FINAL REPORT FOR BENTLY CENTER AWARD (2016-2017)

Awardee
Stephen M. Klisch, Professor, Mechanical Engineering, sklisch@calpoly.edu

Award
24 units (6 in 2016 Summer quarter, 8 in 2016 Fall quarter, 5 in 2017 Winter quarter, 5 in 2017 Spring quarter)

Summary of Accomplishments
As stated in the original proposal, the primary objectives of the assigned time were: “to maintain momentum in establishing Cal Poly’s Human Motion Biomechanics (HMB) Lab and ... to serve as an effective and conscientious steward of the Bently endowment”. Most of my supported time was spent in three areas: 1) working with 21 Cal Poly students, 4 visiting scholars, and 3 high school students conducting research on funded proposals; 2) launching the HMB Lab Diversity Program; and 3) serving as Director of the Bently Center.

During the period of support, my primary activities included 1) mentoring students as they submitted 4 conference papers and prepared related presentations for the 2017 Summer Biomechanics, Bioengineering, and Biotransport Conference (June 21-24, 2017, Tucson, AZ), 2) mentoring students as they submitted 1 conference paper for the 2017 Annual Meeting of the Biomedical Engineering Society (October 11-14, 2017, Phoenix, AZ), 3) mentoring students as they further developed experimental and analysis protocols and conducted motion analysis studies of gait, cycling, elliptical training, and baseball pitching for our funded research projects, 4) preparing IRB protocols for several research projects, 5) submitting a peer-reviewed journal paper based on M.S. thesis research, and 6) performing administrative tasks related to my positions as HMB Lab and Bently Center Directors.

Publications and other Deliverables (students in bold)
Peer-reviewed conference papers
Peer-reviewed journal papers

Miscellaneous presentations / activities
3. Klisch SM. Executive Board Member. *Cal Poly’s Center for Obesity Research, Sep 2016 - present.*

Student Impact
**Supervision of Cal Poly M.S. students**

**Supervision of Cal Poly B.S. students**
1. Daniel Montoya (ME, BS research, Fall 2015-Spring 2017).
2. Greg Orekhov (ME, BS research, Fall 2015-present).
3. Nina Yadlowsky (ME, BS research, Winter 2016-Fall 2016).
5. Greg Lane (ME, BS research, Winter 2016-present).
6. Jordan Skaro (ME, BS research, Spring 2016-present).
7. Katherine Mavrommati (BMED, BS research, Spring 2016-present).
8. Megan Pottinger (BMED, BS research, Spring 2016-present).
9. Sam Tucker (ME, BS research, Spring 2016-present).
10. Kathleen Balfour (BMED, BS research, Spring 2016-Fall 2016).
11. Elizabeth Heyde (BMED, BS research, Spring 2017-present)
12. Emily Hubbard (BMED, BS research, Spring 2017-present)
13. Jay Sterner (ME, BS research, Spring 2017-present)
14. Jonathon Stearns (ME, BS research, Spring 2017-present)
15. Emily Vassilev (BMED, BS research, Spring 2017-present)
Supervision of non-Cal Poly student projects
2. Fabio Angeloni (ME, University of Bergamo, Italy, Summer-Fall 2016)
3. Valentina Profiti (ME, Polytechnic University of Torino, Spring-Summer 2017)
4. Chiara Marino (ME, Polytechnic University of Torino, Spring-Summer 2017)
7. Lindsey MacLeod (SLO High School, Summer 2017).

Proposals and other Leverage
Active awards during the period of support (external awards only: other grants funded by STRIDE and CENG R-IDC)
1. National 4-H Council via The Regents of the University of California. (PI Klisch)
   5/1/17-10/31/17; $10,969 (direct costs). Title: 4-H Career Readiness Pathway: HMB Lab Diversity Initiative. Aims: To expose three 4-H members who are in high school and are female and/or Latino to science & engineering through an "immersion style" approach in Cal Poly’s Human Motion Biomechanics Lab. Status: submitted Mar 2017; awarded Jun 2017.

2. W.M. Keck Foundation – Undergraduate Education Program, Phase II Application. (PI Klisch, co-PIs Self, Hazelwood, Clark, Taylor)
   1/1/16-6/30/19; $350,000 (direct costs only)
   Title: Human Motion Biomechanics lab: Integrating research and education in an interdisciplinary setting. Aims: To 1) engage an interdisciplinary team of students in targeted biomechanics research, 2) develop an interdisciplinary undergraduate course to engage students in biomechanics research, and 3) develop inductive learning modules in several existing courses. Status: awarded Jan 2016.

3. US Army Medical Research and Materiel Command (AMRMC). (PI Klisch, co-PIs Hazelwood, Self)
   3/15/16-3/14/19; $513,645 (total costs)
   Title: Joint loads and cartilage stresses in intact joints of military transtibial amputees. Aims: To investigate the effects of select exercises, for both short-term rehabilitation and long-term fitness sustainment, on joint loads and cartilage stresses for transtibial amputees. Status: awarded Jan 2016.

