Purdue's Engineer of 2020
Seed Grant Funding for 2009-2010
Purdue University

Project Title: Measuring and Modeling Purdue's Engineer of 2020 Attributes using a Neural Network Model of Student Success

Target Attribute(s) to be studied/implemented: Leadership; Teamwork; Communication; Decision-Making; Innovative; Strong Work Ethic; Adaptable in a Changing Environment; Curious and Persistent Continuous Learners.

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A. PROJECT DESCRIPTION

1. OBJECTIVE

The accelerating rate of technology introduction and adoption in our society will require individuals who can successfully apply and expand upon their fundamental knowledge of engineering to create effective solutions to the world's emerging problems. However, recent data suggest that the United States will be unable to meet this technological demand with its current workforce (CAFM, 2000; Johnson and Sheppard, 2004). Engineering education literature predicts that shrinking engineering enrollments pose a potentially serious problem for American industry and society (Board of Engineering Education, 1992; Heckel, 1996). The dwindling pool of new engineers is also exacerbated by low participation of underrepresented students (NSF, 2003; Morella, 2002; Fortenberry, 1994) and an annual graduation rate that has decreased by approximately 15% over the last two decades.

Purdue, like most other engineering schools, has undertaken major recruitment efforts to correct this problem. However, since first-year enrollment is heavily influenced by factors out of the university's control, such as fluctuations in the job market (Heckel, 1996), engineering schools are turning to retention as an effective strategy to improve graduation rates (Felder, 1998a, Prism 2005). The goal of retention, however, must include increasing the availability of a diverse and qualified supply of engineers from underrepresented populations.

Hence, accurately identifying the specific factors that affect student retention in engineering at Purdue is an essential first step towards offering appropriate interventions that can increase student success and persistence. However, it is not as if we are currently unaware of factors that correlate with academic success and failure. The work of Astin (1992), Tinto (1994), and Seymour (1994) and many less ambitious but first-rate studies over the past decade have given us a great deal of useful information. Nevertheless, we are still struggling with high attrition in our engineering curricula. At Purdue we typically lose approximately 25 percent of a beginning cohort of students as a result of their first-year experience and an additional 20 percent of the cohort once they move into their respective professional school (i.e., our typical overall graduation rate in engineering is only 55 percent).

Therefore, we propose to broaden the scope of on-going investigation that uses an existing novel and systematic approach to better understand the direct and indirect relationships among engineering student attributes and outcomes. This effort will leverage prior NSF funded research, which created an artificial neural network (ANN) model that employs a combination of cognitive and self-report affective (noncognitive) indicators students provide prior to their arrival on campus as inputs, to predict persistence after the first-year. The specific research objectives are to:

1) *begin developing additional affective (noncognitive) measures related to the Purdue Engineering of 2020 (PE 2020) attributes that can be incorporated into the model (e.g., adaptable in a changing environment, innovation). Said information can also provide programmatic information on how these attributes develop (or fail to develop) over the course of a student's undergraduate program; and*
2) *use an existing AAN model of student success developed by the authors to study how changes in students' core attributes over time (i.e., from year-to-year) influence persistence/success as well as investigate the NN model's sensitivity to gender and ethnicity.*

The results of this research will provide a basis by which the College of Engineering can obtain longitudinal information for a number of the ABET outcomes and PE 2020 attributes. In turn this data be used to assess how these attributes are related to success and persistence in engineering. In addition, the research will provide pilot data that can be used in future multi-institution NSF proposals.

2. BACKGROUND

The need to attract and retain students in engineering programs of study remains, by necessity, a focal point of interest and effort in engineering education. In 2002, over 386,000 U.S. students were enrolled in engineering undergraduate programs, according to the National Science Board (NSB, 2004). Considering the strong academic records of most students who choose to go into engineering, the observed rates of attrition are dramatic. In his massive study of nearly 25,000 students at over 300 institutions, Astin (1993a, 1993b, 1993c) found that only 43% of the first-year engineering students in his population went on to graduate in engineering. Moller-Wong and Eide (1997) obtained similar results for a cohort of 1,151 engineering enrollees at Iowa State University. They found that

after five years, 32% of their subjects graduated in engineering and 13% were still enrolled, for a potential graduation rate between 40% and 45%. Ultimately, well-documented attrition rates suggest that typically 50% to 70% of the freshman engineering students eventually will not graduate with an engineering degree, and 40% of departing students will end up switching to non-science fields (Besterfield-Sacre, *et. al.*, 1997, Astin, 1992). Significantly, half of that attrition will occur during and/or directly after the first year (Shuman, 1999). Even more striking is the fact that the remaining half of students leaving engineering do so later in their academic career, a period which has not typically been the focus of most retention research initiatives.

