

SUMMARY REPORT OF RESULTS FROM BENTLY CENTER AWARD (2014-2015)

Awardee: William R. Murray, Professor, Mechanical Engineering, wrmurray@calpoly.edu

Award: 14 WTUs [Fall 2104 - 5 WTUs; Winter 2015 – 5 WTUs; Spring 2015 – 4 WTUs]

Summary of Accomplishments: As Director of the Bently Center for Engineering Innovation, I continued my research and development on cooled aerospike rocket nozzles, and I carried out the duties of the Center Director. Under my supervision, two MS students completed their thesis research involving different aspects of cooled aerospike nozzles. Both thesis projects involved in-depth analytical modeling, mechanical design, machining of prototype nozzles, and hot-fire testing of these prototype nozzles for hybrid rocket motors.

Related Documents and other Deliverables:

1. "Development of Local Transient Heat Flux Measurements in an Axisymmetric Hybrid Rocket Nozzle," Christopher D'Elia, MS thesis, February 2015, Digital Commons @ Cal Poly.
2. "Aerospike Rocket Motor Structural Webbing," Andrew Brock, MS thesis, February 2015, Digital Commons @ Cal Poly.

Student impact:

1. Students involved in research during 2014-2015: Christopher D'Elia (BS, MS) and Andrew Brock (BS, MS).

Proposals:

1. **NASA** – STTR Phase III Extension Proposal (PI: W.R. Murray, \$54,329). *Title:* Fluidic Vector Control for Thrust Vectoring an Annular Aerospike Nozzle: A Proposed Phase III Extension to "Optimal Thrust Vectoring for an Annular Aerospike Nozzle," NASA STTR Phase II Grant, Contract NND06AN82C, 06/06 - 06/08. PI: T.W. Carpenter, co-Investigator: W.R. Murray, \$614,000. *Status:* submitted Sept 2015; *Final Status:* unfunded.

SUMMARY REPORT OF RESULTS FROM BENTLY CENTER AWARD (2014-2015)

Awardee: **Russell V. Westphal**, rvwestph@calpoly.edu, Donald E. Bently Professor, Constant J. and Dorothy F. Chrones Professor

Award: 3 units per term, Summer 2014 through Spring 2015 (12 units total)

Summary of Accomplishments: It has been my honor and privilege to hold the title of Donald E. Bently Professor, and to employ Bently Center support to provide the time needed to lead the work of the Boundary Layer Data System (BLDS) project team on seven specific project tasks that further the capability of the Cal Poly BLDS to operate in extreme conditions, particularly rotating environments such as encountered for large-scale rotorcraft and turbomachinery. Twelve students (9 ME, 3 AE) have been involved in the tasks for which the Bently award has supported my time. The work completed on these tasks to date has already proven to be instrumental in securing a \$121 K, two-year contract award from the US Air Force (subcontract from Northrop Grumman), initiated October 2014, as well as a second contract effort for \$25 K, funded by Northrop Grumman. The Bently support also provided the time needed to complete the proposals that resulted in these contracts. Funds to support students, as well as supplies and services needed to complete these tasks, were provided through previously-received cash donations from Northrop Grumman Corporation (the donation does not provide for faculty salary). A 73-page report on the work done through December 2014 was submitted to Northrop Grumman in February 2015 detailing achievements relating to those tasks up to that time. That report contained explicit acknowledgement of the Bently Center support of my time to supervise the work. Other documents resulting from the work I supervised using time provided by the current Bently Center award include a MS thesis and two senior project critical design reports. A final report was submitted to the Bently Director containing details of results for all of the work supported by the award.

Related Documents and other Deliverables (related hardware described in item 1):

1. "Boundary Layer Data System Development for Measurements in Rotating Environments", R. V. Westphal, Final Report to Bently Director on Results from Bently Center Award, June 2015.
2. "Laminar Flow Technology Development Projects Supported by Northrop Grumman Gift Funds, 2014", by R. V. Westphal, submitted February 12, 2015 to Mr. Tom Pieronek, Northrop Grumman Corp., with copies to W. Murray and A. Sullivan
3. "Evaluation of Design Tools for the Micro-Ram Air Turbine", MS Thesis Mechanical Engineering, V. Villa, April 2015. <http://digitalcommons.calpoly.edu/theses/1446/>
4. "High Speed Jet Turbine Test Critical Design Report", K. Enstrom, C. Naugle, I. Thomas, C. Lee; April 2015. ME 429 Senior Project.
5. "Rotor Test Rig Critical Design Report", D. Nelson, H. H. Oo, E. Pautz; April 2015. ME 429 Senior Project.