4. CSU Program for Education and Research in Biotechnology (CSUPERB). (PI Klisch, co-PI Hazelwood)
   6/1/15-11/30/16; $15,000 (total costs)
   Title: Experimental and computational analyses of joint and tissue loading in ACL reconstructed and contralateral knees. Aims: To 1) conduct EMG-driven inverse dynamic analyses of motion analysis experiments to estimate joint loading in ACL reconstructed and contralateral knees during exercise and 2) use whole joint finite element models to estimate cartilage tissue loading in ACL reconstructed and contralateral knees during exercise. Status: awarded May 2015.
Awardee  
Xi Wu, Professor, Mechanical Engineering, xwu@calpoly.edu

Award  
Total 12 WTUs: 7 WTUs in Fall 2016, and 5 WTUs in Winter 2017.

Summary of Accomplishments  
During 2016-2017 academic year, my research focused on rotor dynamics, building new independent Data Acquisition cards for Bently rotor kits in vibration lab, Active Magnetic Bearing (AMB) and planetary gear design analysis for wind turbine. Most of my supported time was spent in the following areas and activities:

(1). Rotor Dynamics Research and Journal Publication. I am doing sophisticated rotor dynamics research and have successfully generated the cascade full spectrums directly from either X, Y transducers or simulation results. Then, we have applied our research to overhung rotor system and achieved very good results, which have been published in “Journal of Applied Mechanical Engineering”. We have not found similar publication yet. Several faculties and students are actively engaged into this outstanding research. This paper demonstrates the methodology and usefulness of full spectrum analysis on theoretical models and experimental measurements. This method establishes another bridge between model and data that is not currently being used to its greatest advantage. Some experimental devices display full spectrum vibration signals but most often half spectrum is reported. Correlating analytical models with experimental data using full spectrum analysis is similarly underutilized. In this paper, 3D full spectrum plots from x and y signals (from either experimental or theoretical results) are shown to match very well with the plots generated by experimental ADRE software. Tracking filters are used to isolate synchronous and non-synchronous vibration and allow for accurate phase angle measurement. The strategy developed by this paper can accurately convert the math angle from theoretical model to experimental instrumentation phase angle. Then we draw direct comparison of experimental results of a flexible overhung rotor with theoretical results to estimate unknown system parameters such as bearing stiffness and skew angle due to the gyroscopic effect. Finally, our paper provides other significant results such as 3D orbit plots. The tools developed here directly connect the experiment to the theoretical model and can be used to verify theoretical models with greater confidence.

(2). New Independent Data Acquisition Cards in Vibration Lab. I submitted a proposal entitled “Replacing ADRE208 for Rotor Kits in Vibration Lab” to Laboratory and Facilities Committee on January of 2017. I was awarded $8,205 to update the outdated data acquisition system ADRE208 used with the Bently rotor kits in the vibration lab. Based on our published research listed above, we propose have successfully built our own post-process data acquisition system in MATLAB using much cheaper DAQ card from National Instruments. Our new DAQ system are unique high-quality performance with cheap price. We believe many engineers in industry will be interested in it. We use the DAQ cards from National Instruments which only cost around $1,700 for each rotor kit. Compared with $50,000 each for ADRE408, we will save a
lot of money. Furthermore, MATLAB is used to serve as the interface on a desktop PC to the DAQ card. By using MATLAB, we can produce the same plots that ADRE408 produces. Furthermore, with our own software, we have the ability of adding more post-processing ability (such as wavelet or 3D orbit plots). The effectiveness of our system should be equivalent to that of the ADRE408. Similar data acquisition rates, number of channels and display of data. Students have the opportunity to learn signal processing techniques in both hardware and software domains. All of the ME undergraduate students and some graduate students will benefit from those new DAQ cards, since ME318 is a required class. Most importantly, this provides an opportunity to really apply the “Learn by Doing” motto of our school. Not only does this opportunity provide a “learn by doing” experience through the design and construction, but it could also provide the same to students to come who use the system in a classroom setting. A custom data acquisition system would foster a more immersive learning environment for students of the ME 318 Vibrations course lab and the ME 518 Rotordynamics lab. Students would learn how the data is acquired and what post processing operations are applied using MATLAB.

The most challenge part of this project is to figure out how to create post-processing plots from vertical and horizontal transducers. Currently, we have successfully solved the following 4 problems: (1). Construction of 3D full spectrum cascade plots using complex FFT through MATLAB programing. (2). Use of tracking windows to filter the transducer data to nX components of rotor speed when the rotor starts up or runs down. (3). Experimental comparison of our results with ADRE data. The results are directly comparable and the MATLAB plots, using our method, provide opportunity of further post processing full spectrum data. (4). Theoretical results of overhung rotor are converted into 3D full spectrum plots which match very well with experimental data with confidence.