This raises obvious questions: *Why do so many students who meet and/or exceed initial admission standards at their respective institutions end up leaving engineering? Why is it that some students, who have lower than "typical" high school metrics (e.g., standardized tests scores, grade point averages), end up excelling in engineering? Why do so many "well qualified" students perform poorly in core engineering courses? Are there other measurable indicators are available to help advise, and/or develop appropriate intervention strategies to help students be more successful (i.e., retained) in engineering? Are there other measurable indicators that will help use create more inclusive learning environments for our students, which in turn will help them be more successful?*

There have been many seminal longitudinal studies that have focused on student retention modeling using various combinations of demographic, cognitive and noncognitive information (Zhang, *et. al.*, 1998, 2002; Huang, *et. al.*, 2000; Besterfield-Sacre, *et. al.*, 1995, 1997, 2002; Hayden and Holloway, 1985; Astin, 1971; Levin and Wyckoff, 1991). For example, Zhang *et. al.* (2002) used a multiple logistic regression model to test for and estimate the predictive relationships between retention and graduation (as a measure of success) and a set of six background variables that represented a student's pre existing demographic and academic characteristics (gender, ethnicity, high school GPA, SAT math score, SAT verbal score, and citizenship status). They found both graduation and retention in engineering significantly depended upon high school GPA and math SAT scores, while verbal SAT scores correlated negatively with odds of graduation. Zhang also showed that gender, ethnicity and citizenship had significant effects for some universities, but these were not consistently positive or negative predictors.

Astin (1971) studied 36,581 students and found that the student's academic record in high school was the best single indicator of how well they would do in college. He also indicated that there was a clear positive relationship between students' performance on tests of academic ability (e.g. SAT) and performance in college. In yet another study, Zhang (1998) tested several cognitive, affective, and psychomotor variables to see which of them predicted college persistence. They identified self-efficacy and physical fitness as positive predictors of freshman retention, while judgment and empathy were negatively associated with persistence. Lastly, Besterfield-Sacre, *et. al.* (1995, 1997, and 2002) developed the Pittsburgh Freshman Engineering Attitudes Survey (PFEAS), which has been used to gather information on incoming freshman engineering attitudes (pre-questionnaire) and changes in those attitudes at the end of the first year (post-questionnaire). The underlying theory behind the use of this survey is that student attitudes affect perceptions of engineering, motivation to learn, self confidence, competency, performance, and retention in engineering (Besterfield-Sacre, *et. al.*, 1998c). This survey underwent rigorous pilot testing in 1993 and 1994 (Besterfield-Sacre, *et. al.*, 1997). The resulting 50 items comprised 13 student attitude and self-assessment measures. This survey has been used in a number of NSF and EIF sponsored studies including prediction of probation in the freshman year (Scalise, 2000) and prediction of attrition (Besterfield-Sacre, *et. al.*, 1997), gender and ethnic differences (Besterfield-Sacre, *et. al.*, 1998a), institutional differences based on size, location, and classification (Besterfield-Sacre, *et. al.*, 1999), and use of control charts in assessment (Besterfield-Sacre, *et. al.*, 1998b).

3. BUILDING ON AN EXISTING MODEL

The undesirable fact regarding engineering student's high attrition rate has provided us a powerful motivation to study the various factors that have

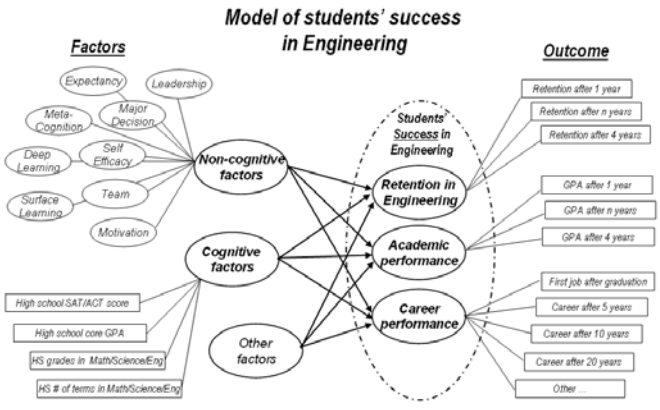

Fig. 1. Theoretical Model of Student Success in Engineering

potential influence over engineering students' success. A graphical representation of the current Model of Students' Success (MSS) in engineering, including numerous factors and outcomes regarding engineering students' success in academics and career, is shown in Fig. 1. The focus of this investigation will be to expand various noncognitive and cognitive factors that have the potential to become good predictors for student retention in engineering as well as provide a bases by which we can evaluate the development (or lack thereof) of students' PE 2020 attributes over the span of their engineering program (i.e., prior to their arrival on campus through graduation).

The existing neural network model used for predicting students' retention is a feed-forward neural network with back-propagation training algorithm (FFBP). The FFBP neural network was chosen because of its strength in modeling prediction/forecast problems involving large amount of data and relatively complex relationship between factors and outcomes. The FFBP neural network model developed for this research consisted of an input layer, a hidden layer and an output layer with various numbers of neurons in each layer. The numbers of neurons in the input and output layers were determined by the number of input items and prediction outcome. The decision on the number of hidden neurons in each ANN model was determined by comparing performance results from extensive ANN experiments covering wide ranges of possible number of hidden neurons in the network, trained with actual student data. A general graphic illustration of applying the AAN model for the prediction of student's persistence after the first-year is shown in Fig. 2.

