental courses where PBL is being applied as part of this innovation.

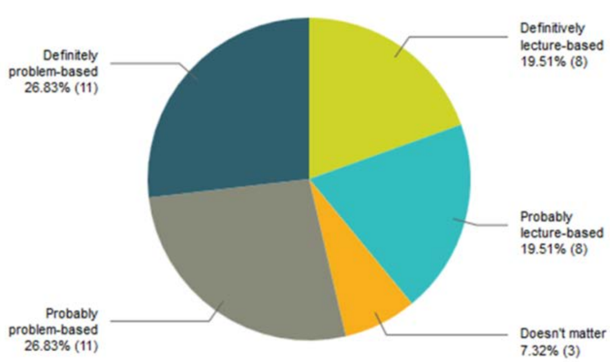

Figure 4: Student responses to the question: "All other things being equal, if you have the option in the future to take [a class in your major] in a section using problem-based learning or in a section using traditional lecture-and-homework format, which would you pick?"

Potential for Broader Implementation: Problem-Based Learning in Aerospace Engineering Education

Prof. Pritchett has shared what she has learned in numerous venues across campus and at national conferences, thereby helping to proliferate understanding and use of the approach among engineering faculty. The innovation itself provides the general template for implementing PBL in engineering courses at Georgia Tech and at other universities where traditional lecture-based instruction is the norm in engineering education. Further, the innovation also provides specific insights gained by implementing it in three different offerings of two different courses, including advice for tailoring the general template to specific courses depending on its course objectives, students, and instructional context. Interest in broader implementation has already been reflected in:

- An invited paper solicited for the 2014 American Control Conference entitled "Applying Problem-Based Learning to Instruction of System Dynamics and Controls"
- An invited presentation to the Georgia Tech Electrical and Computer Engineering Advisory Committee on PBL
- Selection as an NAE Frontiers of Engineering Education fellow, including presenting on the innovation at the 2012 FOEE national workshop.
- Various presentations about PBL on campus at the invitation of CETL, and mentoring of other faculty interested in trying PBL.

These publications/presentations are in addition to those naturally provided within the home school of Aerospace Engineering to the faculty and to the AE advisory committee.

Some of the key take-aways from the implementation and evaluation of this innovation to date relate to the benefits of PBL, highlighting the utility of broader adoption and mirroring the literature with PBL instruction in other domains, or in other institutes traditionally been known for experimenting with novel pedagogy:

- To provide instruction/learning in course content commensurate with, or better than, offerings of the same course using traditional lecture-based instructional methods.
- To uniquely address several ABET criteria in addition to the focus on content in criterion (a) – notably, team-work, life-long learning, problem-solving, design, and use of engineering tools and techniques.

Amy has also compiled an extensive list of other take-aways which are general advice for other instructors in terms of what to expect, which is too voluminous to include here.

Finally, the appropriate resources are also important:

- Good meeting space, where the team can move their desks to face each other and have plenty of white-board space to start working together, is important.
- Groups of 12 or 13 students are too large. Groups of 5, 6 or 7 have been found to be a good size, allowing for a broad, diverse team sized for a project of significant size, but still also allowing each student to have a voice and role within the team without getting 'lost.'
- Only one group should be assigned to each facilitator.
- PBL places an intensive workload on the instructor, including agile instruction and a significant logistics task.
- Applying to a large class PBL requires a significant number of trained facilitators (ideally, a ratio of 1 facilitator for every 7 students). Its effective implementation must be supported not only by the instructor, but by the entire school (support for facilitators). The use of facilitators has the additional side benefit providing undergraduates with a unique level of personal contact and mentoring graduate students to be potential future faculty.
- The facilitators must be carefully selected and trained. Difficulties with English or with the course material (e.g. graduate students coming from a different background) can obstruct effective facilitation; likewise, the facilitators must be genuinely motivated to support the undergraduate students in their PBL group.

The difficulty of finding and compensating facilitators can vary between schools depending on the extent to which graduate students are expected to (or allowed to) participate in teaching as part of their graduate program and/or the funding available to pay graduate facilitators. In this case, the cost of PBL to Aerospace Engineering has been the same as lecture-based instruction in terms of one paid TA per section who, in this case acted as a facilitator. This model actually scales well when multiple sections of the same class are offered as PBL; for example, three sections at different times with three TAs can have each TA facilitate three teams, for a total of nine teams out of a likely eighteen just with that cost model. If those sections were further each halved to span six different class times, still resourced with the same number of instructors and TAs, those same three TAs could cover all the PBL teams.

