Purdue's Engineer of 2020
Seed Grant Funding Proposal for 2008-2009
Purdue University

Project Title: The Engineer as an Entrepreneur: Using Case-Driven, Problem-Based Learning to Develop Adaptive Expertise

Target Attribute(s) to be studied/implemented:

Primary targets will include Synthesizing engineering, business, and societal perspectives, Open-ended design and problem solving skills, Entrepreneurial and Intrapreneurial qualities, and Adaptive learning. Secondary targets that relate closely with the primary targets and are naturally linked to the proposed project output include: leadership, teamwork, communication, decision-making, management of change, working effectively in a diverse team, and innovativeness.

PI Information:

Name: Joe Sinfield
Email:jvs@purdue.edu
Department: N/A
School: Civil Engineering
Campus address: CIVL G231
Phone number: 765-496-2742
Fax: N/A
Department Head Name: Kathy Banks
Department Head email:kbanks@exchange.purdue.edu

Co-PI Information:

Name: Robin Adams
Email:rsadams@purdue.edu
Department: Engineering Education
Campus Address: 1233 ARMS
Campus Phone: 765-496-3267

Name:Aman Yadav
Email:amanyadav@purdue.edu
Department: Educational Studies
Campus Address: BRNG 5120
Campus Phone: 496-2354

A. Project Description

Introduction

As outlined in The Engineer of 2020: Visions of Engineering in the New Century (NAE, 2004) there is general recognition that the Engineer of 2020 will face challenges that require much broader skill sets than those honed in typical engineering coursework which primarily emphasizes the technical facets of the field. Engineers operating in the future will require interdisciplinary and potentially trans-disciplinary approaches to their work that are characteristic of complex problems that link science, technology, and social systems (Klein, 1990, 1996, 2004; Kline, 1995) and efforts to innovate at the interface between perspectives (CFIR, 2005; Johansson, 2004). Such work environments will be inherently ill structured and complex due to conflicting goals, unanticipated problems, multiple solution methods, non-engineering success standards and unavoidable constraints (Jonnasen, Strobel, and Lee, 2006). Thus, there is a need to provide engineering students of the future with a multi-faceted educational experience that will help them develop the abilities, knowledge, and personal and professional qualities that define an individual who can master technical challenges, while also addressing the less structured, and more intangible economic and social issues inherently linked to the engineering endeavor. The skills required to successfully manage these business and societal influences, while uncommon in the formal training of engineers today, represent the hallmark of another category of successful professionals - the *entrepreneur*.

Many of the challenges for which our graduating engineers are arguably ill-equipped parallel the issues routinely encountered by an entrepreneur in a typical business context. The entrepreneur focuses on the needs of their existing or anticipated customers much as the engineer develops an understanding of the needs of their project and the inhabitants in the environment in which that project must be created. As the entrepreneur develops products or services for their customer base, the work of the engineer is targeted toward the development of technological solutions that address emerging needs in society. Finally, to succeed, the entrepreneur must develop a means to deliver their offering to their customers in a cost-effective way that generates the profits required for their nascent business to grow and flourish. In the same manner, the engineer must evaluate new technological concepts and adapt their "development and commercialization" approach to ultimately deploy "solutions" to facilitate long-term sustainability of the engineered system for the benefit of its users. As such, a focus on the entrepreneurial engineer facilitates a variety of complementary abilities, knowledge, and qualities for the Purdue Engineer of 2020.

The rationale to pursue entrepreneurial skills as an analog for the desired attributes of the Purdue 2020 engineer is further solidified through recognition that the nature of entrepreneurial endeavors inherently involves uncertainty and requires entrepreneurs to adapt their knowledge, skills, and thinking to their circumstances. In his 1996 work, "Road Well Traveled: A Note on the Journeys of HBS Entrepreneurs", Harvard Business School Professor Amar Bhide (1996) discussed the challenges faced by those pursuing new ventures and indicated that those who succeed in finding a path to market, test their ideas rapidly and frequently and then adapt their strategies, often multiple times. Foster (1986) demonstrated that new companies, typically commanded by entrepreneurs, put forward concepts early in their development unencumbered by the wishes of a market's "best" customers, and thus learn quickly what will and will not satisfy the needs of the broader spectrum of the market population. Similarly, Christensen et al. (2002), who call out the merits of "disruptive innovations," argue that the commercial pursuit of ideas early in their development, which most incumbent competitors would deem to be inferior in

quality along commonly accepted dimensions of performance, can have significant impact and offer solutions to the problems faced by the masses if presented in a manner that helps people overcome challenges of access, expertise, cost or time. These same concepts can be applied to rapidly iterate the byproducts of engineering activities with the key stakeholders in society (users of engineered products and systems) and will thus be critical for those striving to address the complex engineering problems of the future.

With these parallels in mind, the investigators intend to leverage the experiential contexts familiar to an entrepreneur as a means to develop desired attributes of the Purdue Engineer of 2020. More specifically, this proposal outlines a plan to develop and pilot the use of entrepreneurially-oriented, *problem-based learning* methods as a means to cultivate the attributes of the Engineer of 2020 and facilitate the development of *adaptive expertise* which will be required for engineers to successfully fulfill the mission of their profession in the future.

Problem-Based Learning (PBL) is a pedagogical technique which conditionalizes students' knowledge, helping them understand "when, where, and why to use the knowledge they are learning", and requires them to integrate multiple sources of information in an authentic context (Bransford, Brown, & Cocking, 1999). A fundamental approach to problem based learning entails the use of case studies that place an emphasis on situating learning in authentic and meaningful contexts (Brown, Collins, & Duguid, 1989). A focus on problem-based learning will prepare engineering students to work in an environment that is continuously changing, complex, and ill-structured.