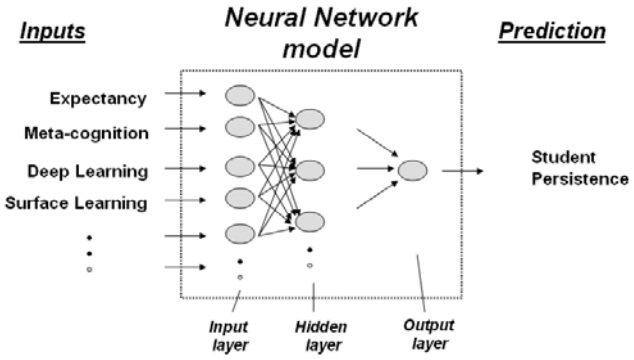

Fig. 2. Using noncognitive factors as inputs for Neural Network prediction models

3.1 Current noncognitive survey instruments and cognitive data.

The students' noncognitive measures (a number of which are directly related to PE 2020 attributes) are collected across nine scales in a self-reported online survey completed prior to their first-year. The scales are: Leadership (23 items), Deep vs. Surface Learning Types (20 items), Teamwork (10 items), Self-efficacy (10 items), Motivation (25 items), Meta-cognition (20 items), Expectancy-value (32 items), and Major decision (28 items). All Cronbach's coefficient alphas for these eight scales were ≥ .80, except for the Teamwork scale (r=.74). Scales may be divided into subscales with various numbers of items. Multiple studies have supported the scales' construct validity based on the results of confirmatory factor analyses.

The current cognitive items from students include: overall GPA and core GPA from high school, standardized test results (SAT/ACT), average high school grades in mathematics, science, and English classes, and finally the number of semesters taking mathematics, science, and English.

3.2 Current state of modeling.

Table 1 displays the current capability of the AAN model to identify "at risk" students using noncognitive information they provided prior to starting at Purdue. In this example, the model was trained using responses to sixty noncognitive items from a sub-set of 2004 academic year (AY) students as input along with their current major at the beginning of the third semester. The AAN model was then used on the remaining 2004 AY cohort as well as the 2005 AY and 2006 AY cohort responses to predict whether a student would (or would not) be retained in engineering.

Table 1. Predicting future student's retention status with 60 noncognitive items as input to an ANN model.

Cohort year	2004 AY*	2005 AY*	2006 AY*
Overall Prediction Accuracy	70.5%	70.3%	71.8%
POD Retained	78.3%	78.1%	77.6%
POD** Not Retained	37.9%	37.4%	40.2%

*predictions based on training with a single dataset with no overlapping in membership.
** POD is the Probability of Detecting

3.3 Connecting the existing model to ABET criteria and PE 2020 attributes.

The Accreditation Board for Engineering and Technology (ABET, 2004) calls for the development of a process of ongoing evaluation for attainment of engineering program objectives. The Success Scale, when implemented at multiple points throughout a student's academic program, has great potential to provide evidence across the ABET Criterion 3 a-k Program Outcomes of relative changes in students' cognitive and noncognitive abilities. Many of the Success Scale sub-scales can be mapped to the ABET Criterion 3 a-k. Of particular interest are criteria related to professional and personal skills development that are often difficult to measure, such as (i) a recognition of the need for, and an ability to engage in life-long learning. The Deep Learner/Surface Learner, Motivation, and Expectancy-Value subscales each address aspects of life-long learning and provide a mechanism to track student changes as they progress to graduation. This information can be used to inform programmatic reform and improve the rate and nature of these changes. Table 2 provides a comparison between subscales of the current version of the Success Scale and ABET outcomes.

Table 2 Comparison of success instrument to current ABET outcomes.

ABET Criterion 3 a-k as appropriate	Success Scale Sub-Scales
(a) an ability to apply knowledge of mathematics, science, and engineering	Academic self-efficacy
(c) an ability to design a system, component, or process to meet desired needs (e) an ability to identify, formulate, and solve engineering problems	Academic self-efficacy, Leadership, Deep learner/Surface learner
(d) an ability to function on multi-disciplinary teams	Teamwork, Academic self-efficacy Leadership
(f) an understanding of professional and ethical responsibility	Expectancy-value
(g) an ability to communicate effectively	Academic self-efficacy, Leadership
(h) the broad education necessary to understand the impact of engineering solutions in a global and societal context	Deep learner/Surface learner
(i) a recognition of the need for, and an ability to engage in life-long learning	Deep learner/Surface learner, Motivation, Expectancy-value
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	Academic self-efficacy

In addition to aforementioned sub-scales (dimensions) of the Success Scale, we will begin adding new affective dimensions that will provide a measure of noncognitive self-report abilities directly related to the PE 2020 attributes. This will provide a mechanism to track student changes as they progress to graduation. In addition, this information can be used to inform programmatic reform and improve the rate and nature of these changes.

4. PROPOSED PLAN OF RESEARCH

We will administer the web-based Success Model scale to Purdue Engineering sophomores, juniors, and graduating seniors at the end of the spring semester in the 2009 AY and 2010 AY. We will then compute the change in students' cognitive and noncognitive measures and use it as input to an ANN model to investigate how said change is related to retention in engineering. We currently have baseline data (i.e., response to the current noncognitive items) for beginning engineering cohorts from the 2004 AY through the 2008 AY. Therefore, this one-year pilot study we will enable us to collect and analyze data for the entire spectrum of students. The dataset will be

insufficient to construct a complete graduation model. However, it will be provide valuable insight regarding pattern changes we can anticipate in the future. The dataset will also enable us to investigate the magnitude of response change from the baseline data for each cohort student. Finally, we will have the opportunity to investigate evidence to see if scores have equal meanings (i.e., are not biased) across groups (e.g., gender, ethnic).