In the implementation to date in aerospace engineering, unpaid facilitators participated in the Teaching Practicum for credit. The extent to which this model can be scaled up depends on how the school's graduate curriculum encourages or discourages such participation in teaching in general within the graduate program. However, while the tendency is to want more facilitators, some selection criteria is required and they must be carefully trained and themselves mentored, preferably in close collaboration with the PBL instructor.

Vigor Yang
William R. T. Oakes Professor and Chair
School of Aerospace Engineering
Atlanta, Georgia 30332-0150 U.S.A.
PHONE 404.894.3002
FAX 404.894.2760

February 3, 2014

Dear Dr. Weinsheimer,

It indeed gives me great pleasure to strongly recommend Dr. Amy Pritchett for the Curriculum Innovation Award. Prof. Pritchett is the David S. Lewis Associate Professor of Cognitive Engineering in the School of Aerospace Engineering and also holds a joint appointment in the School of Industrial and Systems Engineering. In addition to leading a vibrant research program, Prof. Pritchett has been a courageous innovator in instructional methods. She has been investigating a variety of curricular approaches over the years and this nomination is made for her development, implementation and evaluation of problem based learning (PBL) techniques.

The PBL techniques she has developed focus on extraordinarily important skills including (but not limited to) the ability to design and conduct experiments and analyze/interpret results, ability to function in multidisciplinary teams and the ability to identify, formulate and solve engineering problems. Her approach places a strong emphasis on having students identify information and knowledge needed to address an engineering problem, developing a strong sense of student responsibility for their own learning and developing communication skills.

There are several elements of Prof. Pritchett's contributions that are particularly novel and valuable:

1) Dr. Pritchett has developed a PBL approach designed to be particularly effective for Georgia Tech engineering students. She has done a remarkably careful and thorough job in documenting the learning objectives, assessments and specific educational techniques investigated so that similar techniques can be experimented with by other educators.
2) Dr. Pritchett has demonstrated this approach in two very different Aerospace Engineering courses. The courses are AE 1350 Introduction to Aerospace Engineering, a broad overview course taken by first-year students; and AE 3515 Systems Dynamics and Controls, a much more focused disciplinary course taken by juniors. The maturity level of the students and breadth and depth of material between these two courses is quite different so they make good test cases for her curricular innovation.
3) Dr. Pritchett has done an outstanding job of evaluating and documenting the effectiveness of the PBL techniques in these two courses. She has compared educational outcomes, assessments of similar final exams aggregated by topic and student opinion surveys from students taking the PBL based courses vs. those taking the course using a more traditional educational methodology. Her work is helpful in identifying strengths and weaknesses of the approach for multiple sets of students.
4) Dr. Pritchett is effectively communicating her work and findings at Georgia Tech to the national community of educators. For this particular curricular innovation, she is communicating her results in the following ways:
   - Selected as fellow and the Georgia Tech representative to the National Academy of Engineering (NAE) Frontiers of Engineering Education Symposium. Presented experiences in applying problem based learning in large, content-intensive engineering courses, October 2012.
   - Invited Paper: Applying Problem-Based Learning to Instruction of System Dynamics and Controls, 2014 American Control Conference, Portland, OR, June, 2014.
   - Numerous on-campus presentations on the topic that include (among others):
     - Briefing the CETL Junior Faculty Fellows on Problem-Based Learning
     - Briefing the ECE (External) Advisory Committee
     - Various working groups and panels on problem based learning including the upcoming CETL Celebrating Teaching Day

It should be noted that Dr. Pritchett also conducts a strong research program in Cognitive Engineering, has exercised national leadership as Director of NASA's Aviation Safety Program and has served on several senior executive committees including the OSTP Aeronautic Science and Technology sub-committee. She has won the RTCA William H. Jackson Award, the Collier Trophy as part of CAST, and the AIAA has named a scholarship for her. Professor Pritchett is the Editor in Chief of the Journal of Cognitive Engineering and Decision Making. She is a member of the FAA REDAC and chairs the Human Factors REDAC sub-committee.

In summary, Professor Pritchett is a true leader in her field, with passion and demonstrated skill in educational innovation. Her methodologies have instilled passion and unique skills in our students and her lessons-learned are of value to numerous other educators. I recommend her wholeheartedly for this award.