(3). Magnetic bearing controller design and FEA analysis. The following Active Magnetic Bearing (AMB) has been successfully manufactured and installed with Bently rotor kit. Two graduate students focused on controller design of AMB and Finite Element Analysis of the whole combination of AMB and rotor kits. Magnetic bearing technology combines the knowledge of control systems and vibrations together. We already wrote MATLAB FEA codes for rotor systems with magnetic bearings. Some of the simulation results are successfully validated with the journal publications. The real-time controllers work properly for the magnetic bearings using Labview software. Active magnetic forces have been successfully applied to the rotor kits. Our significant results will be published in near future. Having a bearing in the lab
would provide immense learning opportunities and will surely bolster our curriculum as a whole. Research into magnetic bearings and testing on this bearing will provide ample material for many research papers to come and possible external funding.

(4). **Planetary gear design and analysis for Wind Turbine Nordex90.** In history, wind turbines have experienced premature component failures, which consequently rise the cost of energy. The majority of these failures are caused by cracks in planetary gearbox un-monitored. I continued my research on health monitoring of planetary gears. 3-stage gear drivetrain from Nordex N90, very popular industrial used wind turbines, has been modeled. Modeling parameters have been derived from input and output speed data from Nordex. The input speed to the transmission ranges from 9.6 to 16.8 RPM. The output speed to the generator spans a speed range of 740 to 1300 RPM. This gives an overall gear reduction ratio of 77.38 to 1. The model is practical wind turbine currently used in industry. We have used the combination of ADAMS and new FEA software Patran/Nastran to make the gear models more realistic to identify vibration signatures of damaged gearing system. Several important parameters such as the stiffness, force exponent, penetration depth, and damping coefficients are carefully chosen based on practical modeling experience. Constraints, bearing resistant torques, and some key parameters are applied to emulate realistic operation conditions. Comprehensive frequency-domain analysis of dynamic contact forces will reveal unique vibration spectra called modulated sidebands, at distinct frequencies around the stage mesh frequencies, and sub- and super- synchronous frequencies. These spectral lines comprise a substantial portion of the vibration and are closely related to the complicated nonlinear dynamics induced by the interaction between backlash and damaged teeth at different locations on different components of the transmission system. The results may serve as the useful fault indicators of the planetary gears.
Publications and other Deliverables (students in bold)

Peer-reviewed journal paper

Student Impact

Supervision of Cal Poly Graduate Students
1. Cameron Naugle (ME, MS research, Fall 2015-present).
2. Pedro Rivera (ME, MS research, Fall 2015-present).
3. David Baker (ME, MS research, Spring 2017-present)
4. Gordan Bradaric (ME, MS research, Spring 2017-present)
5. Benny Morris (ME, MS research, Winter 2017-present)
6. Gregory Pellegrino (ME, MS research, Spring 2017-present)
7. Tananant Boonya-ananta (ME, MS research, Spring 2017-present)

Proposals and other Leverage

Proposal submitted during the period of support
1. Proposal for Laboratory and Facilities Proposal of California State Fund
   Awarded on May 2017. Total of $8,205
   Title: “Replacing ADRE208 for Rotor Kits in Vibration Lab”

2. Proposal for Bently Nevada GE Oil & Gas Measurement & Control, GE
   Title: “Requesting Donation of the SCOUT220-IS Device and Other Unused Equipment”
   (Submitted), the total equipment will be worthy of more than $30,000.
FINAL REPORT FOR BENTLY CENTER AWARD (2016-2017)

Awardee
John Chen, Professor, Mechanical Engineering, jchen24@calpoly.edu

Award
Twelve (12) units awarded for two projects (three (3) in 2016 Summer quarter, nine (9) in 2017 Winter quarter)

Summary of Accomplishments
Project 1: Grit and Student Success
There is growing awareness that innate talent – i.e., IQ or intelligence – is neither the only nor the most important trait for predicting future success or a wide range of achievement outcomes in adults or younger populations from adolescents to university students. Many traits not directly related to knowledge acquisition have been shown conclusively to have a significant impact, including grit, the subject of this project. Recent research by psychologists studying grit has led them to theorize that the essential elements for developing grit are (1) a growth mindset and (2) deliberate practice. Growth mindset is the belief that intelligence is malleable, rather than being a fixed quantity. Its suspected role in enabling grit growth comes from data demonstrating that children with a growth mindset persevere through failures and setbacks while those with the opposite belief (fixed mindset) see these as evidence of their lack of innate talent or ability, which leads to their giving up when faced with a challenge or setback. Deliberate practice, which has been extensively studied for several decades, is firmly established as the predominant factor leading to expert performance in a wide range of domains, including scientific research, chess, creative arts and sports.