Student impact:

1. **Students directly involved:** Andy Diep (grad, AE), Victor Villa (MS, ME), Kris Lawrence (grad, ME), Joe Gagliano (undergrad, AE), Patrick Fillingham (undergrad, AE), Ken Enstrom (undergrad, ME), Cameron Naugle (undergrad, ME), Isaac Thomas (undergrad, ME), Cody Lee (undergrad, ME), Derek Nelson (undergrad, ME), Htet Htet Oo (undergrad, ME), Ethan Pautz (undergrad, ME)
2. **Other student impacts:** Students employed on the two grants obtained with Bently support include Jakob Graf (undergrad, ME), Kris Lawrence (grad, ME), and Alex Powers (grad, ME).

Proposals:

1. "Swept BEES/SWEETER: Cal Poly Support", Oct 2014-Oct 2016, \$121.4 K., awarded (53069)
2. "Cal Poly Instrumentation IRAD 2015", June 2015-Dec 2015, \$25.4 K, awarded (53068)

SUMMARY REPORT OF RESULTS FROM BENTLY CENTER AWARD (2014-2015)

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

Award: 12 units (2015 Spring quarter)

Summary of Accomplishments: As stated in the original proposal, the **primary objective** of the assigned time was: “to continue an aggressive initiative to develop a new scholarly direction that aims to establish a Cal Poly Human Motion Biomechanics Laboratory (HMB Lab).” Most of my supported time was spent in three areas: 1) working with my core HMB Lab interdisciplinary team of 8 students to develop the HMB Lab and conduct research, 2) preparing proposals for external funding, and 3) developing expertise for my new scholarly direction. My faculty collaborators, students, and I specifically worked on developing 1) experimental protocols for marker placement and gait/bicycling studies, 2) novel analysis methods to minimize errors due to soft tissue artifact of skin-based marker systems, 3) analysis protocols for determining knee joint loads from our motion analysis data; and 4) finalizing finite element studies of cartilage tissue loading in knee joints during gait.

Related Documents and other Deliverables:

1. Sylvia MK et al. Development of a human knee joint finite element model to investigate cartilage stress during walking in obese and normal weight adults. *SB3C Conference*, 2015.
2. Czapla NA et al. Human knee joint finite element model using a two bundle anterior cruciate ligament: validation and gait analysis. *SB3C Conference*, 2015.
3. Deschamps JE et al. Pseudo-rigid body method for reducing soft tissue artifact: validation and application to gait. *SB3C Conference*, 2015.
4. Kraemer LI et al. Design and implementation of an instrumented pedal for cycling biomechanics research. *SB3C Conference*, 2015.
5. Dudum KC et al. Using OpenSim to predict knee joint moments during cycling. *SB3C Conference*, 2015.
6. Stender ME et al. An equilibrium constitutive model of anisotropic cartilage damage to elucidate mechanisms of damage initiation and progression. *Journal of Biomechanical Engineering*, 137(8), 081010 (Aug 01), 2015.
7. Sylvia MK. Finite element analysis of cartilage tissue loading in the knee joint: combined effects of body weight and varus-valgus alignment. *MS Thesis*, Jun 2015.
8. Czapla N. Finite element analysis of soft tissue loading in the normal, ACL deficient, and ACL reconstructed knee joints. *MS Thesis*, Jun 2015.

Student impact:

1. Students involved in research: Meghan Syliva (MS, ME), Nick Czapla (MS, ME), Jake Deschamps (MS, ME), Juan Gutierrez-Franco (MS, ME), Eshan Dandekar (MS, KINE), Karim Dudum (BS, BME), Luke Kraemer (BS, ME), Alejandro Gonzalez-Smith (BS, ME).
2. Submission of Keck Phase I application (see below); that application was successful in receiving an invitation to submit a Phase II application.

Proposals:

1. **W.M. Keck Foundation** – Undergraduate Education Program, Phase I Application. (PI Klisch, Co-PIs Hazelwood, Self, Clark, Taylor). \$397,000 (direct costs). *Title:* Human Motion Biomechanics Lab: Integrating Research and Education in an Interdisciplinary Setting. *Status:* submitted Apr 2015.
2. **Arthritis Foundation**. (PI Klisch, Co-PI Hazelwood). \$124,924 (total costs). *Title:* Knee Biomechanics in Weight Control Exercise. *Status:* submitted May 2015.