We expect individuals will display patterns of performance across these measures and similar individuals will form groupings or taxonomies suggestive of subtypes. These groupings thus will enable use to build on an existing neural network model based on the cognitive and noncognitive measures. As students progress through an engineering program, these taxonomies naturally may vary over time.

4.1 Research questions

The proposed effort will enable the investigators to begin answering the following research questions:

1) What PE 2020 attributes are appropriate to include in the Success Model?
2) How do student attributes (i.e., current noncognitive items that relate to ABET outcomes and new PE 2020) change over time and how will that change impact the AAN model predicative behavior?
3) Do subgroups (gender, ethnic) within the sample differ on the underlying latent traits (e.g., teamwork, motivation) measured by the noncognitive instruments?
4) Do changes in beliefs vary by gender and ethnicity?
5) What are essential neural network characteristics of students' scores across noncognitive and cognitive measures for each academic year (e.g., freshmen, sophomore)?

Having the opportunity collect pilot data as well as begin answering the aforementioned research questions will strengthen our future plans to submit a multi-institution research proposal to NSF's STEM Talent Expansion Program (STEP) program (type II).

5. EVALUATION PLAN

The research team will assemble a local (Purdue) assessment review panel to meet three times over the course of the project. The panel will consist of a member of the PE 2020 committee, the College of Engineering Assessment Committee (Diane Beaudoin), and an individual from the Discovery Learning Center Assessment and Research Evaluation Team. The invited Assessment Review Panel will examine project goals, methods, progress and final results. Initially, panel members will be asked to identify what they consider to be the strengths and weaknesses of the proposed work to ensure the PI and Co-PI's carefully work through unanticipated problems/issues before updating survey instruments and starting data collection. After the project is underway, the panelists will meet annually to identify and evaluate: 1) progress toward meeting project goals, 2) major accomplishments, 3) problems and barriers to success, 4) effective use of data to support the project deliverables, and 5) suggestions for project improvement and increased impact. This evaluation process will provide the research team responsive feedback regarding strengths and weaknesses of the project as well as a semi-annual summary of progress toward meeting the stated project goals.

6. DISSEMINATION PLAN

As stated in the RFP, awardees will be expected to submit a short mid-year report as well as a final report. In addition, although specific travel funds have not been requested, results of the research will be present at either 2011 ASEE Annual Convention or the 2011 Frontiers in Education Conference. We will also seek to obtain a time slot in the Department of Engineering Educations Seminar sequence, which is held both in the Fall and Spring semesters. Finally, once the College of Engineering Assessment Committee is formed, we will request the opportunity to present the current state of our research and findings.

B. Timeline and Implementation Strategy

Item		2009											2010	
		2	3	4	5	6	7	8	9	10	11	12	1	2
1	Form Advisory Board	■												
2	Meet with Schools to arrange to collect data with their students and arrange for IRB approval	■	■											
3	Release Web-Based instruments for all students (collect data on all COE students)			■	■									
4	Begin lit. search for affective instruments for PE 2020 attributes	■	■	■										
5	Begin creating new PE 2020 scales		■	■	■				■	■	■	■	■	■
6	Release new PE 2020 scales to FYE students					■	■							
7	Data analysis of change scores					■	■	■	■	■				
8	Analyze data for gender/ethnicity effects					■	■	■	■	■				
9	Analyze data and refine ANN modeling								■	■	■	■	■	■
10	incorporate pilot data into NSF STEP proposal						■	■	■					
11	Presentation at ENE Seminar									■	■			
12	Advisory Board Meetings		■					■					■	
13	Prepare project report						■							
14	Submit abstract to national conferences (ASEE and FIE)									■			■	

C. PERSONNEL REQUIREMENTS

Faculty member	Summer 08	Fall 08	Spring 09
P.K. Imbrie	0.25		
Teri Reed-Rhoads	0.25		

D. BUDGET

Faculty/Staff Member Funding			
	Grant funds requested		
Faculty/Staff Name:	% Time	Fringe Benefits	$$
P.K. Imbrie	25% of a 1 month	$758	$2,910
Teri Reed-Rhoads	25% of a 1 month	$863	$3,313
Subtotal Faculty/Staff Funding		$ 1,621	$ 6,223

Graduate Students				
	Grant funds requested			
Type of position	% Time	Insurance + Fee Remit	Fringe Benefits	$$
TBA Graduate Student	50% FY	$7,603	$139	$30,542
Subtotal Graduate Student Personnel		$ 7,603	$ 139	$ 30,542

Undergraduate Student Funding.			
	Grant funds requested		
Type of position	Hrs/week	Fringe Benefits	$$
TBA Undergraduate Student Worker	5 hrs/week	$383	$1,100
Subtotal Undergraduate Student Personnel		$383	$1,110

Equipment Funding	
Name of Equipment	Funds Requested
2 - Seagate Cheetah 15K.5 - hard drive - 300 GB - Ultra320 SCSI	$1135
Subtotal Equipment	$1135
Printing/Page Charges for dissemination	$500
Subtotal miscellaneous	$500
Total Grant Funds requested for the Project	
	$40,000

E. BUDGET JUSTIFICATION

Faculty: Prof. P. Imbrie, (PI) will receive 1 week of summer support for his role as PI on the project as well as for his role in developing the success instrument and neural network model. Prof. Reed-Rhoads will receive 1 week of summer support for conducting quantitative elements of the proposed effort as well as for overall evaluation of the model.