Sincerely,

Vigor Yang

January 30, 2014

CETL Awards Committee

RE: Nomination of Dr Amy Pritchett for the Curriculum Innovation Award

Dear Committee Members,

It is with pleasure and admiration that I lend my support to the nomination of Dr Amy Pritchett for the CETL Curriculum Innovation Award. I say admiration because the bold and insightful curricular innovations she catalyzed in Aerospace took a great deal of courage. She did not just dip her toe into the waters of curricular innovation, she took a full, confident dive, one I would have been terrified to make, but she had a reason.

During her tenure at NASA as the Director of their Aviation Safety Program, she began to seriously question how students in AE were being educated at GT. She became acutely aware that solving canned, textbook problems ill-prepared them for the complexity of the aerospace industry. She returned to Georgia Tech with a mission—to develop and implement new models for aerospace engineering education. Trained as a cognitive engineer, she appreciated the need to develop innovative educational approaches based on what we know about learning and cognition. Problem-based Learning (PBL) first developed for medical education and based on strong cognitive pillars seemed a logical route to Amy for transforming AE education. She met several times with me and with Donna Llewellyn as she planned for the transformation of perhaps the most notoriously difficult class in the AE curriculum, AE 3515: Systems Dynamics and Control. This is a required class, so she could expect 100+ students. Significantly, it is very quantitative, which added another challenge. There were no PBL models that approached the complexity of the material she intended to introduce and cover. An added complication was the student level—juniors, students well entrenched into the passive mode of “witnessing” a faculty at the board writing equations. Getting student buy-in was going to be hard, compounded by the difficulty and student mythology concerning the class.

Amy knew the course material very well, which helped her transform lectures into problems for teams of eleven, hardly an optimal size. She enlisted graduate students as facilitators, roles none of them had ever assumed. These students knew how to teach, not how to support students learning on their own. Over the term, there were complaining and harassing student emails to Amy and the TAs signifying a generally tumultuous first start. At the same time, certain AE faculty vociferously argued that PBL was totally inappropriate for such a course and actively sabotaged efforts to expand its use in AE. But these grumblings could have easily been predicted and Amy knew it. However, a quote from a complaining student sent at the end of the course sums things up: “In the end, this was the hardest, most stressful, busiest, yet most worthwhile semester I've had at this school. Working on interesting and actually practical problems related to the field revitalized my interest in my major, and that showed in my other courses as well.” In a follow-up analysis of students in the PBL course compared to one taught traditionally, it was found the PBL students did better, without the direct lecture instruction.

Georgia Tech needs more educational pioneers like Amy Pritchett if we are to achieve one of our strategic initiatives: *Enrich the student experience by innovating in instructional methods and course design.* I enthusiastically support her nomination for the CETL Curriculum Innovation Award.

Sincerely,

Wendy C. Newstetter

Georgia Institute of Technology

School of Aerospace Engineering
Atlanta, Georgia 30322-0150 U.S.A.
Phone 404-894-3000
Fax 404-894-2760

February 2, 2014

Selection Committee, Curriculum Innovation Award,

I am writing this letter in support of Prof. Amy Pritchett's nomination for the "Curriculum Innovation Award". Amy has developed 'Problem Based Learning' approaches for two courses: AE 1350, Introduction to Aerospace Engineering and AE 3515, Systems Engineering. These courses represent two extremes of a spectrum. The Intro course is a conceptually simpler course but is focused on the novice, preoccupied with his/her transition from high school to college. The latter is conceptually difficult where GPAs in the lower two's are not uncommon. I am pleased to report that Prof. Pritchett's approach proved successful for both.

One would expect that the 'Problem Based Learning' approach would hone the students' group dynamics and their communication skills. It was, nevertheless, a pleasure to see a freshman giving a presentation with a similar level of confidence and skill as we have become accustomed to from our seniors in, for example, Fluids Lab.

What some of us were worried about was mastery of content. We need not have worried. The students' presentations that I witnessed as part of the evaluation process demonstrated a thorough understanding of the material covered in class. Furthermore, I tracked the students who completed the class in this format and compared their performances in the follow on class (AE 3521 Flight Mechanics) with those who took a regular section of AE3515. Both groups performed comparably in AE 3521 and the grade obtained by individual students in the "Problem Based Learning" section of AE 3515 was a reasonable predictor of their performance in AE 3521.

In summary, I believe that the "Problem Based Learning" approach developed by Dr Pritchett is a valid approach for many aerospace engineering courses. I look forward to further evaluating the outcomes and having Prof Pritchett and some of her colleagues expand the approach to other course materials.