SUMMARY REPORT OF RESULTS FROM BENTLY CENTER AWARD (2014-2015)

Awardee: Steffen Peuker, Assistant Professor, Mechanical Engineering, speuker@calpoly.edu

Award: 8 units, AY 2015-2015

Summary of Accomplishments:

Development and assessment of Team-Based Learning (TBL) in Mechanical Engineering courses in collaboration with Dr. Jennifer Mott Peuker. Revising course materials for ME302, ME359 and ME457 to implement Team-Based Learning. Development and submissions of several proposals, see Proposals below. Development, implementation and assessment of the “Design Your Process to Become a “World Class” Engineering Student” in ME163.

Student impact:

- The implementation of the “Design Your Process to Become a “World Class” Engineering Student” impacts all 183 2015 ME freshmen students. Assessment is ongoing to quantify impact.
- A total of 155 students were exposed to TBL. The assessment demonstrates that students are accountable for their learning and are interactively engaged in the classroom. Furthermore, the TBL framework promotes high functioning, cohesive teams who do not depend on the strongest or smartest students, which results in an improved learning experience for all students and prepares all student for team work beyond college.

Proposals:

- Proposal to develop ME 470/471 Introduction to Building Energy Modeling and Lab – approved
- Proposal to use the Collaborative Learning Space 38-121 for Fall 2015 courses – active
- IRB proposal “Implementation and Assessment of the “Design Your Process to Become a “World Class” Engineering Student” Project in Mechanical Engineering First Year Seminar” – active
- Promising Practices Course Redesign proposal titled “Freshmen Orientation to Mechanical Engineering” was fully funded, in the amount of \$4,364 – active

Related Documents and other Deliverables:

- Presented workshop “Improving First-Year Engineering Student Retention Success and Time to Graduation” at the 122nd Annual ASEE Conference, June 14, 2015, Seattle, WA
- Peuker, S., Schauss, A.G., “Improving Student Success and Retention Rates in Engineering: An Innovative Approach for First-year Courses”, 122nd ASEE Annual Conference and Exposition, June 14-17, Seattle, Washington, USA, 2015
- Peuker, J.M., Peuker, S., “Using Team-based Learning to Ensure Student Accountability and Engagement in Flipped Classrooms”, 122nd ASEE Annual Conference and Exposition, June 14-17, Seattle, Washington, USA, 2015
- Peuker, J.M., Peuker, S., “Achieving High Functioning Teams Using Team Based Learning in Flipped Classrooms”, 122nd ASEE Annual Conference and Exposition, June 14-17, Seattle, Washington, USA, 2015

SUMMARY REPORT OF RESULTS FROM BENTLY CENTER AWARD (2014-2015)

Awardee: Xi (Julia) Wu, Associate Professor, Mechanical Engineering, xwu@calpoly.edu

Award: 7 units

Summary of Accomplishments: During the past academic year, I, along with my graduate students, achieved the following: (1). I developed 10-week lab for ME442 “Design of Machinery”, which includes several practical design projects about linkages, cam-follower and gears. The new lab provided the students the opportunities to apply newly learned skills of mechanism/machine synthesis and analysis to designing creative solution to real-world problems using CAD and ADAMS software and familiarize design process starting from recognition of functional requirements. (2). Simulated the practical dynamical behavior of the offset rotor and gear pairs with gyroscopic effects and cracks using Solidworks, Finite Element Analysis software, MSC Adams and MATLAB. Wavelet was first time applied to identify cracks. (3). artistically apply wavelet to sophisticated theoretical model of the gearing pair with different sizes of the cracks to identify the small crack and location. (4). successfully constructed 3D full spectrum plots directly from x,y rotor transducers using MATLAB. We use tracking windows to filter the transducer data to nX components of rotor speed when the rotor starts up or runs down. Our results are directly comparable with experiments for overhung rotor and provide opportunity of further post processing full spectrum data. (5). configured ADRE 408 (New Bently data acquisition system) with Bently rotor kits, Bently torsional equipment and Spectrum quest rotor system. Majority of the transducers installed on the gearbox are configured with ADRE 408.