The advantages of case-based instruction carry over into the development of adaptive expertise, which allows students to become flexible thinkers and to transfer their knowledge to novel situations (Fisher and Peterson, 2001). Previous research on adaptive expertise has suggested that the organization of information between experts and novices is significantly different (Bransford, Brown, & Cocking, 1999). Case based instruction is rooted in a cognitive and socio-cultural constructivist perspective that emphasizes students taking an active role in learning through conceptual activity and social interaction with peers using problem related and collaborative practices (Bilicia, 2004; Mayo, 2002; Mayo, 2004). Case based instruction has a long and effective history in the business, law, and medical fields to teach students the complexities and ill-structured nature of those disciplines (Herreid, 2006; Mayo, 2004). Specifically, case based instruction is a technique that is "problem oriented rather that discipline oriented" (Block, 1996, p. 484). Hence, this pedagogical technique is ideally suited to enhance the educational experience of future engineers.

Objective

The primary **objective** of this project is to develop a series of 5 – 7 case-based instructional modules that leverage entrepreneurial contexts to convey key lessons that will help engineering students develop many of the attributes sought in the Engineer of 2020.

Project approach

To achieve the stated objective, emphasis will be placed on three primary activities:

1. Identify business cases that exemplify and encourage the practice of specific attributes sought in the Engineer of 2020 (emphasis will be placed on leadership; teamwork; communication; decision-making; management of change; working effectively in a diverse teams; examination and response to engineering, business, and societal

perspectives; building analytical skills to approach unstructured, open-ended problems; innovativeness; entrepreneurial and intrapreneurial capabilities; and demonstration of continuous, adaptable learning).

2. Develop case content, teaching approaches and supporting materials that enable modular communication of key concepts.
3. Pilot case study formats in select student settings to gauge their effectiveness and inform the formulation of a case teaching program relevant across the College of Engineering. Pilot settings will be strategic so that we can assess the extent to which these cases can be scaled up for the broader cross-section of educational experiences present at Purdue.

Team Expertise

The topic of this proposal lies at the boundary of engineering, business, and education, thus requiring a cross-disciplinary team with specific competencies in these areas. The PI brings expertise in the field of engineering, deep professional background in innovation and business contexts, and an extensive network of engineering entrepreneurs. Professor Yadav brings expertise in case-based instruction in science and engineering, adaptive expertise, research methodology, and data analysis. Professor Adams brings expertise in cross-disciplinary inquiry, research techniques to elicit data of engineering professional practice, and design of experiences for building capacity in engineering education.

Case identification

The cases selected for this project must meet several criteria. It is the intent of the investigators to identify cases which:

- Capture the interest of the student
- Provide a real insider view to knowledge that is often "behind closed doors"
- Convey a key lesson pertinent to the future engineer
- Encourage deep conceptual learning of key concepts, some of which may conflict with student's prior conceptions
- Encourage the use of analytical approaches and peer interactions that will foster the skills sought in the Engineer of 2020

As a result, the investigators will seek cases anchored in popular culture such as Apple's effort to develop and launch the *i-pod*, or e-Bay's rise to the top of the e-business ranks. Further, we will develop cases that each has at their heart a major challenge that exemplifies the issues likely to be encountered by our future engineers. To the extent possible, a sub-set of the cases will be based on knowledge of existing and start-up enterprises linked to the Purdue community, and as such will have a unique contextual relevance.

While the exact focus of the cases would be developed through this effort, examples of issues that could be examined include consideration of social or political forces, mastery of problem solving under uncertainty, managing interpersonal relations or teams in the context of a project, thinking and working across different perspectives, or balancing engineering and economic considerations. Further, secondary lessons will also be sought in the cases which help develop an appreciation for the skills and thought-processes characteristic of the entrepreneur. For example, cases could involve application of "disruptive innovation" principles (e.g., early field trials,

tradeoffs in performance benefits, and adaptation) in engineering contexts, or could contrast the entrepreneurship lessons of typical short lifecycle product and service environments (e.g., consumer packaged goods, retail, service industries) with the techniques required to manage long-lifecycle endeavors (e.g., aircraft, automobiles, and water infrastructure development), or perhaps call attention to the elements of traditional entrepreneurial project planning, financial assessment, risk analysis, and market understanding that can be adapted for the conditions likely to be encountered in engineering contexts. In each case, effort would also be made to identify situations in which exploration of the core issues necessitates the use of problem structuring skills, understanding of the entrepreneurial mindset, and rich peer interaction.

Case development

We will build on corporate and academic relationships of the investigators to identify a set of cases that exemplify the key learning objectives. To develop the background for each case, the investigators will work closely with a graduate and undergraduate student to elicit information regarding the case which may involve interviewing executives involved in the case or gathering marketing materials or other artifacts associated with the case (e.g., sketches, mock-ups, market analyses). Effort will be made to ensure all necessary case confidentiality as required. The goal will be to develop content that immerses the student in the case context, detailing the circumstances surrounding the case, the key stakeholders and external influences on their behavior, the decisions that had to be made, alternative scenarios and related consequences that were considered as the case progressed, and the final decisions, rationale and outcomes achieved.