Graduate Student Research Assistant: Graduate student funding (50% FY) is included for one position to support the ANN model development as well as perform the literature search to identify existing scales or theories related the PE 2020 attributes to be incorporated in the model.

Undergraduate Students: The requested funds provide support for one undergraduate engineering student to be employed, part time, for the duration of the project. The student will be solicited for his/her expertise in using web-development tools, since the instruments being deployed are web-based.

Equipment: Funds are requested to purchase two Seagate Cheetah 15K.5 - hard drive - 300 GB - Ultra320 SCSI. The disc drives will be added the ECN Oracle server to store data being collected during and after the project.

Miscellaneous: Funds have been requested for printing and page charges for dissemination at the national conference (FIE or ASEE)

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G. PI BIOSKETCHES

P.K. IMBRIE, Associate Professor

a. Professional Preparation

Texas A&M University	Aerospace Engineering	B.S, 1980
Texas A&M University	Aerospace Engineering	M.S, 1985
Texas A&M University	Aerospace Engineering	Ph.D., 2000

b. Appointments

Associate Professor, Engineering Education, Purdue University, W. Lafayette, IN, 2006 – Present
Assistant Professor, Engineering Education, Purdue University, W. Lafayette, IN, 2000 – 2006
Lecturer, Aerospace Engineering, Texas A&M University, College Station, TX 1984-1997

c. Publications

(i) Closely Related:

1. Smith, K.A. and Imbrie, P.K. (2007). *Teamwork and Project Management*. 3rd ed. New York: McGraw-Hill. BEST Series.
2. Immekus, J.C. and Imbrie, P.K. (2007) "Dimensionality Assessment using the Full-Information Item Bifactor Analysis for Graded Response Data: An Illustration with the State Metacognitive Inventory," *Educational and Psychological Measurement* (submitted in June 2007 and in review)
3. Imbrie, P.K., Lin, J.J., Oladunni, O.O. and Reid, K. (2007). "Use of a Neural Network Model and Noncognitive Measures to Predict Student Matriculation in Engineering," *Proceedings of the 2007 American Society of Engineering Education Annual Conference and Exposition*, Honoluulu, Hawaii. 10 pgs.
4. Moore, T.*, Diefes-Dux, H, and Imbrie, P.K. (2006) "Spontaneous Groups Versus Long-Term Teams: An Investigation Using Complex Problem Solving In A First-Year Engineering Course," *Proceedings of the 2007 American Society of Engineering Education Annual Conference and Exposition*, Honolulu, Hawaii. 14 pgs.
5. Imbrie, P.K.*, Lin, J.J. (2006) "Work in Progress" Engineering Students' Change in Profile over the Freshman Year Across Male and Female Samples: A Neural Network Approach." *Proceedings of the 2006 Frontiers in Education Conference*, San Diego, California. 2pgs.

(ii) Other:

1. Raghavan, S., and Imbrie, P.K. (2007) "A 3D Stress Measurement Model for Chromium-doped Alumina using the Photo-stimulated Luminescence Spectroscopy Technique," Proceedings of the 44th Annual Technical Meeting of the Society of Engineering Science, college Station Texas. 4 pgs. (to appear)
2. Raghavan, S., and Imbrie, P.K. (2007) "The Development of Photo-stimulated Luminescence Spectroscopy for 3D Stress Measurements in the Thermally Grown Oxide Layer of Thermal Barrier Coatings," *Proceedings of the 2007 Materials Science & Technology Conference and Exposition*, Detroit, Michigan. 12 pgs. (to appear)
3. Imbrie, P.K. and Haghighi, K. (2006) "Creating the Research Agenda for Engineering Education" *ASEE/ABENGE 5th Annual ASEE Global Colloquium on Engineering Education*, Rio de Janeiro, Brazil.
4. Moore, T.*, Diefes-Dux, H., and Imbrie, P.K. (2006) "The Quality of Solutions to Open-Ended Problem Solving Activities and its Relation to First-Year Student Team Effectiveness" *Proceedings of the 2006 American Society of Engineering Education Annual Conference and Exposition*, Chicago, Illinois. 13 pgs.
5. Moore, T.*, Diefes-Dux, H., and Imbrie, P.K. (2005) "Developing First-Year Students' Perceptions of the Engineering Profession Through Realistic Client-Driven Problems" *Proceedings of the 2005 Frontiers in Education Conference*, Indianapolis, Indiana. 7 pgs.

d. Synergistic Activities

Technical Research:

1. I am currently collaborating with faculty members from Mechanical Engineering and Materials Engineering at Purdue University to develop a fundamental understanding of degradation processes, such as moisture and contaminant limits, for plasma-sprayed thermal barrier coatings (TBCs), which are subjected to a hostile thermal environment. The goal of the research effort is to identify the interrelationship between sintering, thermally grown oxide (TGO) formation and thermal fatigue life.