Related Documents and other Deliverables:

1. Wu, X., Naugle, C., Meagher, J., “Full Spectrum Analysis of an Overhung Rotor to Identify Anisotropy Induced Gyroscopic Effects and Support Stiffness”, 2015, International Journal of Rotating Machinery, Article Number: 415684 (under review).
2. Wu, X., Sommer, A., Meagher, J., “Spectrum Diagnostics of a Damaged Differential Planetary Gear during Various Operating Conditions”, Physical Science International Journal, 2015 (under review).
3. Hu, X.; Wu, X., Wang, J., Meagher, J., “Fault Detection of Gears with Different Root Crack Size Using Wavelet”, Proceedings of the ASME 2015 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference, IDETC/CIE 2015, Article Number: DETC2015-47263.
4. Nenad Gavrilovic, “vibration-based health monitoring of rotating systems with gyroscopic effect”. *MS Thesis*, Dec 2014.

Student impact:

Students involved in research: Nenad Gavrilovic (MS, ME), Cameron Naugle (MS, ME), Garrett Olson (BS, ME).

Proposals:

1. **Strasbaugh Company**----(PIs: Xi Wu & Peter Schuster) “Deflection Analysis and Stiffness Improvements in Precision Wafer Grinder” Submitted on June, 2015. Phase I, \$32,700.
2. **Engine Systems Innovation (ESI): (PI: Xi Wu)**“Dynamic Analysis and Anti-Rotation Mechanism Design for Continuously Variable Displacement Engine”, submitted on October, 2015, **Phase 1**, \$10,200.

SUMMARY REPORT OF RESULTS FROM BENTLY CENTER AWARD (2014-2015)

Awardee: Joseph D. Mello

Award: 3WTUs Summer 2014, 3WTUs Spring 2015

Summary of Accomplishments: Advanced Composites Compression Molding Development

Summer 2014 activities focused mainly on compression mold development. A small laboratory press was secured via a donation from Quatro composites. This machine was set up and configured to run 250 °F pre-preg cure cycles typical of the material used in industry. I teamed with an undergraduate researcher, Karlos Guzman to develop the first Cal Poly molds.

In the spring of 2015 the release time supported continued effort in the area of compression molding started in the summer now with a graduate student Corinne Warnock. This effort focused on learning more about compression molding and associated parameters such as ply count, pressure, temperature and time. Testing was performed in attempt to assess molding these parameters influence on resulting mechanical performance of the parts compression molded.

Related Documents and other Deliverables:

1. Memo report with attachments delivered to Steve Klisch, Bently Director October 29, 2015
2. Corinne Warnock Master's Thesis Winter 2015

Student impact:

1. Karlos Guzman undergraduate ME400 researcher graduated and is now employed at Tesla.
2. Corinne Warnock Master's Thesis soon to be employed in Sandia National Laboratory Lightweight Structure Lab.
3. Future Cal Poly undergraduates as this work will hopefully grow into an innovative undergraduate course laboratory experiment.

Proposals:

1. Proposal out to Quatro Composites W2015 to support compression molding senior project

SUMMARY REPORT OF RESULTS FROM BENTLY CENTER AWARD (2014-2015)

Awardee: Kim A. Shollenberger, Mechanical Engineering, kshollen@calpoly.edu

Award: 6 units total (2 units 2014 Fall, 1 unit 2015 Winter, and 3 units Spring 2015)

Summary of Accomplishments:

As stated in the proposal, I used the assigned time to serve as a faculty advisor for the Solar Cal Poly team that competed in the 2015 Solar Decathlon competition held in Irvine, CA, during the month of October 2015. I am a co-PI on the \$50,000 grant that was awarded by the Department of Energy to support this project and I served as one of the three main faculty advisors. Thus, I made significant contributions to the programmatic, fund raising, and technical requirements needed in order to insure the success of this project. To assemble a team of Mechanical Engineering undergraduates to work on the project, I taught one section of the senior project sequence from Fall 2014 to Spring 2015. My section included 6 teams that worked on all the mechanical designs required for the 2015 Solar Decathlon house. This project supports the mission of the Donald E. Bently Center for Engineering Innovation by enhancing the educational experience of undergraduate and graduate level students by providing a hands-on project that investigated innovative solar technologies for building a complete net zero house for the prefabricated housing market.