The content of each case will be structured in a manner that ensures consideration of the functional, social, and emotional aspects that influenced the case outcome, building on the construct increasingly employed by innovative entrepreneurs and intrapreneurs to assess business opportunities (Anthony, et. al., 2008). This comprehensive view of a situation anchored in an understanding of the "jobs-to-be-done" of the stakeholders, will help elicit the broader range of issues that the students must learn to interpret in their future engineering careers.

As part of the case development process we will create comprehensive and user-friendly curricular materials. Thus the output of this phase of the effort will provide not only materials to help students understand the case situation, but also materials that will enable instructors to rapidly understand and convey the key lessons that should be emphasized in the case analysis.

Case piloting

The intention in this program is to employ the developed cases in a controlled set of contexts that will provide valuable feedback for their broader use across the College of Engineering. While the longer term goal is to create case content that can be used to complement elements of the engineering curriculum such as freshman engineering coursework, sophomore seminar series (e.g., CE290) and capstone course, within the one year time frame of this effort, the cases will be piloted in two settings: (1) the PI's course CE597B: Entrepreneurship and Business Strategy in Engineering, and (2) ½ day campus workshops open to the broader Purdue student body.

CE597B will provide a highly structured and cohesive environment in which to pilot the cases. The course was first offered in the Fall of 2007 and gained the interest of nearly 30 students (2/3 undergraduate, 1/3 graduate) with representation from the School of Civil Engineering, Electrical Engineering, Chemical Engineering, and the Multi-disciplinary Engineering Program. The diverse group of students that participate in the course will provide an excellent test-bed for the case content developed in this program and the PI's familiarity with both business and

engineering issues will enable immediate incorporation of the new content. The focus of the cases developed in through the work proposed herein is also naturally aligned with the subject matter of CE597B. This course received average course scores of 4.9 out of 5.0 and instructor scores of 5.0 out of 5.0 among 26 survey respondents, indicating that the potential for future demand will likely be strong.

The effectiveness of the cases and case teaching approach in CE597B will be assessed using an A-B-A-B design to examine the impact of case studies on students' problem-solving skills in CE597B. This research design involves measuring the dependent variable (i.e., students' problem-solving skills) during the baseline phase (A), introducing the treatment and measuring the dependent variable during the treatment phase (B), returning to traditional lecture methods for a third topic and measuring the dependent variable (A), and re-introducing the case method (B) for teaching a fourth topic and measuring the dependent variable.

Measures of student understanding in the above study will include pre and post tests of conceptual understanding (e.g., typical problems) and use of four problem scenarios to measure transfer of knowledge to new situations not discussed in class, one for each of the four topics. The students would then be asked to solve the problem posed in the scenarios to assess the impact of case studies on students' problem solving skills and their ability to transfer their learning to novel situations.

As a complement to the course setting, the campus workshops will enable examination of the case modules with a broader range of students and in a context-less setting. We will invite faculty and teaching assistants to participate in this workshop so that they may observe first hand the process of using the case, the ways in which students engage with the case, and the learning benefits of the case. Particular attention will be given to inviting instructors from the First Year program, representative instructors from the various departments in the College, and faculty involved in the Signature Areas (cross-disciplinary research programs that have an inherent entrepreneurial goal). Follow up focus groups will be used to gain feedback from instructors as well as discuss opportunities for instructors to use the cases in their own teaching contexts. This will provide insight into the potential to port the cases into different learning environments across campus.

Outcomes and broader impact

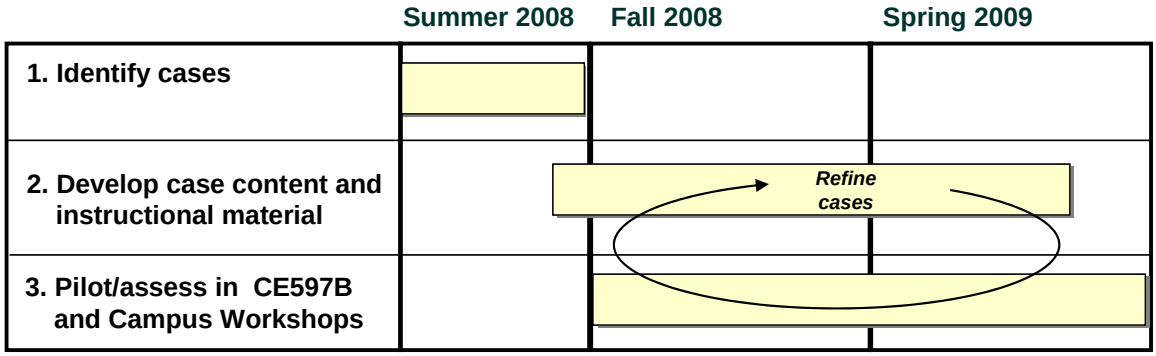
Overall, this project will yield several tangible end products:

- Set of ready-to-use case studies including background materials, key lesson points and teaching guides
- Pilot-level assessment of case effectiveness and teaching value in CE597B and a seminar/workshop format
- Inputs and collaboration networks to shape a broader roll-out of case-based learning approaches to Engineer of 2020 objectives across the entire College of Engineering

The broader impact of this work will be a highly modular, and well structured means to facilitate the development of targeted Engineer of 2020 attributes. The case-study approach to capability building, in particular, facilitates the development of a multitude of desirable attributes simultaneously providing an effective and efficient mechanism for learning. The benefits of this effort will be valuable for engineering students across the College and at various stages of their journey through the curriculum.