J. Jagoda
Professor and Associate Chair
for Graduate Studies and Research
School of Aerospace Engineering

Parker Vascik
329819 Georgia Tech Station
Atlanta, GA 30332
540.798.3117

December 8, 2013

RECOMMENDATION FOR DR. AMY PRITCHETT

Every college student has had at least one professor who made a profound impact upon their young-adult life. Such a professor may have been an exceptional teacher, a gifted research manager, or even a trusted mentor. I am pleased to write this letter of recommendation for Dr. Amy Pritchett because she was the Georgia Tech professor who far exceeded my expectations and enriched my overall college experience. Dr. Pritchett inspired me to think outside the box, take hold of my education, and pursue a career that utilized my talents and passions not only to earn a living, but also to contribute something to the public and scientific communities.

I first came to know Dr. Pritchett through my enrollment in her undergraduate "System Dynamics and Automatic Control" aerospace engineering class in Spring 2012. This class was Dr. Pritchett's first attempt to utilize "problem-based learning" as an advanced method to instill real world research skills and system dynamics capabilities in students. I found myself, like many of my friends, a little concerned about enrolling in a class with a radically different structure from the lecture style coursework we had become accustomed to. However, we soon realized that the challenge of multi-week problems, coupled with the guidance and support of the graduate teaching assistants and Dr. Pritchett herself, was a more effective method to learn and retain the core material of the class. At the end of the course, we (the students) found ourselves with excellent case examples of projects, challenges, and self-guided research to share with potential employers. Additionally, we also felt better prepared for our senior design research and design as a result of the problem based learning approach.

Since completing her class, I have followed Dr. Pritchett's efforts to expand the problem-based learning approach to additional aerospace courses. Many of my fellow students were asked to support her presentations to the department faculty and administration and I found myself in discussions with other professors concerning my impressions of the course. I also took the liberty to sit in on one of Dr. Pritchett's problem-based "Introduction to Aerospace Engineering" classes in Spring 2013. First-year students in Intro to AE often feel as if they are drinking from a fire hose of technical information but not getting a good feel for what an aerospace engineer does as a career. When I watched the students respond to Dr. Pritchett's lecture and ask questions about their team projects, I recognized how effective the problem based learning approach was for this introductory class. The students were prompted by their problem to conduct research into various aspects of the aerospace industry. Additionally, due to the class structure and Dr. Pritchett's approachability, even the first semester students felt comfortable discussing problems with the professor and building a positive working relationship.

In addition to Dr. Pritchett's drive to bring problem-based learning into Tech's aerospace classrooms, she is also an excellent lecturer in the traditional sense of the word. I distinctly remember a lecture in system dynamics when Dr. Pritchett brought a multi-yard ruler to class, stood on the lab table in the front of the classroom to command the students' attentions, and then proceeded to visibly demonstrate the concepts of wave propagation and modes while relating the demonstration to forcing functions and equations displayed on the screens behind her. Dr. Pritchett's ingenuity in presenting complex material and willingness to step outside the traditional bounds to engage students contributes to her excellence as a professor.

Perhaps her most stand-out feature, Dr. Pritchett epitomizes the concept of a professor being a "friend of the student." Her office was so frequently visited during office hours that she periodically gave impromptu "mini-lectures" on concepts multiple students had issues with. Going above and beyond, Dr. Pritchett also would visit each project team during their "lab" sessions to discuss how their project was going, any problems they were experiencing, or just to gain feedback and ideas for the course in general. From a student perspective, these visits made Dr. Pritchett feel accessible and "on my side" as a professor who was honestly looking for the best way to instruct the core competencies of the class.

Finally, Dr. Pritchett's dedication to students extends far beyond her course roster. Although I enrolled in her systems class two years ago, Dr. Pritchett has continued to act as a mentor and resource for my schooling and research. During my capstone course Dr. Pritchett took the time to advise my team on how to conduct an effective international consumer survey to appropriate capture this stakeholder. I have sought her advice and support for career planning, graduate school applications, and even summer internship placement. In each case Dr. Pritchett was willing to set up a time to meet with me and often times went above and beyond to support my dreams by any means she could.