Related Documents and other Deliverables:

As part of the competition, our team supplied complete design drawings and narratives as part of the documentation required for the competition. Our successful completion of this significant project and our 3rd place overall award at the competition served as an excellent and highly visible representation of the engineering and architecture programs at Cal Poly.

Student impact:

A total of approximately 100 students from a wide range of disciplines contributed to this project, thus it had a broad impact on our students. The following is a list of senior projects I advised directly:

1. Burt, Robert, Lutze, Chris, and Tyler Dunaway, "Solar Decathlon Plumbing Subsystem Final Design Report," Senior Project Report, Mechanical Engineering Department, Cal Poly State University, June 2015, <http://digitalcommons.calpoly.edu/mesp/252>.
2. Ambrose, Timothy, Begue, Mateo, and Andrew Elliott, "Solar Decathlon Instrumentation and Controls" Senior Project Report, Mechanical Engineering Department, Cal Poly State University, June 2015, <http://digitalcommons.calpoly.edu/mesp/249>.
3. Cornish, James, Cosmo, Jake, and Patrick Weston, "Solar Cal Poly Active HVAC Project," Senior Project Report, Mechanical Engineering Department, Cal Poly State University, June 2015, <http://digitalcommons.calpoly.edu/mesp/253>.
4. Fillingham, Patrick, Goodson, Wesley, and Kenneth Li, "Team Solar SIP," Senior Project Report, Mechanical Engineering Department, Cal Poly State University, June 2015, <http://digitalcommons.calpoly.edu/mesp/250>.
5. Morris, Jake L., Yasuda, Zachary F., and Lauren P. Jones, "Solar Cal Poly Water Systems," Senior Project Report, Mechanical Engineering Department, Cal Poly State University, June 2015, <http://digitalcommons.calpoly.edu/mesp/256>.
6. Paquin, Cristina, Blarel, Julien, and Sanchit Joshi, "Solar Decathlon 2015, Solar Cal Poly; Solar Cal Poly Project Engineers," Senior Project Report, Mechanical Engineering Department, Cal Poly State University, June 2015, <http://digitalcommons.calpoly.edu/mesp/258>.

Proposals:

No new proposals have been submitted at this time because the call for the next competition has not yet been posted.

SUMMARY REPORT OF RESULTS FROM BENTLY CENTER AWARD (2014-2015)

Awardee: John Chen, Professor, jchen24@calpoly.edu

Award: 6 WTU total – 3 WTU in winter 2014, 3 WTU in spring 2015 (later deferred to summer 2015 at the department's request)

Summary of Accomplishments:

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 as well. Grit – defined as passion and perseverance for long-term goals – is likely to be important to individuals trying to achieve the challenging, long-term goal of attaining an engineering degree, which requires not only talent but also its focused and sustained application over a long period. This work-in-progress study investigates the relationship between grit and various achievement outcomes among engineering students.

The most noteworthy finding for this work-in-progress is confirmation that, as hypothesized, grit is a strong predictor of academic performance as measured by GPA. Grit in the highest GPA group is significantly higher than that of all other groups. While the second highest GPA group also had higher grit than the two remaining groups, this difference did not rise to significance. This result confirms previous finding that grit is correlated with academic performance, but this time for the specific population of Cal Poly engineering students. Since both self-control and self-efficacy were also found to be strong predictors of high GPA (again confirming previous findings, the relative importance of each of these traits is unknown. This will be the subject of a future study. Grit was found to be highest among first-year engineering students, and lower and constant beyond this year of study. This is somewhat discouraging in that it suggests perhaps the university experience is diminishing the grit that engineering students possess. Whatever the cause, this finding presents an opportunity for engineering educators to help students build their grit in authentic and productive ways.

Related Documents and other Deliverables:

1. Chen, J.C., McGaughey, K.J., Janzen, D.S., Teramoto Pedrotti, J., and Widmann, J.M., “Grit and its role in achievement among engineering students,” The 6th Research in Engineering Education Symposium, July 2015, Dublin, Ireland.

Student impact:

1. 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. 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.

Proposals:

1. *Does Active Learning Build Grit?* Submitted to the National Science Foundation, Education and Human Resources (EHR) Core Research program, September 2015. J. Chen, J. Widmann, D. Janzen (Computer Science), K. McGaughey (Statistics), and J. Teramoto Pedrotti (Psychology).
2. *Collaborative Research: True Grit – Engaged Learning and the Character Trait of Grit.* Submitted to the National Science Foundation, Research in the Formation of Engineers program, October 2015. J. Chen and M. Koretsky (Oregon State University).