Educational Research and Teaching:

1. Workshop entitled "The Active/Collaborative Classroom and the Use of Teams" – I have developed and continue to deliver a 16-hour workshop which: describes what Active-Collaborative Learning (ACL) is all about and how a person can start using the methodology in their courses; what some of the ACL structures are; what benefits of ACL are and why ACL works; trains faculty on how to teach students about effective teaming and how they can use teaming in the classroom to enhance student learning; trains faculty on team facilitation; exposes faculty to various leaning styles; teaches faculty how to write learning objectives for outcome based assessment methods. This workshop has been presented at engineering education conferences, as well as numerous universities across the country and internationally.

2. First-Year Engineering Course Development – I have developed and facilitated innovations in the first and second semester honors first-year engineering courses to provide opportunities for students to learn about engineering through the application of fundamental engineering concepts. The innovations in the course include the incorporation of engineering focused problem solving, careful selection of technical team members to work on problem solving situations, use of computers as tools in problem solving, incorporation of engineering fundamental topics (e.g., economics, statistics, conservation principles), and connections to other course work (e.g., freshmen calculus). The role of coordinator has included working with the graduate teaching assistants, incorporating computer tools to facilitate the learning processes and monitoring of student teams, and the development of a virtual classroom environment to deliver course material and/or provide assistance to individuals and students teams over the internet.

e. Collaborators & Other Affiliations

Collaborators:

1. Budny, D., Assoc. Prof., Civil Engineering and Director, Freshman Engineering Programs, University of Pittsburgh.
2. Diefes-Dux, H.A., Assoc. Prof., Department of Engineering Education, Purdue University.
3. Everett, L.J., Professor, Department of Mechanical Engineering, University of Texas, El Paso.
4. Lagoudas, D.C., Prof., Department of Aerospace Engineering, Texas A&M University.
5. LeBold, William, Prof. Emeritus, Department of Engineering Education, Purdue University.
6. Malavé, C., Assistant Dean of Engineering and Professor, Industrial and Systems Engineering, Texas A&M University.
7. Morgan J., Assoc. Prof., Department of Civil Engineering, Texas A&M University.
8. Oakes, William, Assoc. Prof., Department of Engineering Education, Purdue University.
9. Slattery, J.C., Prof., Department of Aerospace Engineering, Texas A&M University.

Graduate Advisors:

1. Allen, David H., Professor, Department of Aerospace Engineering, Texas A&M University, (Ph.D. Committee Member).
2. Bradley, Walter L., Associate Professor, Professor, Department of Mechanical Engineering, Texas A&M University, (Ph.D. Committee Member).
3. Lagoudas, Dimitris C., Professor, Department of Aerospace Engineering, Texas A&M University, (Ph.D. Chair).
4. Pollock, Thomas C., Associate Professor, Department of Aerospace Engineering, Texas A&M University, (Ph.D. Committee Member).
5. Slattery, John C., Professor, Department of Aerospace Engineering, Texas A&M University, (Ph.D. Committee Member).

Thesis Advisor:

1. Wahid Mamun, School of Aeronautics and Astronautics, Purdue University (Ph.D. 2001 - 2005).
2. Seetha Raghavan, School of Aeronautics and Astronautics, Purdue University (Ph.D. 2003 - 2007).
3. Jien-Jou Lin, Department of Engineering Education, Purdue University (Ph.D. 2005-present).
4. Kenneth Reid, Department of Engineering Education, Purdue University (Ph.D. 2005-present).
5. Junqui Wang, Department of Engineering Education, Purdue University (Ph.D. 2007 - present).

Total Graduate and Post Doctoral Students Directed: Ph.D. 5

TERI REED-RHOADS, Assistant Dean for Undergraduate Education
Purdue University, Department of Engineering Education
Phone: (office) 765-494-4966 (fax) 765-496-1180 E-Mail: trhoads@purdue.edu

A. PROFESSIONAL PREPARATION

The University of Oklahoma (OU)	Petroleum Engineering	B.S.	1985
University of Texas of the Permian Basin	Business Administration	M.B.A.	1992
Arizona State University	Industrial Engineering	Ph.D.	1999

B. APPOINTMENTS

6/06-present	Assistant Dean	Undergrad Education, College of Engineering, Purdue
6/06-present	Associate Professor	Department of Engineering Education, Purdue
6/06-present	Executive Director	Institute for P-12 Engineering Research and Learning
1/05-6/06	Associate Dean	Education, College of Engineering, OU
8/02-12/04	Director	Engineering Education, College of Engineering, OU
1/00-6/06	Assistant Professor	School of Industrial Engineering, OU
10/98-10/99	Strategy Director	Foundation Coalition Assessment and Evaluation
8/97-10/98	Assessment Director	ASU Foundation Coalition (NSF sponsored).

C. SELECTED PUBLICATIONS - i. Project-Related Publications

Allen, Kirk, Teri Reed-Rhoads, Robert Terry, Teri J. Murphy, and Andrea Stone, "Coefficient Alpha: An Engineer's Interpretation of Test Reliability". *Journal of Engineering Education*, January 2008.

Murphy, Teri J., Randa L. Shehab, Teri Reed-Rhoads, Cindy E. Foor, Betty J. Harris, Deborah A. Trytten, Susan E. Walden, Mary Besterfield-Sacre, M. Susan Hallbeck, and William C. Moor, "Achieving Parity of the Sexes at the Undergraduate Level: A Study of Success". *Journal of Engineering Education*, October 2007.