The specific aims of this project for the 2016-17 funding cycle are to:
1. Develop out-of-class learning activities that are aligned with deliberate practice;
2. Deploy the activities with a cohort of mechanical engineering students as they study along the mechanics sequence in the mechanical engineering curriculum;
3. Develop brief mindset interventions that will be integrated into the above learning activities; and
4. Measure the association between the level of learning engagement, mindset belief and grit among the students in the study.

All of the aims were achieved for this project in the past year. Forty-two mechanical engineering students who were enrolled in ME 211 (statics) in fall 2016 were recruited into the study, which will last for approximately the next two years as they progress through the curriculum. (A second cohort of approximate 40 students will be recruited in fall 2017 to complete the study population.) Out-of-class learning activities were study sessions for ME 211 (statics) led by me, and for ME 212 (Dynamics) led by two faculty members, Charles Birdsong and Jim Widmann in the winter 2017 quarter. A mindset workshop was developed and delivered by Jim Widmann in the fall quarter, and our current plan is to convert this to an online activity to accommodate future study participants, who will likely also have difficulty meeting with us in person for this intervention. Finally, the study participants have been taking data through a smartphone app to track their active learning experience, which is a proxy for deliberate practice, in addition to completing surveys to measure grit and other traits of interest.
Project 2: Nondestructive Testing of Carbon Fiber Composites

In the years 2011-2013, research assistant Luz Gomez, Joe Mello and I developed and patented a novel technique to create actual delaminations in carbon fiber-reinforced polymers (CFRP). We refer to such creations as “designed defects” since the technique can be used to create an actual delamination of any shape or size and, in theory, the defect can be built into any final product. This project had two goals related to the patent: to improve the process by shortening production time and to publicize the superiority of our delamination proxy to the research and material-inspection communities.

In the fall of 2016, the awarding of a third grant related to our work on studying student success and non-cognitive traits (see listing below under Proposals and Other Leverage) forced me to scale back the scope of this project. I decided to focus on the sole goal of publicizing the patent through focused research on both the experiment and the supporting finite-element modeling (FEM) of the nondestructive testing process. To achieve this goal, I engaged a three-person senior project team to develop an active-cooling system to improve the testing technique, and further hired one of the team members to separately develop the FEM. The senior project team will complete its work this December and the project looks to be a success with the delivery of the cooling system. The student/research assistant doing the FEM has completed the first stage of the model, which involves development of an Abaqus model of a flat-plate CFRP and fitting the thermophysical parameters to previously gathered experimental data. He is further considering staying with this project and making it his M.S. thesis to be completed in the coming year.

Publications and other Deliverables (students in bold)

Peer-reviewed conference papers

Peer-reviewed journal papers

Reports

Student Impact

Supervision of student projects
1. Evard, A., Giffoni, G., and Johnson, D. (Senior Project team; Department of Mechanical Engineering; project period: January 2017-December 2017).
Proposals and other Leverage

*Active awards during the period of support*

1. National Science Foundation (PI: John Chen; co-PIs: David Janzen (CS), Karen McGaughey (Statistics), Jennifer Teramoto Pedrotti (Psychology), and Jim Widmann (ME))
   10/1/2014 – 9/30/2017; $199,991
   **Title:** Actively Building the Drive to Achieve through Everyday Engineering Learning.
   **Aims:** This project is investigating the role of active learning in building grit through a longitudinal observational research design. As a result of their natural progression through the curricula, students have widely varying experiences along the active-learning continuum, from low quantity and quality, to high. This highly diverse engineering-learning ecology presents a unique opportunity to study the association between active learning and grit growth. This project is developing a smartphone application (“app”) for participants to measure the quantity and quality of active learning they experience. These data, along with extensive measures of other psychological traits and student achievement, are elements of a model that will clarify the relationship between active learning, grit growth and student achievement. This study is seeking to improve the retention and graduation rates of all STEM students, which in itself is a societal benefit with implications for the nation’s well-being. Furthermore, because women and underrepresented minorities leave STEM majors at disproportionately higher rates, improvements in retention and graduation for these groups will positively impact the makeup of the STEM workforce.
   **Status:** Active; funded through 9/30/2018 (with one-year no-cost extension).