In my opinion Dr. Pritchett is an excellent candidate for the Eichholz Faculty Teaching Award. She has an excellence of character and passion for her work which has inspired me to dream bigger in my own academic and career plans. Dr. Pritchett's efforts to utilize problem-based learning in introductory and core aerospace classes symbolize her care for Georgia Tech. I believe she has made significant first steps to evolve the school's programs to meet the needs of a changing higher education environment. If I can answer any questions or be of further support, please feel free to contact me.

Sincerely,

Parker Vascik

Parker D. Vascik
Aerospace Engineering, Georgia Institute of Technology
NASA Aeronautics Scholar

To Whom It May Concern,

It is my sincere pleasure to author this letter in support of Dr. Amy Pritchett's nomination. As a former student of hers, I can say without hesitation that Dr. Pritchett is the best professor I had during my tenure at Georgia Tech. Now, every student has a "best" or "favorite" professor, each with their own reasons for their loyalty. Having worked in different offices throughout my time at Tech, I had the opportunity to meet almost every professor at Georgia Tech. Dr. Amy Pritchett surpasses each of them in my mind and I hope that after reading this, she will hold the same position of respect in your mind as well.

I met Dr. Pritchett as my professor for what is arguably one of the most difficult classes in Georgia Tech's Aerospace program – System Dynamics and Linear Control. Dr. Pritchett strode into the classroom and began vibrantly expounding not about herself, but about her students (us) whom she had already taken the time to learn something about – before day one! Her enthusiasm for teaching is infectious. I had walked into the classroom expecting a typical four and a half hours per week of lecture with regular homework assignments. Instead, I enjoyed an hour of vibrant intellectual discussion before she threw a curve ball our way. This would not be a "normal" class. Instead, she had discussed and deliberated behind the scenes to be permitted as the first class in Georgia Tech's Aerospace department to be taught as a problem-based learning course.

While the students (including myself) were initially skeptical and frankly, horrified, at the volume of work expected from this instruction method, her enthusiasm and energy drove the students to at least give it a trial run. For me and many other students, this innovative teaching paradigm proved to be the perfect solution. Dr. Pritchett ran the course superbly with stellar organization and constant encouragement to perform to the limits. Her constructive criticism helped the students to comprehend and surpass their errors rather than feel that they were being torn down. Additionally, the regular lectures sealed our appreciation of her skills as an orator, instructor, and mentor to every student in her one-hundred and eighty person class. Dr. Pritchett made the time to meet with each student and each group individually to assist us as needed, and as a result, what was traditionally the most difficult course in Aerospace engineering became one of the most intuitive.

System Dynamics and Linear Control is a course that has a historical record of failing more students than any other Aerospace course. This is true to the degree that, as an "A/B" student, I would have been thrilled to walk out of that class with a low "C." The fail/drop rate of the class was historically greater than forty percent. Dr. Pritchett deemed this unacceptable and worked purposefully to change that number. I finished my class with a high "A." So did 30% of the class. Only 20% failed. Dr. Pritchett sought to make a change that would last – she took the initiative and made a difference. Her students went on to succeed in the next class in the series and graduate from Georgia Tech with high marks.

For me, the motivation to finish strong came from Dr. Pritchett. Her motive force and sheer enthusiasm helped push me along even after I left her class. I received more "A" grades at Georgia Tech after her course than I had in the three years prior. I credit Amy Pritchett with the rejuvenation of my academic spirit more than any other event in my Tech career.

Am I biased? Probably. Do I feel that my reasons are sound? Without a doubt. It is my sincere belief that Dr. Amy Pritchett provided me my greatest impetus to succeed at Georgia Tech. I hope that after reading this letter, she has claimed your loyalty and respect as well. If not, drop by her office any day – she will be happy to share her enthusiasm for education in person and hopefully, push you to greatness.

Sincerely,

Michael A. Hodgson

Michael J Hodgson
Simulation and Software Engineering
Gulfstream Aerospace Corporation
Georgia Tech Aerospace Engineering, 2013

January 2, 2014

Dear Selection Committee;

When I entered Dr. Amy Pritchett's Introduction to Aerospace class (AE 1350) in the Fall 2012, I expected the normal, lecture based introductory course. Much to the surprise of the entire class, we were quickly sorted into groups and told that the class would be project based. In fact there would be no class, but only facilitated group meetings and final presentations. The only given lectures would have to be specifically requested. Needless to say, the 50 freshman had no idea what was about to happen.

However, through the semester, I watched in awe as Dr. Pritchett pushed my peers and me to new heights. We were applying the information from our introductory textbook to current, real world problems. When our textbook didn't have enough information, we found the need information in 4000 level textbooks, recent journals, and industry data sheets. In fact, we watched as the projects we were simulating became headline news.