B. Timeline and Implementation Strategy

The activities outlined in this program will be pursued over the course of 1 year as outlined below:



The activities outlined in this program are viewed as the first phase in a broader effort to employ case based learning methods to encourage development of Engineer of 2020 capabilities among the engineering student population. Subsequent phases of work that can be envisioned include incorporation of the core case modules into the sophomore seminar series courses of the various schools of engineering and development of workshop content for the most effective case lessons that could be delivered in an engineering wide context.

During the Fall of 2008 the investigators will be building on the proposed activities to explore opportunities for funding to scale-up these programs. Potential funding sources include the National Science Foundation CCLI Program, EEP Programs, and REC, ESIE Programs. In addition, interactions with various program directors at the National Science Foundation suggest that proposals focusing on the development of adaptive expertise and entrepreneurial skills, as emphasized herein, are high priorities.

C. Personnel Requirements
Please indicate the portion of FTE that each faculty member will dedicate to the project

Faculty member	Summer 08	Fall 08	Spring 09
Sinfield	1 week		
Adams	1 week		
Yadav	1 week		

D. Budget
The total budget for this effort amounts to $49,113 as outlined below.

Faculty/Staff Member Funding Please indicate the funding (dollars and time) you are requesting for the grant for this project)			
	Grant funds requested		
Faculty/Staff Name:	% Time	Fringe Benefits	$$
Sinfield	1 week Summer	$687	$1,953
Adams	1 week Summer	$832	$2,367
Yadav	1 week Summer	$508	$1,448
Subtotal Faculty/Staff Funding		$ 2,027.00	$ 5,768.00

Graduate Students				
	Grant funds requested			
Type of position	% Time	Insurance + Fee Remit	Fringe Benefits	$$
Research Assistant (Master's)	100% 12 months	$7,561	$113	$18,879
Subtotal Graduate Student Personnel		$7,561.00	$ 113.00	$ 18,879.00

Undergraduate Student Funding *Please indicate the student resources (funding and time) you are requesting from the grant for this project.*			
	Grant funds requested		
Type of position	Hrs/week	Fringe Benefits	$$
Undergraduate research (2 students)	20 hrs/wk	765.00	9,000.00

Subtotal Undergraduate Student Personnel			

Equipment $ Software Funding *Please list all specialized equipment and software required for the project. (Do not include standard computer equipment and commonly-available software, e.g. Microsoft Office, Microsoft Windows). Mark whether any of the equipment or software is provided by the department. (Note that only 10% of the funds can be used to purchase equipment and it needs to be dedicated to the goals of the project.*	
Name of Equipment	Funds Requested
Subtotal Equipment	$0.00
Name of Software	
Subtotal Software	$0.00
Other miscellaneous items (e.g., computer media, cables)	
Interview transcriptions – guess – 1,000 max (20 hours of tape)	
Photocopy services and publication costs	
Telephone service costs	
Subtotal miscellaneous	$2,500.00

Other supplies and expenses	
Travel	
Subtotal other expenses	$2,500.00

E. Budget Justification

Personnel:

Investigators: One week of summer salary support per is requested for each of the three investigators to support the the level of commitment to this project.

Graduate Students:

Funding is requested to cover the stipend, fringe benefits, insurance and fee remits for one year of support for one full time Master's student.

Undergraduate Students:

The budget also includes costs ($9,765) for support of two undergraduate students hired on an hourly basis to assist in the research work. The amount is estimated assuming 10 hours of work per week for each student during 45 weeks of each academic year.

Miscellaneous

$2,500 is budgeted for miscellaneous supplies and expenses (e.g., photocopying, phone line costs for interviews) as well as interview transcripts.

Other supplies and expenses

$2,500 is also budgeted for travel that will be associated with interviews used to develop case content.

F. References

Anthony, S.D., Johnson, M.W., Sinfield, J.V., Altman, E.J., "The Innovator's Guide to Growth – Putting Disruptive Innovation to Work", Harvard Business School Publishing, complete and scheduled for print in May 2008.

Bhide, A.V., *Road Well Traveled: A Note on the Journeys of HBS Entrepreneurs*. Product #396277, Harvard Business School Publishing, 1996.

Bilica, K. "Lessons from Experts: Improving College Science Instruction through Case Teaching." *School Science and Mathematics* 104, no. 6, pp. 273-78, 2004.

Block, Karen K. "The 'Case' Method in Modern Educational Psychology Texts." Teacher & Teacher Education, 12, pp. 483-500, 1996.

Bransford, J., A. Brown, and R. Cocking, *How people learn: Brain, mind, experience, and school*. Washington, DC: National Academy Press, 1999.

Brown, J.S., A. Collins, and P. Duguid, *Situated cognition and the culture of learning.* Educational Research, **18** (1): p. 32-42, 1989..

Christensen, C.M., M.W. Johnson, and D.K. Rigby, *Foundations for Growth: How to Identify and Build Disruptive New Businesses.* Sloan Management Review **43**(3), 2002.

Committee on Facilitating Interdisciplinary Research (CFIR), Committee on Science, Engineering, and Public Policy. *Facilitating Interdisciplinary Research*. Washington, DC: National Academies Press, 2005.

Fisher, F. and Peterson, P.. “A Tool to Measure Adaptive Expertise in Biomedical Engineering Students” Multimedia Division (Session 2793) Proceedings for the 2001 ASEE Annual Conference, June 24-27, Albuquerque, NM, 2001.

Foster, R.N., *Innovation: The Attacker’s Advantage*. Summit Books, 1986.

Herreid, C. F. *Start with a Story: The Case Study Teaching Method of Teaching College Science*. Arlington, VA: National Science Teachers Association Press, 2006.