2. National Science Foundation (PI: John Chen; co-PIs: David Janzen (CS), Karen McGaughey (Statistics), Jennifer Teramoto Pedrotti (Psychology), and Jim Widmann (ME))
   6/15/2016 – 6/14/2019; $499,275
   **Title:** Does Active Learning Build Grit?
   **Aims:** Grit, which is defined as unwavering interest in and perseverance for a long-term goal, is likely to be important to individuals trying to achieve the challenging, long-term goal of attaining an engineering degree. This study is seeking to quantify the importance of this non-cognitive trait on student success. One objective of this project is to determine if active learning, which acts as a proxy for deliberate practice, builds the character trait of grit among engineering students while they learn in a sequence of engineering mechanics courses. A second research question is whether increased grit leads to other success outcomes such as retention in the major and progress toward degree. These questions are being investigated through a direct intervention that includes intensive, peer-based, active-learning experiences, along with activities designed to boost optimism and endorsement of growth mindset. A control group is also undertaking learning activities to improve its mechanics learning, but in ways that do not meet the definition of deliberate practice, which is theorized to be a path to building grit. The ultimate goal of this project is to improve the retention and graduation rates of all STEM students, which in itself is a societal benefit with implications for the nation’s future well-being.
   **Status:** Active; funded through 6/14/2019.

3. National Science Foundation (PI: Jim Widmann; co-PIs: John Chen, Brian Self)
   10/1/2016 – 9/30/2020; $479,337
**Title:** IUSE:EHR: Collaborative Research: The Role of Non-Cognitive and Affective (NCA) Factors in Engineering and Computing Student Academic Performance

**Aims:** This collaborative project between Cal Poly, Purdue University and University of Texas, El Paso, seeks to measure the non-cognitive profile of engineering and computing students across the U.S. through a nationally distributed survey. The survey measures latent factors of personality, community, grit, thriving, identity, mindset, motivation, perceptions of faculty caring, stress, gratitude, self-control, mindfulness, and belongingness which are representative of multifaceted aspects of success in prior literature. Furthermore, the survey data from the three partner institutions will be matched with students’ transcripts and student behavior data so that a model of student success, defined broadly, can be developed. Once completed, the model will highlight those factors that have the highest impact on student success, and our goal is to develop and test interventions to improve those factors.

**Status:** Active; funded through 9/30/2020.

4. **Cal Poly College of Engineering, Summer Undergraduate Research Program** (PI: John Chen)
   5/31/2017-8/30/2017; $4,000

**Title:** Designed Defects in Carbon Fiber Composites

**Aims:** Undergraduate student Dallas Johnson will conduct the numerical simulations of heat transfer within a flat plate carbon fiber composite sample. Dallas has already built a simplified heat transfer model of a CFRP sample with a single defect. He has done this within Abaqus, a widely used software for finite element analysis. For this summer, he will refine the model to include a series of defects, which simulates experiments that will be conducted in the laboratory, and explore methods to make the model run more efficiently.

**Status:** Inactive; project completed.

*Proposals submitted during the period of support*

1. See #4 above.
Awardee
Peter Schuster, Professor, Mechanical Engineering, pschuste@calpoly.edu
John Ridgely, Professor, Mechanical Engineering, jridgely@calpoly.edu

Award
6 units (3 units each in 2017 Summer quarter)

Summary of Accomplishments
The primary goal of this project was to convert the lecture content of ME 428 (first quarter of senior project) into online content (using the Flipped Classroom model) for delivery throughout the three quarters of the course sequence. In 2015, the ME department voted to convert the lecture unit from the first quarter of senior project into a lab unit in the final quarter, changing the student unit count for the three quarters from 3-2-1 units to 2-2-2 to better reflect the workload in the course. As a result, the content previously delivered to the students through lectures must be presented in a different format. An additional challenge of the effort was that the new format was intended to be used by all faculty teaching senior project labs for the foreseeable future. The focus was on creating robust, usable content for a variety of users.

Although the original proposal was for five units each for Jim Widmann and Peter Schuster, the award was for a reduced three units each. After Dr. Widmann became department chair, John Ridgely took his place on this project with the approval of the Bently Center director. Due to the reduction in units, the full set of course material was not developed during summer 2017. Instead, the focus over the summer was to define the course learning modules and then develop the full suite of content required for the first several weeks of the course; skeletal content was developed for the rest of the course. Incorporating faculty and student feedback with the early content, the delivery approach is now being adapted for the rest of the material. Our goal is to have the full content of the course completed during Fall quarter 2017, with each module ready at least 1-2 weeks before it is needed by our students.

Publications and other Deliverables

Overall Course Improvements
1. Reformatted lecture material from the course into learning modules to be covered on a specified schedule
2. Developed consistent layout and scope of materials for each module
3. Integrated modules into PolyLearn site for Senior project course

Content Implemented for First Three Weeks of the Course
1. Located, reviewed, and embedded relevant reading and video content
2. Developed new short videos as necessary to support the linked content
3. Developed and implemented PolyLearn quizzes on the reading & videos
4. Created PolyLearn Assignments for all team deliverables
5. Updated lab presentations to build on online content
Student Impact

Impact of Changes on Students

1. All ME students will use this course material during their senior year.
2. The online content will ensure consistency across a variety of projects and faculty advisors
Awardee
Patrick Lemieux, Professor, Mechanical Engineering, plemieux@calpoly.edu

Award
6 units (6 in Spring Quarter of 2017)

Summary of Accomplishments
The original proposal, titled “The Future of Alternative Energy”, proposed a plan of research focused on three main points:

1) seeking support to develop a new type of monitoring system for distributed wind turbines, one that is capable of providing warnings of impending malfunction, before such malfunctions create a catastrophic failure of the system;
2) continue the research on compressed air energy storage (CAES) that started during my sabbatical leave of absence in 2016; and
3) continue research on the fluid mechanics and heat transfer of two-phase N₂O.