Chimka, Justin R., Teri Reed Rhoads and Kash Barker, "Proportional Hazards Models of Graduation", *Journal of College Student Retention: Research, Theory & Practice*, Winter 2008.

Rhoads, Teri Reed, Susan E. Walden, Brent A. Winter, "The Sooner Elementary Engineering and Science Clubs – a model for after-school science clubs based on university and K-5 partnership". *The Journal for STEM Education: Innovations and Research*, 5(3-4), pp. 47-52.

Harris, Betty J., Teri Reed Rhoads, Susan E. Walden, Teri J. Murphy, Reinhild E. Meissler, and Anne Reynolds, "Female Perceptions of the Industrial Engineering Major Compared: A Pilot Study". *National Women's Studies Association Journal*, 16(1), 2004, pp. 186-193.

ii. Additional Publications

Teri Reed Rhoads and Norma Faris Hubele. "Student Attitudes Toward Statistics Before and After a Computer-Integrated Introductory Statistics Course". *IEEE Transactions on Education*, vol. 43, no. 2, pp. 182 - 187.

Reed Rhoads, Teri, Susan E. Walden, Brent A. Winter, "The Sooner Elementary Engineering and Science Clubs – a model for after-school science clubs based on university and K-5 partnership". *The Journal for STEM Education: Innovations and Research*, 5(3-4), 2004, 47-52.

Allen, Kirk, Teri Reed-Rhoads, and Robert Terry, "Misconception or Misunderstanding? Assessing Student Confidence of Introductory Statistics Concepts", *FIE 2006 Annual Meeting CD Rom*, San Diego.

Reed-Rhoads, Teri , Kirk Allen, and Andrea Stone, "Concept Inventories: A Borderless Opportunity?", ASEE/AaeE 5th Global Colloquium on Engineering Education, Rio de Janeiro, Brazil, October 9 – 12, 2006.

Rhoads, Teri Reed, Mark A. Nanny, and Mary John O'Hair, "After the Funding: Sustaining an NSF GK-12 Outreach Initiative", ASEE/AaeE 4th Global Colloquium on Engineering Education, Sydney, Australia, September 26 – 30, 2005.

D. SYNERGISTIC ACTIVITIES

Selected Research Awards in Assessment

2007-2009, **NSF DUE: Assessing the State of STEM Concept Inventories: A National Workshop,** $68,068, PI: Reed-Rhoads, Co-PI: Imbrie

2002-2007, **NSFASA: Statistical Concepts Inventory,** $499,997, PI: Reed-Rhoads, Co-PI: Murphy.

2009-2011, **NSF IEECI: Entrepreneurial Learning in Engineering Students: Examining the Impact of Faculty Beliefs, Teaching Practices, and Program Features,** Purdue PI: Reed-Rhoads, Co-PI: Duval-Couteil.

Selected Research Awards in Education

2005-2008, **STEP: Portraying Success Among URM Engineering Majors,** National Science Foundation, $1,460,431, PI: Shehab, Co-PI: Reed-Rhoads, Murphy, Walden, and Davidson.

2002-2005, **PGE: Why does it work? A Study of Successful Gender Equity in Industrial Engineering at the University of Oklahoma,** National Science Foundation, $896,000, PI: Murphy, Co-PI: Reed-Rhoads, Shehab, Fleener, Harris.

2002-2005, **REU Site: Manufacturing Metrology and Quality Engineering,** National, Science Foundation, $347,005. PI: Raman, Co-PI: Reed-Rhoads.

2001-2005, **ATA – Authentic Teaching Alliance,** National Science Foundation, K-12 Graduate Fellows Program (DGE0086457): $1,495,000. PI: Nanny, Co-PI: Reed-Rhoads and O'Hair.

Selected Research Awards in Electronic Learning

2/01-1/02, **Adaptable Learning Tools***,* The College of Engineering Dean's Fund: $231,000. Co-PI's: Court, Reed-Rhoads, Shehab and Trytten

2001-2004, **Electronic Media in Teaching Project,** Hitachi Found., $249,840: Co-PI: Gramoll.

Selected Presentations and Invited Meeting Participations in Assessment

2004, Engineering Tomorrow Today Collaboratively Affecting Change in the Educational Tapestry, Invited Presentation, University of Purdue, West Lafayette, IN, January 22 and at University of Indiana-University of Purdue, Indianapolis, Indianapolis, IN, January 23.

2003, ASME invited presentation to the Arkansas Legislator Forum on K-12 Engineering Education, Little Rock, AR, March and *The K-12 Tapestry: Weaving Collaborative Efforts at the University of Oklahoma*, IEEE Dean's Summit, Miami, FL, January 10.

2001, *Forum for Engineering Education Leadership*, ERM Division of ASEE, Albuquerque, NM, June 23 and the 2001, *National Forum on Cross-Disciplinary Approaches to Scientific and Technological Literacy in K-12 Education*, Washington, D.C., May 3.

2000, Best Assessment Practices III Seminar, *Developing Course and Curriculum Objectives*, April 3, 2000, presentation at Rose-Hulman Institute of Technology, Terre Haute, IN.

Selected Awards in Education

2007 – 2008, *Committee on Institutional Cooperation Academic Leadership Program Fellow.*

2002, *Brandon H. Griffith Outstanding Teaching Award*, College of Engineering at OU.