Johansson, F., *The Medici Effect: Breakthrough Insights at the Intersection of Ideas, Concepts & Cultures*. Cambridge: Harvard Business School Press, 2004.

Jonnasen, D., J. Strobel, and C.B. Lee, *Everyday Problem Solving in Engineering: Lessons for Engineering Educators.* Journal of Engineering Education, **95**(2): p. 1-14, 2006.

Klein, J.T., *Interdisciplinarity: History, theory, and practice.* Detroit: Wayne State University, 1990.

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Kline, S.J., *Conceptual Foundations for Multidisciplinary Thinking*. Stanford UP, 1995.

Mayo, J. A. "Case-Based Instruction: A Technique for Increasing Conceptual Application in Introductory Psychology." *Journal of Constructivist Psychology* 15, pp. 65-74, 2002.

Mayo, J. A. "Using Case-Based Instruction to Bridge the Gap between Theory and Practice in Psychology of Adjustment." *Journal of Constructivist Psychology* 17, pp.137-46, 2004.

National Academy of Engineering, “The Engineer of 2020: Visions of Engineering in the New Century”, 101 pp., 2004.

G. Investigator Biosketch - Sinfield

Curriculum Vitae: JOSEPH V. SINFIELD

Address: Purdue University, School of Civil Engineering, West Lafayette, IN 47907-2051
Ph:(765) 496-2742 **Fax**:(765) 494-0644 **E-mail:** jvs@purdue.edu

A. Professional Preparation

Bucknell University	Civil Engineering**,** B. Sc. **(**Summa Cum Laude)	1992
Massachusetts Institute of Technology	Civil and Environmental Engineering, M. Sc.	1994
Massachusetts Institute of Technology	Civil and Environmental Engineering, Sc. D.	1997
Massachusetts Institute of Technology	Civil and Environmental Engineering, Post-doc	1997-1998

B. Academic Appointments

Assistant Professor of Civil Engineering	Purdue University	May 2004 -present

C. Non-academic Appointments

Innosight, LLC (Watertown, MA) Jan 2004 - present

- Consultant - Facilitate executive training and provide council to leaders of both established firms and start-ups on innovation, entrepreneurial leadership skills, growth strategy and innovation process design.

McKinsey & Company (Chicago, IL/Boston, MA) Dec 1998 – Jan 2004

- Senior engagement manager - led multiple teams of diverse and highly talented individuals in efforts to advise leaders of Fortune 100 companies on issues of growth, technology investment, innovation management, and go-to-market strategy; drove internal knowledge building efforts on disruptive technologies, innovation, and lean manufacturing [Associate, Jan 1999 – Mar 2000; Engagement Manager Apr 2000 – Jan 2004]

  Selected engagements:
  Technology investment
  - helped an $11 billion international IP services provider upgrade its business model and network to deal with industry transition from copper-line to fiber-optic technology through an $850 million acquisition
  - created a program to expand a leading optical fiber manufacturer's capabilities into the emerging area of active optical components for communications; recommendation lead to a $450 million merger
  - devised an aggressive growth strategy for a $150 million fledgling manufacturer of fiber optics and copper-line test and measurement equipment founded on the acquisition of new technologies

  Innovation management
  - facilitated a major chemical company's efforts to transform the market for high-cost, labor-intensive optical communication components through the use of its low-cost thin-film polymer capability
  - helped a $2.4 billion manufacturer of network power equipment refine its product offering to address shifts in the telecommunications infrastructure that dramatically altered power requirements
  - assessed the technological and economic impact of a step-change in engine emissions standards on the viability of a $13 billion industrial equipment manufacturer's engine business

  Research and development
  - devised a flexible product development plan to help a manufacturer of film and professional-level cameras move down-market and serve general consumers by leveraging low-cost digital technology
  - developed a strategy to combat a near-term gap in the R&D pipeline of a major biotech company through in-licensing and the acquisition of new technologies and products
  - launched a biopharmaceutical contract solutions business to help a leading chemical company manage an industry move from chemical synthesis of active pharmaceutical ingredients to biological manufacturing

Haley & Aldrich Company, Inc. (Cambridge, MA) May 1994- Jan 1995

- Geotechnical Engineer - performed design calculations, reviewed site exploration data, carried out on-site inspections, prepared project reports.

Germaine & Associates (Cambridge, MA) Jan 1995 - Apr 1997

- Consulting Engineer - conducted advanced soils tests and radiographic investigations.

D. Selected Publications

Five related publications

- Anthony, S. D., Johnson, M.W., Sinfield, J.V., and Altman, E.J. **The Innovator's Guide to Growth: Putting Disruptive Innovation to Work,** Harvard Business School Publishing, book in press, May, 2008.
- Anthony, S., Johnson, M., and Sinfield, J. "Institutionalizing Innovation", **MIT Sloan Management Review**, accepted to appear in Winter 2007 Issue.
- Anthony, S. D., and Sinfield, J.V. "Product for Hire: Master the Innovation Lifecycle with a Jobs-to-be-Done Perspective", **Marketing Management**, March/April, pp. 17-24, 2007.
- Sinfield, J., Anthony, S. "Constraining Innovation: How Developing and Continually Refining Your Organization's Goals and Bounds Can Help Guide Growth", **Strategy & Innovation**, November – December, Vol. 4, No. 6, p. 1, 6-9, 2006.
- Sinfield, J., Thomson, D., and Carter, C. "Blueprint to a Billion: From Disruption to Dominance", **Strategy & Innovation**, July – August, Vol. 4, No. 4, p. 1, 6-10, 2006.