For the work that I carried out in these three areas, I am happy to report the following milestones: 1) submitted four grant applications during the period of support. One proposal, on prognostic health monitoring for wind turbines, received Phase I STTR support through the Department of Energy. The research activities funded are now currently under way. 2) two new collaborations with researchers outside of Cal Poly to research new CAES cycles were created, following presentations of my work on at a university in Canada and at a conference in Utah, during a sabbatical leave of absence in 2016. Work over the period of support culminated in a visiting professor coming to Cal Poly to continue this research in-house, and a graduate student coming to Cal Poly to develop some new concepts under consideration. 3) advised 3 graduate students from Politechnico di Torino, at Cal Poly, on research on heated nitrous oxide, and co-authored a paper with them, which was presented at a conference in the summer of 2017.

Publications and other Deliverables (students in bold)
Peer-reviewed conference papers

Student Impact
Supervision of non-Cal Poly M.S. student projects
Proposals and other Leverage

Proposals submitted during the period of support:

1. U. S. Department of Energy SBIR/STTR FY 2017 Phase I Release 2 FOA Number: DE-FOA-0001619. (PI Lemieux) $150,000 (total cost) **Title:** SMART Wind Health: Development of an Inexpensive Prognostic Condition Monitoring/Control System for Distributed Wind Turbines **Aims:** Develop a flexible, inexpensive health monitor and control system for wind turbines of many sizes, with a base material manufacturing production price targeted at $100. System aims at streamlining maintenance and provide feedback on field performance. **Status:** submitted February 2017; **awarded July 2017.**

2. U. S. Department of Energy National Renewable Energy Laboratory: Distributed Wind Turbine Competitiveness Improvement Project Prototype Testing – Round 5. (PI Lemieux) $207,010 (total cost). **Title:** Populating SMART Wind Health Repository with Prototype Testing Results. **Aims:** Expand and revitalize U.S. leadership in the domestic and international wind turbine market sector by assisting several different U.S. manufacturers in lowering the levelized cost of energy (LCOE) of certified, quality wind turbines installed in a wide range of applications and geographic locations. **Status:** submitted May 2017; not funded.

3. California Energy Commission: EPIC Wind Energy Research Solicitation. (PI Lemieux) $1,610,720 (total costs) **Title:** Advanced Small Wind Field Demonstration Project. **Aims:** Establish small wind turbines as a viable clean energy generation technology with the potential to meaningfully contribute to California’s aggressive clean energy and greenhouse gas reduction goals **Status:** Initiated the necessary industrial collaborations required to submit such a proposal during the Spring quarter 2017; submitted the proposal, in partnership with Bergey Windpower, in August 2017.

4. Summer Undergraduate Research Program. (PI Lemieux) $8,000 (total costs) **Title:** Hatz Diesel Engine Vibrations Experiment; JFS-100 Gas Turbine Commissioning. **Aims:** To setup two new experiments in the Engines Laboratory, with the help of summer research students. **Status:** submitted May 2017; **awarded June 2017.**
Awardee
Sthanu Mahadev, Assistant Professor (Tenure-track), Mechanical Engineering, smahadev@calpoly.edu

Award
6 units (6 in 2017 Summer quarter.)

Summary of Accomplishments
This document outlines an abridged summarized version of my research work associated with the Bently summer 2017 appointment. As a part of this endeavor, I was actively involved in developing a novel comprehensive mathematical framework for predicting the sectional properties and stress-strain based mechanical response in thin-walled unsymmetrical composite beam cross-sections using the fundamentals of composite material mechanics. Thin-walled anisotropic composite beams possessing open-ended cross sections are used extensively in the aeronautical/aerospace industry as primary load bearing mechanical members and as reinforcing stiffener members. Thin-walled composite beam models have been widely utilized to simulate the behavior of such engineering structural elements.