SUMMARY REPORT OF RESULTS FROM BENTLY CENTER AWARD (2014-2015)

Awardee: Patrick Lemieux, Professor, Mechanical Engineering, plemieux@calpoly.edu

Award: 6 units, Spring 2015

Summary of Accomplishments: The original 2014-15 proposal targeted three areas of activities: 1) Establish a Fee-for-Service funding practice for the Engines Laboratory; 2) Continue two-phase flow research on heated nitrous oxide and 3) Continue research at the Cal Poly Wind Power Research Facility. The proposal called for 18 units of release time to achieve the proposed goals. Still, in the end, significant progress was achieved on continuing wind research and heated nitrous oxide flow.

Heated two-phase flow research:

- 1) Continuing collaboration with Politecnico di Torino (Italy), including advising exchange students conducting all of their experimental research at Cal Poly.
- 2) Paper presented at the American Institute of Aeronautics and Astronautics (AIAA) and American Society of Mechanical Engineers (ASME) Joint Propulsion Conference

Wind Power Research:

- 1) Developed a test rig for wind turbine projects to be used in an undergraduate wind turbine performance class;
- 2) Planned upgrades to meteorological tower instrumentation and wind monitoring equipment on campus;
- 3) Development of a roadmap for the Distributed Wind Energy Association (DWEA) to help guide US manufacturers in gaining a competitive edge in distributed wind.
- 4) Sponsored and advised a senior project on the development of a hydraulic gearbox for our research wind turbine.

Related Documents and other Deliverables:

1. MS Thesis, Pablo Sanchez Arribas, Politecnico di Torino, Torino, Italy.
2. Arribas PS, Lemieux P, Pastrone D “Modeling of N₂O Heat Transfer Rates in the Nucleate Boiling Regime, with Experimental Verification”, AIAA/ASME/ASME 51st Joint Propulsion Conference, Orlando, FL, July 2015

Student impact:

1. Apparatus for rotor design test (designed and built). This apparatus will affect approximately 25 UG students per year who take ME 488, by allowing the on-site test of a quarter-long rotor building project in a competitive setting.
2. Sr Project: Continuously Variable Wind Turbine Hydraulic Transmission Project. R. Baskett, A. Carlberg, A. Campbell.
3. Wind test site maintenance crew. A. Feinstein, G. Kardener, J. McTigue (UG students)

Proposals:

1. Distributed Wind Energy Association (DWEA) SMART Wind Consortium Phase II Proposal (in development).

SUMMARY REPORT OF RESULTS FROM BENTLY CENTER AWARD (2014-2015)

Awardee: Jim Widmann, Professor of Mechanical Engineering and Interim Director of General Engineering, jwidmann@calpoly.edu

Award: 6 units, Summer 2015

Summary of Accomplishments: Recently, Duckworth and co-workers described a new psychological construct they called “grit” [1-4], which is defined as passion and perseverance for long-term goals. Among its notable attributes, grit predicted the grade-point-average (GPA) among undergraduates better than standardized test (SAT) scores. At Universities across the United States there is a growing awareness of the power of grit and a desire to grow grit in undergraduate to promote academic success. The original Bently proposal requested 12 units to study Grit in students and to create Active Learning activities in mechanics courses to be used in part of a larger NSF grant. Since only six units were granted, the proposed work was scaled back to generate a single Active Learning experience to promote grit growth. One major way to increase grit is through the promotion of a “Growth Mindset” in students. In this work, the PI developed a psychological Intervention to be used with first and second year engineering undergraduates based on an extensive literature review. The Mindset Intervention consists of an Active Learning exercise where students are presented factual information regarding Neuroplasticity (the ability of the brain to grow and change when undertaking challenging cognitive tasks). Next the students listen to a personal story of cognitive growth and then are assigned the task of writing a letter to a junior high school student that encourages effort and explains cognitive growth. The PI then deployed this mindset intervention to 70 students in ENGR 110 class as well as 15 students in a Statics Study Session group in the fall quarter of 2015. The Intervention was also used by Kathy Chen for 17 students in her ENGR 101 class. Assessment of growth mindset was made prior to the Intervention and post assessment will be made at the end of fall quarter to determine the possible effect of the intervention.