Other recent publications

- Dunston, P.S., Sinfield, J.V., Lee, T.Y., **ASCE Journal of Construction Engineering and Management**, "Technology Development Decision Economics for Real-time Rolling Resistance Monitoring of Haul Roads," Volume 133, Issue 5, pp. 393-402, May 2007.
- Sinfield, J.V., Hemond, H.F., Germaine, J.T., Johnson, B., and Bloch, B., **ASCE Journal of Environmental Engineering**, "Contaminant Detection, Identification, and Quantification Using a Microchip Laser Fluorescence Sensor," v 133, n 3, pp. 346-351, 2007.
- Santagata, M.C., Sinfield, J.V., and Germaine, J.T. **ASCE Journal of Geotechnical and Geoenvironmental Engineering**, "Laboratory Simulation of Field Sampling: Comparison to Ideal Sampling and Field Data," v 132, n 3, pp. 351-362, 2006.
- Sinfield, J.V., "A Structured Approach to Technology Assessment", ***Strategy & Innovation***, September – October, Vol. 3, No. 5, pp. 1, 10-13, 2005.
- Culligan, P.J., Sinfield, J.V., Maas, W.E., Cory, D.J., ***Water Resources Research***, "Use of NMR relaxation times to differentiate mobile and immobile pore fractions in wetland soil," Vol. 37, No. 3, pp. 837– 842, 2001.

F. Synergistic Activities

- **Director of the Discovery Park Office of Industrial Collaboration** focused on the development of collaboration strategies and policies aimed at enhancing joint research between industry and academia
- **Faculty Advisor** to Purdue Lunar In-Situ Resource Utilization Competition Team focused on development of remotely controlled methods for resource analysis and extraction in lunar environments
- **Faculty Advisor** to Purdue Student Chapter of LEED – Leadership in Energy & Environmental Design, and Construction and Engineering Management Student Chapter of Beta Tau

G. Collaborators and Other Affiliations

(i) Collaborators: R. Adams, S. Brouder, C. Christensen (Harvard), N. Elvin (MSU), D. Abraham, A. Bobet, P. Dunston, C. Johnston, J. Frankenberger, G. Miles, M. Santagata, A. Varma, A. Yadav

(ii) Graduate and Thesis Advisor: J.T. Germaine and H.H. Hemond, MIT

(iii) Graduate Advisor (Research): Daniel Fagerman – Master of Science Candidate; Chike Monwuba – Doctor of Philosophy Candidate; Seungwoo Paik – Master of Science Candidate; Nakul Virat – Master of Science Candidate; Tai Yuan Lee – Doctor of Philosophy Candidate

Robin S. Adams

(a) Professional Preparation

California Polytechnic State University San Luis Obispo, CA	Mech. Engr.	BS, 1986
University of Washington, Seattle WA	Mat.Sci. & Engr.	MS-MSE, 1994
University of Washington, Seattle WA	Education	PhD, 2001

(b) Appointments

July 2005–present	Assistant Professor, Department of Engineering Education – Purdue University
2003 – June 2005	Assistant Director for Research, Center for Engineering Learning and Teaching – University of Washington, Seattle, WA
2001-2003	Research Scientist, Center for Engineering Learning and Teaching – University of Washington, Seattle, WA
2000-2001	Pre-Doctoral Research Assistant, Center for Engineering Learning and Teaching – University of Washington, Seattle, WA
1997 – 2000	Local Evaluator, Engineering Coalition of Schools for Excellence in Education – University of Washington, Seattle, WA
1991 – 1997	Graduate Research Assistant, Engineering Coalition of Schools for Excellence in Education – University of Washington, Seattle, WA
1987 – 1991	Senior Design Engineer, Olin Interconnect Technologies, Santa Clara, CA

(c) Publications

Closely related

Allendoerfer, C.A., Adams, R.S., Bell, P., Fleming, L. and L. Leifer (2007). "Becoming an Engineering Education Researcher: Finding Pathways toward Interdisciplinarity." Proceedings of the annual American Educational Research Association, Chicago.

Adams RS, J Turns and CJ Atman (2003). "What could design learning look like?" In N. Cross (ed), Expertise in design: The sixth annual Design Thinking Research Symposium. Sydney: University of Technology Sydney Press.

Adams RS, J Turns and CJ Atman (2003). "Educating effective engineering designers: The role of reflective practice". *Design Studies*, Special Issue on Designing in Context, **24** (3), pp. 275-294.

Atman, C.J., Adams, R.S., Cardella, M.E., Turns, J., Mosborg, S. and J. Saleem (2007). "Engineering Design Processes: A Comparison of Students and Expert Practitioners." Journal of Engineering Education, October.

Turns, J., R. S. Adams, J. Martin, M. Cardella, S. Mosborg & C. J. Atman (2006). "Tackling the Research-to-Practice Challenge in Engineering Design Education: Insights from a User-Centered Design Perspective," *International Journal of Engineering Education* (invited paper).

Synergistic

Adams, R.S., C. Allendoerfer, P. Bell, H. Chen, L. Fleming, L. Leifer, B. Maring and D. Williams (2006). "A Model for Building and Sustaining a Community of Engineering Education Research Scholars." Proceedings of the Annual *American Society for Engineering Education* Conference, Chicago.

Adams, R. S. (2002). "Understanding design iteration: Representations from an empirical study." In D. Durling & J. Shackleton (Eds), *Common Ground: Proceedings of the Design Research Society International Conference at Brunel University* (pp. 1151-1161). Staffordshire University Press: UK.