I was successful in formulating an elaborate procedure that accurately quantifies the mechanical response of such composite configurations under externally subjected hygrothermomechanical loading environment. The analytical results obtained by tuning a host of mechanical parameters was further substantiated with a Finite Element based ANSYS routine. Excellent agreement was achieved between the analytical predictions and numerical estimates. The overarching goals of this exercise were a) To provide composite material based structural designers with an effective mathematical tool that is able to serve as a viable means to generate preliminary structural behavior data and assist in performing broad parametric studies with hopes to alleviate the need to immediately resort to complex FEA analysis. b) Incorporate the research findings toward developing an advanced level composite class for Fall-2019 ME curriculum c) Develop a custom computational algorithm in C or FORTRAN that can be later compiled into a ready-to-use app based problem-solver d) Systemic translation of this work into an international conference paper at the next ASME or AIAA or SAMPE conference.

One of my undergraduate students from ME 412 was involved in assisting with the numerical analysis of this work. Her efforts and learning outcomes will be extended in designing and developing a testing platform in the near future. Some of the funding provided will be utilized towards developing an experimental routine to generate test results.

Publications and other Deliverables (students in bold)
Peer-reviewed conference papers
Student Impact

Supervision of Cal Poly B.S students

1. Melanie Lim (ME, Bachelor of Science, Cal Poly, Spring 2017-Summer 2017).

Other Leverage

This project leveraged Bently supported funding in two ways. First, the proposed project leveraged my technical experience to mechanically investigate the structural response of fundamental composite structural configurations. I strongly feel that, I am on a promising stepping stone towards developing a research area that is of interest and adds value to a diverse array of composite industries. Secondly, the successful completion of this project will offer the potential to acquire future funding to continue and extend this research.
**FINAL REPORT FOR BENTLY CENTER AWARD (2016-2017)**

**Awardee**
Andrew Kean, Professor, Mechanical Engineering, akean@calpoly.edu

**Award**
3 WTU (2 WTU of release time in Winter 2017 and 0.8 WTU of assigned time in Summer 2017)

**Summary of Accomplishments**
My request for Bently release time for 2016-2017 was for 12 WTU to investigate a sensory substitution technique which converts sounds to sensory input on the underside of the lower arm, provided by a yet-to-be-created electronic sleeve. Instead of the requested 12 WTU, I was awarded 6 WTU. Given my reduced proximity to the intended user of this haptic device, and her ever degrading medical condition, I asked in 2016 to change my Bently award for 2016-2017. I declined 3 of my awarded WTU because it would be impossible to complete the work proposed for the amount of the award. With my remaining 3 WTU of award, I planned to integrate all of my current efforts into the M300 Smart Glass (see last year’s report) and help write a NSF Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM) proposal.

Both of these plans were successfully completed with the support of the Bently Center. In November 2016, Vuzix shipped the M300 Smart Glasses to replace the previously used M100 glasses. As proposed, I was able to integrate the Dragon Anywhere speech recognition application by Nuance Communications onto the new glasses. Somewhat fortuitously, the new Smart Glasses have better microphone technology, so no directionally-focused microphone was needed for the new version of this product. The new glasses are also a lot more rugged than the previous version, which makes their care a lot easier.

In addition to successfully using the M300 glasses for speech recognition, I co-wrote and am co-PI (with Jane Lehr and others) on a new NSF S-STEM grant proposal titled “Collaborative Research: The Central Coast Coalition to Connect Campuses: C5 Scholars.” The goal of this Multi-Institutional Consortia (Cal Poly, Hancock College, and Cuesta College) is to increase the number of low-income academically talented students with demonstrated financial need who begin their pathway to an engineering degree at community colleges, successfully transfer to accredited, B.S.-granting engineering schools, are retained in and graduate with bachelor’s degrees, and enter the STEM workforce or STEM graduate programs. The proposal asks for ~$3,000,000 with roughly half of that to come to Cal Poly. This was submitted in March 2017 and we have not yet heard back from NSF.
Awardee
Steffen Peuker, The James L. Bartlett, Jr. Asst. Prof., Mechanical Engineering, speuker@calpoly.edu

Award
3 units in 2016 Summer quarter

Summary of Accomplishments
As stated in the original proposal I developed—with my collaborator Dr. Rachel McCord from the University of Tennessee, Knoxville—a cross-institutional, longitudinal study about the impact of developing engineering freshmen students into self-regulated learners through the implementation of the DYP program.

Our proposal asking for $545,682 was submitted to NSF but not funded. We will continue our research efforts and plan to resubmit to NSF.

In the meantime we published a work in progress paper at the 2017 FYEE conference about the initial work we conducted to understand how students discuss their self-regulated learning skills through an end of semester reflective assignment.