Related Documents and other Deliverables:

1. Attended the 2015 Research in Engineering Education Symposium (REES) where the following paper was presented by John Chen: Chen, J. C., McGaughey, K., Janzen, D., Pedrotti, J., and Widmann, J., “Grit and its Role in Achievement among Engineering Students,” Research in Engineering Education Symposium, Dublin, Ireland, July 2015. Feedback on the project was given by researchers in the field of engineering education.
2. The “Engineering Thinking and the Brain” learning module was created. This consists of a PowerPoint module that links two videos, a personal story of cognitive growth, a set of discussion questions and a reflective assignment for the students. This module is intended for an introductory engineering course to build a growth mindset.
3. A paper with results from this study is being developed for the ASEE PSW meeting in April, 2016.

Student impact:

1. 70 students in ENGR 110, 15 students in a Statics Study Session and 17 students in ENGR 101 under the teaching of Kathy Chen participated in the intervention study.
2. If the mindset intervention is successful, it will be considered for integration into ME163 in 2016 and will be available to other instructors. Growth Mindset is strongly linked to academic success.

Proposals:

1. In December a new NSF Proposal, “Building Grit through Active Intervention” will be submitted with John Chen as the PI and Jim Widmann as one of the Co-Pi’s. Data collected from this Bently supported study will be used to justify the proposal.

SUMMARY REPORT OF RESULTS FROM BENTLY CENTER AWARD (2014-2015)

Awardees: John Ridgely, Professor of Mechanical Engineering, jridgely@calpoly.edu and Glen Thorncroft, Professor of Mechanical Engineering, gthorncr@calpoly.edu

Award: 6 WTU's of Summer support for Summer 2014, with 3 WTU's for each awardee

Summary of Accomplishments: The proposal for this work was to create equipment which enables new laboratory exercises and improvements to existing exercises in the laboratory of ME 236, Engineering Measurement and Data Analysis. This work was part of a broader project, supported by a year-long Difference-in-Pay leave by Thorncroft, to upgrade the ME 236 course. The work supported by the Bently award resulted in the development and fabrication of the data acquisition system which is designed to maximize student learning of measurement and data acquisition concepts while simultaneously being less expensive and more reliable than the equipment previously used. Named PolyDAQ, this hardware-software suite is currently in use in the ME 236 laboratory, and has been integrated into four experiments, with two more in current development. The informal feedback obtained to date from students and instructors has been positive. In addition, a version of the PolyDAQ system has been adapted for the laboratory of ME 410, the elective course in Mechanical Measurements. The ME 410 systems have so far undergone only a first test deployment; the students and instructor have reported that the use of these systems was successful.

Related Documents and other Deliverables:

1. PolyDAQ 4-4-2 circuit board design. This custom printed circuit board is distributed under an open source license to encourage adoption and the formation of an open source community of users and contributors.
2. PolyDAQ 0-4-4 circuit board design, a substantially modified design, also distributed as open source.
3. The PolyDAQ firmware, which is the software contained on the PolyDAQ circuit boards. This software is based on the open-source real-time operating system FreeRTOS and is released as an open-source product under the LGPL License.
4. The PolyDAQ System for ME 236, developed by Thorncroft during professional leave after the conclusion of the Bently support. This is a combined, stand-alone DAQ, computer (a Raspberry Pi), and pre-wired signal "breadboard" with thermocouple sockets and banana terminal lugs. A complete set of five systems has been built and deployed.
5. The PolyDAQ application software, also developed by Thorncroft during professional leave. This software runs on Linux/Unix™, Mac™, or Windows™ systems, allowing students to interact with the data in real time. It is unique in that it is optimized to assist students in learning key data acquisition concepts and in assisting instructors in recognizing how well students are learning those concepts.
6. The PolyDAQ support website at <http://wind.calpoly.edu/polydaq>, on which support is made available to users and open-source material is made available to developers.

Student impact:

1. All students taking the required ME 236 course use the PolyDAQ 4-4-2 system to learn key data acquisition concepts. This is approximately 240 students per year.
2. Students taking the ME 410 technical elective course have so far used PolyDAQ 0-4-4 if needed for specific course projects; about 12 students used the equipment in Spring 2015. It is expected that 25-35 students per year will use this equipment in ME 410 projects in future years.