Implementation of a problem based curriculum is not easy; studies show that educators spend 100+ hours preparing for such a class. Dr. Pritchett has now spent years tweaking curriculum to best serve her students. When speaking to her about problem-based classes, she can easily speak on the progress of every group of students, the problems they have faced, how she has worked to help.

Ultimately, my peers and I left her class with a thorough introduction to aerospace engineering. The class also encouraged us to form personal connections through the aerospace department. My peers and I entered the class with drastically different levels of knowledge, but soon learned each other's strengths and weaknesses. This allowed us to teach each other the material. We learned how to break up a problem into pieces and synthesis them back to a final solution.

Two specific instances from the class remind me of Dr. Pritchett's impact. First, I remember specifically visiting Dr. Pritchett's office hours and spending 45 minutes in her office. We discussed the class technically and logistically, but she also answered my questions about her research, the aerospace department, and gave me sincere advice that has guided me since. Second, at our final presentation, I remember my group being able to intellectually discuss orbital mechanics with a NASA Fellowship recipient after our presentation. This was significant because it was an amazing chance for us to develop meaningful work and discuss it with those more versed in the material but who nonetheless listened and respected our work.

Dr. Pritchett's class left me prepared academically for Georgia Tech. She prepared me to work in groups professionally. And she has since served as a mentor whom I know I can turn to.

Sincerely,

Christine Gebara

Christine Gebara
Aerospace Engineering Student
Georgia Institute of Technology
Christine.Gebara@gatech.edu

A few weeks before the beginning of the spring semester of 2012, I received an email from Dr. Pritchett offering the opportunity for any interested graduate students to participate in a *Teaching Practicum*. Dr. Pritchett was working with specialists in the learning sciences and higher education to apply novel teaching methods to the instruction of the core undergraduate course *AE3515 System Dynamics and Automatic Control*. Her idea was to apply for the first time *Problem-Based Learning*, a very successful teaching method in the health sciences, to aerospace engineering and to this course in particular. *Problem-Based Learning* includes project teams guided by *facilitators*. Dr. Pritchett's was offering the opportunity for graduate students to be facilitators as part of an optional graduate course *AE8000 Teaching Practicum*. The facilitators would have to monitor these project teams, probe them to learn problem solving skills and think problems through, and potentially help with lectures and recitations. In return, the facilitators would have direct supervision and mentoring from Dr. Pritchett and other experts in higher education in teaching methods on an almost daily basis. Wanting to learn more about a career in academia, I decided this opportunity was right for me and applied.

When I first met Dr. Pritchett in person in preparation for the upcoming course, my first impression was that she was an extremely kind and intelligent person. She was trying a new strategy that was never tried in aerospace engineering. There were no manuals or instructions on how to accomplish this, but she was determined to improve the way this course was taught and, most importantly, to make sure the undergraduate students would be better prepared for the real world. At the same time, she wanted to challenge us, facilitators, to experience the other side of the class room, its difficulties and challenges, and to motivate us to a possible career in higher education.

Throughout the semester, Dr. Pritchett divided herself between the different project teams, making sure they were getting the new teaching method and the course material, and the graduate facilitators, making sure they were not overwhelmed by this new teaching experience. Although *Problem-Based Learning* did not require Dr. Pritchett to lecture multiple times a week like in a typical lecture-based class, she gave a lot more of her time to this class than she would have to give had she taught it in the traditional way. She was always available, even after office hours, to answer any questions the undergraduate students and graduate facilitators may have.

My experience as a facilitator in Dr. Pritchett's class was very motivating. After her class, I have volunteered to assist teaching two other classes. Moreover, I had the opportunity to write a conference paper about this experience and the lessons learned that is currently being reviewed. As for the undergraduate students, a survey showed that a majority of them believe that the *Problem-Based Learning* class was very effective in helping them learn the contents of the class and that, given a choice in the future between the *Problem-Based Learning* method and the lecture-based method, they would prefer the *Problem-Based Learning* method.

Dr. Pritchett is a rare case of someone thinking outside the box and pushing the limits of higher education. She is truly committed to her students and she goes the extra mile to guarantee their success inside and outside the classroom. For this, I believe Dr. Pritchett deserves a teaching award.

Nuno Ricardo Salgueiro Filipe
Ph.D. candidate
School of Aerospace Engineering
Georgia Tech ID: 902765971