Publications and other Deliverables (students in bold)

Peer-reviewed conference papers

Student Impact
Preliminary research has shown that developing engineering freshmen students into self-regulated learners through the implementation of the DYP program has significant impact on student success. Higher sustained GPAs, improved retention rates in engineering majors and improved four year graduation rates are the quantitative results of implementing the DYP program. Other impacts on student success, such as improving grit, affecting positive behavioral changes, improving student learning and self-regulation are expected as well. Since almost every institution in higher education offers an introduction to engineering course for engineering majors, the potential impact of an even more widespread implementation of the DYP program (currently implemented at more than 30 institutions) will affect thousands of undergraduate engineering students.
Proposals and other Leverage

Proposals submitted during the period of support

1. National Science Foundation (Dr. Steffen Peuker, Dr. Rachel McCord)
   07/01/17-07/01/20; $545,682

Title: Collaborative Research: Investigating the Impact on Engineering Student Success through the Implementation of the "Design Your Process" (DYP) Program. Aims: Study the longitudinal impact of the implementation of the DYP program at eleven four-year institutions. The institutions are purposely selected to provide maximum diversity and to represent a range of different institutional structures, sizes, demographics and geographic locations. This project will identify why and what aspects of the DYP program—related to sub-groups of first-year engineering students—leads to improved student success, and it will provide insight into how educators involved in first-year engineering education can adapt the DYP program to their specific student population. Status: submitted Jan 17, not funded Jun 17.
**FINAL REPORT FOR BENTLY CENTER AWARD (2016-2017)**

**Awardee**  
Brian P. Self, Professor, Mechanical Engineering, bself@calpoly.edu

**Award**  
Total units 3 (2016 Summer quarter)

**Summary of Accomplishments**  
A number of new online videos were created to support the flipped environment for ME212. These can be viewed on my YouTube channel at the following link: [https://www.youtube.com/channel/UC2TMhMYUoolfE3mDzQHgSLQ/videos](https://www.youtube.com/channel/UC2TMhMYUoolfE3mDzQHgSLQ/videos). Some of videos were made previous to the support, but the majority were created during the summer and last academic year. The videos have been incorporated into my ME212 version of the course, which is organized according to:
1. **Before Class:** a) online lecture, ~10 min, with some embedded questions, b) online example problem, sometimes with embedded questions, c) online quiz on what they have watched
2. **Class** – generally involves more active learning components and questions because the lecture content has been moved online
3. **After Class:** a) Slides and material from class, b) solutions to problems that were worked in class, c) homework due the next day.

**Publications and other Deliverables (students in bold)**
Some linked work that still has to be incorporated into the class (I will try it in Germany during the fall) is some of the work done on the Elliptical machine and the rowing machine. This was leveraged with the Keck funding we have received, and the laboratory analyzing the rowing machine was presented at the ASEE section meeting (poster) and at the SEFI meeting last month.

*Peer-reviewed conference paper*
Self, B.P., Montoya, D.J., Mavrommati, K. (2017) Incorporating a Motion Analysis Research Laboratory into a Dynamics Course using Model Eliciting Activities. SEFI Annual Conference, Azores, Portugal.

*Poster Presentation*

**Student Impact**
Students are now able to watch the videos to review for tests and exams, and to replay portions that might be confusing. After further refinement, material will be shared with other instructors and possibly integrated with an online Dynamics textbook, reaching over 10,000 students each year. Future plans include developing additional interactive example problems with engineering context, and using YouTube analytics to see how often students access the materials and how they utilize the videos (eg, only watch once, fast forward, etc).
FINAL REPORT FOR BENTLY CENTER AWARD (2016-2017)

Awardee
Jim Widmann, Professor and Chair, Mechanical Engineering, jwidmann@calpoly.edu

Award
Total units: 3 units in Winter 2017. (Note that original award was for an additional 3 units in the spring, but these were not used due to my new position as Department Chair)

Summary of Accomplishments
During the Winter quarter of 2016 I developed and provided active learning study sessions to students who were enrolled in an NSF sponsored Grit study led by Dr. John Chen and myself as co-PI. The sessions were given to students on a drop-in basis. This student cohort in our study is the “treatment” group who are being given more exposure to active learning experiences as we study how this relates to measures of Grit. Grit is psychological construct shown by Angela Duckworth to provide better correlations to student success than SAT or GPA scores. The control group in our study are given help as well, but with less emphasis on active learning pedagogies. Meanwhile both cohorts are monitoring the amounts of Passive and Active learning they participate in during their academic life by entering data on a cell phone App developed through the grant. Data from students was correlated to classroom observations undertaken by the co-PIs to verify the App and the student’s ability to accurately characterize their learning experiences and enter the data correctly. The verification of the App is documented in a conference paper that I presented in July 2017 at the Research in Engineering Education Symposium in Bogota, Colombia.

Publications and other Deliverables
Peer-reviewed conference papers

Student Impact
1. A large number of ME212 students benefitted by attending the sessions throughout the quarter.

Proposals and other Leverage
Active awards during the period of support

Title: Everyday Engineering Learning and the Character Trait of Grit. Aims: We are investigating the relationship between Grit and various achievement outcomes among engineering students.
Status: Fall 2014 funded: Spring 2014