Turns, J., C.J. Atman, R.S. Adams & T. Barker (2005). "Research on Engineering Student Knowing: Trends and Opportunities", *Journal of Engineering Education, Special Issue*, 94(1), pp. 27-40.

Turns, J., R. S. Adams, A. Linse & C. J. Atman (2003). "Bridging from Research to Teaching in Undergraduate Engineering Design Education." *International Journal of Engineering Education*, 20(3), pp. 379-390.

Turns, J., C. J. Atman and R. Adams (2000). "Concept maps for Engineering Education: A cognitively motivated tool supporting varied assessment functions," *IEEE Transactions, Special Issue on Assessment*, 43(2), pp. 164-173.

(d) Research and Education Activities

Scholarly research on engineering learning; bridging learning and teaching: (1) **NSF – EEP / EHR (CAREER)** "Intentional Serendipity, Cognitive Flexibility, and Fluid Identities: Cross-Disciplinary Ways of Thinking, Acting, and Being in Engineering" to investigate cross-disciplinary inquiry and develop a scholarship of teaching and learning community around cross-disciplinary pedagogy, $495,830 (8/1/08 – 7/31/13), (2) **NSF – EHR/REC (ROLE)** "An engineering design expertise continuum: Filling it in and linking it to practice" to create knowledge on design expertise and demonstrate a research-informed approach to design education in the context of informal educational settings (co-op education) with C. J. Atman (PI) and J. Turns, $508,196, (9/1/01 – 9/31/05); (3) **NSF – EHR/EEP CLT** "Center for the Advancement of Engineering Education" – research on pathways for becoming interdisciplinary engineering education researchers; (4) **NSF – EEP** "The Teaching Challenges of Engineering Faculty: Insights from a Model Instructional Development Program," with J. Turns (PI), A. Linse and C. J. Atman, $374,972, (9/1/02 – 12/31/05).

Educational innovations and curriculum development: (1) **NSF – DLR** "Multidisciplinary Engineering", Haghighi (PI) – planning grant to develop an integrated program on multidisciplinary engineering; (2) **GE Fund** "Toward Enhancing Engineering Design Education: Bringing Research Results into the Classroom," with C J. Atman and J. Turns, $50,000, (01/01-12/01), (3) Graduate courses in Engineering Education (Design Cognition and Learning, Problem Solving for Diverse Learners, Introduction to Engineering Education, History and Philosophy of Engineering Education), (4) Undergraduate courses (Multidisciplinary Engineering Professional Seminar), and (5) Community of practice workshops (FIE 2005, FIE 2007).

Building capacity and community in engineering education research: (1) **NSF – EHR/EEP CLT** "Center for the Advancement of Engineering Education," Atman (PI) - Lead for Institute for Scholarship on Engineering Education – a program in which faculty and graduate students engage in year long research projects around engineering student learning (particular goals of this program were on broadening participation in STEM education research and contributing to the scholarship on issues related to STEM participation), and (2) **Stepping Stones Project** with Sally Fincher - a program in which faculty in Sweden engage in a year long research project around conceptions of engineering from a Swedish perspective.

Broadening participation: (1) Leadership role on a NSF funded summer bridge programs to support women and minorities in pursuing STEM majors, collaborations between colleges of engineering and education for K-12 teacher preparation, and collaborations between K-12 educators and undergraduate engineers to develop and implement engineering curriculum in K-12 classrooms and (2) a NSF funded project (ECSEL Coalition) with a focus on teacher education and pathways for integrating engineering into K-12 contexts.

(e) Collaborators & Other Affiliations

Graduate and Postdoctoral Advisors (U Washington): Steven Olswang, Edward Taylor, Nancy Beadie, Gerald Gillmore, Cynthia J. Atman

Collaborators and Co-Editors (past 48 months):

Cheryl Allendoerfer (U Washington), Cynthia Atman (U Washington), Philip Bell (U Washington), Keith Bowman (Purdue), Lori Breslow (MIT), Sean Brophy (Purdue), Monica Cox (Purdue), Mats Daniels (Uppsala U), Denny Davis (Washington State U), Hiedi Diefes-Dux (Purdue), Sally Fincher (U Kent), Lorraine Fleming (Howard U), Kamyar Haghighi (Purdue), Carol Handwerker (Purdue), Dan Hirleman (Purdue), Inez Hua (Purdue), PK Imbrie (Purdue), Lisa Lattuca (Penn St), Larry Leifer (Stanford), Ron Miller (CSM), Susan Mosborg (U Washington), Wendy Newstetter (Georgia Tech), Loring Nies (Purdue), David Radcliffe (Purdue), Sheri Sheppard (Stanford), Joe Sinfield (Purdue), Karl Smith (Purdue), Reed Stevens (U Washington), Ruth Streveler (Purdue), Jennifer Turns (U Washington), Aman Yadav (Purdue), Monica Cardella (Purdue), Kathy Banks (Purdue)

G. Investigator Biosketch - Yadav

Aman Yadav, PhD.

(a) Professional Preparation

Deenbandhu Chhotu Ram University Of Science and Technology, India	Electrical Engineering	B.S., 1999
Michigan State University	Electrical Engineering	M.S., 2001
Michigan State University	Educational Psychology and Educational Technology	Ph.D., 2006

(b) Appointments

2006-present	Assistant Professor, Educational Psychology and Research Methodology, College of Education, Purdue University
2004-2006	Research Assistant, National Center for Case Study Teaching in Science & Michigan State University

(c) Publications

(i) Most closely related to proposal project

Arnold, M., Yadav, A., Nauman, E., & Shaver, G. (accepted). Measuring student perceptions of case-based instruction in mechanical engineering: Development of a Survey. Paper accepted at the annual meeting of American Society for Engineering Education, Pittsburg, PA.