SUMMARY REPORT OF RESULTS FROM BENTLY CENTER AWARD (2014-2015)

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

Award: 5 units (Summer 2014)

Summary of Accomplishments: I am a co-PI (with Kathy Chen as PI) on a National Science Foundation grant titled “PEEPS” – **Program for Engineering Excellence for Partner Schools**. This research effort presents a holistic, institutional approach towards recruiting, retaining, and graduating engineering students from disadvantaged backgrounds. Our targeted students come from high schools in the established Cal Poly Partners Program, which means these students are not only more likely to have low socioeconomic status, but also be first generation college students and/or underrepresented minorities. We offer scholarships of up to \$10,000 for at least four years to admitted engineering students from our Partner High Schools with high financial need, and we offer a support structure to help the students succeed academically.

As stated in the original proposal, the **primary objective** of the assigned time was to: “*enable me to serve as the academic advisor and professional mentor to these seven initial recipients of the scholarship.*” This role has been both challenging and very rewarding. Specifically, the Bently Release time has enabled me to contribute to these portions of the PEEPS Scholarship grant:

- 1) I have served on the scholarship committee for both cohorts of the program. Each time, we have selected seven engineering students from Cal Poly partner high schools to receive a significant scholarship and support from the PEEPS team. The first cohort is all ME students and the second cohort is from across the College.
- 2) I have participated in “book club” type meetings with the students as well as other team building activities on campus.
- 3) I have met with students throughout the year as a supplement to their normal academic advising. When necessary, I acted as a liaison to help resolve some academic issue with which they were confronted.
- 4) Much of our efforts have focused on trying to build camaraderie between the students, so I also participated in the many off-campus PEEPS activities.
- 5) I have helped prepare our first grant status report to NSF.

Student impact:

- 1) Seven Mechanical Engineering students have participated in one complete year of the scholarship program. The PEEPS program provided much more than tuition, it has provided a support structure to help these students succeed. All the students in the cohort refer to each other as family and I am proud to have contributed to their success academically and to have helped them financially. Their scholarship will continue until they complete their degree.
- 2) Seven more students from across CENG were selected for the PEEPS scholarship program this past spring. This is their first quarter on campus, but things appear to be going well so far. The first cohort is providing a lot of support for the second cohort of scholarship recipients.

SUMMARY REPORT OF RESULTS FROM BENTLY CENTER AWARD (2014-2015)

Awardee: Andererw Davol, adavol@calpoly.edu

Award: 4 units summer 2014

Summary of Accomplishments: The proposed work encompassed design and analysis work on a fiber reinforced solar collector for cooking applications. This work is in collaboration with Dr. Pete Schwartz in the Physics Department. Pete has consistently involved students from the college of engineering in his solar projects. The main goal of the project for me personally was to renew my familiarity with the design and analysis tools I commonly use including CAD, FEA and MATLAB. This goal was completely met. There were 3 specific projects proposed, FEA analysis of dish deformations for seasonal adjustment, rapid evaluation of prototypes for accuracy of solar concentration and Solar Decathlon house concentrated solar cooking surface. Progress was made on the first two projects. The last project was never pursued.

The main goal of the FEA portion of the project was successful and techniques for imposing the desired displacements on the dish have been developed. We are currently working on software to extract the shape of the deformed dish from the FEA analysis to bring it into custom MATLAB code developed by a previous grad student, Simo Alberti, to perform ray-tracing analysis to quantify the efficacy of the new design. We have been forced to write custom code to recreate the nodal normals on the deformed dish as ABAQUS does not export them. Progress was also made on the second project. An X-Box connect was purchased and used to scan existing solar collectors. Several free commercial software packages were tested and found to be insufficient for the needs of this project. Finally a software package, SKANECT, was purchased and we were successful in scanning in an existing dish. This data is in a form difficult for us to import into our ray-tracing code. More work is needed to refine this methodology.

The work continues and I am currently working with 1 ME graduate student and using this project as a lab project in ME328.

Related Documents and other Deliverables:

1. Invited Presentation "The Graphics Revolution in Engineering with Application to Solar Concentrator Design, Analysis and Testing", XXV International Conference on Graphics Engineering, San Sebastián, Spain, 2015

Student impact:

1. John Sekerak, Masters Thesis starting 2015
2. ME328 Design Project, Fall 2015

Proposals:

1. This work supported a \$66,000 proposal to Solar Cookers International by Dr. Peter Schwartz to build a mock solar kitchen at Cal Poly. Several ME students were involved in this effort.