2001 – 2002, *Educators' Leadership Academy, Outstanding Professors Academy.*

2001, *Frontiers in Education New Faculty Fellowship*.

E. COLLABORATORS & OTHER AFFILIATIONS

i. Collaborators: P.K. Imbrie, H. Diefus-Deux, M. Cox, K. Haghighi – Purdue, B. Harris, T.J. Murphy, M. Nanny, M.J. O'Hair, S. Raman, R. Shehab, D. Trytten, R. Knox, R. Kolar, R. Terry, S. Walden, C. Foor, J. Davidson – OU; D. Evans, N. Hubele, D. Montgomery, W. Moor – ASU, S. Hallbeck–Univ of Nebraska, M. Besterfield-Sacre, H. Wolfe, L. Shuman–Univ of Pittsburgh, E. Mitchell – OSU, E. Seymour – retired.

ii. Graduate Advisor: D. C. Montgomery, D. Rollier (deceased), and Dr. B. Keats, ASU.

iii. Total number sponsored/advised: postdocs 1; doctoral students 8; masters students 12
Masters Students Completed in the past five years: Mauldin, Madole, Barker, Winter
Ph.D. Students Completed in the past five years: Allen, Johnson

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: **P.K. Imbrie**	Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Collaborative Research: The Success Scale: Modeling Student Success in Engineering-A Systematic Approach to Measuring the Impact of Both Cognitive and Affective Indicators
Source of Support: National Science Foundation
Total Award Amount: $820,019 Total Award Period Covered: 08/1/2009-07/31/2013
Location of Project: Purdue University
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 0.50

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: S-STEM Scholars of Purdue: Program to Promote and Sustain Interest in Engineering Through Engaging in Experiential Learning
Source of Support: National Science Foundation
Total Award Amount: $600,000 Total Award Period Covered: 05/18/2009-05/17/2013
Location of Project: Purdue University
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 0.00

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Assessing Engineering Students' Mathematical preparation to Create Engineering Solutions
Source of Support: National Science Foundation
Total Award Amount: $150,000 Total Award Period Covered: 11/01/05 – 10/31/09
Location of Project: Texas A&M University / Purdue University
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 0.50

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Assessing Student Team Effectiveness
Source of Support: National Science Foundation
Total Award Amount: $499,999 Total Award Period Covered: 08/01/05 – 07/31/09
Location of Project: Purdue University
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 1.00

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Reforming Engineering Education: Multidisciplinary Engineering
Source of Support: National Science Foundation
Total Award Amount: $999,993 Total Award Period Covered: 09/01/04 – 08/31/09
Location of Project: Purdue University
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 0.90

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: **Teri Reed-Rhoads**	Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Research with Industry Context Experience for Teachers
Source of Support: National Science Foundation
Total Award Amount: $516,000 Total Award Period Covered: 6/1/2009 – 5/31/2012
Location of Project: Purdue University
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:0.5

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: R&D: Quality Cyber-Enabled, Engineering Education Professional Development to Support Teacher Change and Student Achievement (E2PD)
Source of Support: National Science Foundation
Total Award Amount: $3,000,000 Total Award Period Covered: 8/15/08 – 8/14/12
Location of Project: Purdue University
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:0.75

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Entrepreneurial Learning in Engineering Students: Examining the Impact of Faculty Beliefs, Teaching Practices, and Program Features
Source of Support: National Science Foundation
Total Award Amount: $500,000 Total Award Period Covered: 1/1/09 – 12/31/11
Location of Project: NCIIA subaward to Purdue University
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 0.5

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Purdue Center for Faculty Success
Source of Support: National Science Foundation
Total Award Amount: $3,950,000 Total Award Period Covered: 08/2008 – 08/2013
Location of Project: Purdue University
Person-Months Per Year Committed to the Project. Cal: 0 Acad: 1.00 Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: S-STEM Scholars of Purdue: Program to Promote and Sustain Interest in Engineering Through Engaging in Experiential Opportunities
Source of Support: National Science Foundation
Total Award Amount: $600,000 Total Award Amount: 05/14/09 – 05/13/13
Location of Project: Purdue University
Person-Months Per Year Committed to the Project. Cal: 0 Acad: 0.00 Sumr: 0.00

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Assessing the State of STEM Concept Inventories: A National Workshop
Source of Support: National Science Foundation
Total Award Amount: $68,068 Total Award Amount: 04/30/07 – 04/29/09
Location of Project: Purdue University
Person-Months Per Year Committed to the Project. Cal: 0 Acad:0 Sumr:0

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Portraying Success Among URM Engineering Majors
Source of Support: National Science Foundation
Total Award Amount: $ 1,444,284.00 Total Award Period Covered: 1/1/2005 – 12/31/2008
Location of Project: The University of Oklahoma
Person-Months Per Year Committed to the Project. Cal: 0.0 Acad: 0.0 Sumr: 0.0

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Collaborative Research: The Success Scale: Modeling Student Success in Engineering – A Systematic Approach to Measuring the Impact of Both Cognitive and Affective Indicators
Source of Support: National Science Foundation
Total Award Amount: $1,500,000 Total Award Period Covered: 8/1/2009 – 7/31/2013
Location of Project: Purdue University
Person-Months Per Year Committed to the Project. Cal: Acad:0.5 Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.