Yadav, A., Meckl, P., & Shaver, G. (accepted). Comparing the lecture method with case method in a mechanical engineering course. Paper accepted at the annual meeting of American Society for Engineering Education, Pittsburg, PA.

Yadav, A., Lundeberg, M.A., DeSchryver, M., Dirkin, K. H., Schiller, N., Maier, K., & Herreid, C. F. (2007). Teaching science with case studies: A national survey of faculty perceptions on the benefits and challenges of using cases. *Journal of College Science Teaching, 37*(1), 34-38.

Lundeberg, M. A., & Yadav, A. (2007). Assessment of case study teaching: Where do we go from here? In C. F. Herreid (Ed.), *Start with a story: The case study method of teaching college science* (pp. 407-418). Arlington, VA: National Science Teachers Association Press

Lundeberg, M. A, & Yadav, A. (2006). Assessment of case study teaching: Where do we go from here? Part II. *Journal of College Science Teaching, 35*(6), 8-13.

Lundeberg, M. A, & Yadav, A. (2006). Assessment of case study teaching: Where do we go from here? Part I. *Journal of College Science Teaching, 35*(5), 10-13.

(ii) Other significant publications

G. Investigator Biosketch - Yadav

Yadav, A., & Barry, B. E. (submitted). Using case-based instruction to increase ethical understanding in engineering: What do we know? What do we need? *International Journal of Engineering Education.*

Yadav, A., & Koehler, M. J. (2007). The role of epistemological beliefs in preservice teachers' interpretation of video cases of early-grade literacy instruction. *Journal of Technology and Teacher Education, 15*(3).

Koehler, M. J., Yadav, A., Phillips, M., & Cavazos-Kottke, S. (2005). What is video good for? Examining how media and story genre interact. *Journal of Educational Multimedia and Hypermedia, 14*(3), 249-272.

Ferdig, R. E., Roehler, L. R., Boling, E. C., Knezek, S., Pearson, P. D., & Yadav, A. (2004). Teaching with video cases on the web: Lessons learned from the Reading Classroom Explorer. In A. Brown & N. Davis (Eds.), *The World Yearbook of Education 2004: Digital Technology, Communities and Education* (pp 164-175). London: RoutledgeFalmer.

(d) Synergistic Activities

- Involved in the dissemination of case study teaching in science at a national level by conducting workshops, conferences, developing online resources and support groups through the National Center for Case Study Teaching in Science.
- Conducted a national survey to investigate how science faculty are using cases in order to make science accessible to all students and what are their perceptions of benefits of cases on student learning, engagement, and motivation.
- One of the lead developers of an online video-case based hypermedia system to improve teacher preparation of literacy instruction and examined its effectiveness in preparing prospective teachers to teach effectively.
- Member, Editorial Board, *Contemporary Issues in Technology and Teacher Education.*

(e) Collaborators & Other Affiliations

Collaborators and Co-Editors

Erica Boling, Rutgers University, Emily Bouck, Purdue University; Sean Cavazos-Kottke, The Robert B. Miller College; Michael DeSchryver, Michigan State University; Kathryn H. Dirkin, Michigan State University; Richard Ferdig, University of Florida, Clyde Freeman Herreid, University at Buffalo, State University of New York; Suzy Knezek, Michigan State University; Matthew J. Koehler, Michigan State University; Mary A. Lundeberg, Michigan State University; Kim Maier, Michigan State University; Punya Mishra, Michigan State University; David Pearson, University of California – Berkley; Michael Phillips, Michigan State University; Laura Roehler, Michigan State University; David Sears, Purdue University; Nancy Schiller, University at Buffalo, State University of New York

Graduate and Postdoctoral Advisors: Matthew J. Koehler, Michigan State University.

Graduate Students Advised: none as major professor (second year professor); 3 total as committee member

H. Current and Pending Support - Sinfield

(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: Joseph V. Sinfield	Other agencies (including NSF) to which this proposal has been/will be submitted. None

Support: X Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Development of a Real-Time, Mobile, Macro Nutrient Sensor

Source of Support: Dickey-john Corporation

Total Award Amount: $87,000 Total Award Period Covered: 01/08/07-01/09/08

Location of Project: Purdue University

Person-Months Per Year Committed to the Project. Cal: Acad: 0 Sumr: *0.5*

Investigator: Joseph V. Sinfield	Other agencies (including NSF) to which this proposal has been/will be submitted. None

Support: X Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Refine Process to Identify, Evaluate, and Adopt New Technologies and Identify New Proven Technologies for Indiana

Source of Support: Indiana Department of Transportation/Joint Transportation Research Program

Total Award Amount: $91,320 Total Award Period Covered: 01/01/08-12/31/09

Location of Project: Purdue University

Person-Months Per Year Committed to the Project. Cal: Acad: 7.5% Sumr: 7.5%

Support: X Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

In-situ Nitrogen and Phosphorous Sensing Using Diode Laser Raman Spectroscopy

Source of Support: Discovery Park Center for the Environment

Total Award Amount: $27,500 Total Award Period Covered: 01/01/07-05/31/08

Location of Project: Purdue University

Person-Months Per Year Committed to the Project. Cal: Acad: 0 Sumr: 0

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

NSF Form 1239 (10/99)

Investigator: Joseph V. Sinfield	Other agencies (including NSF) to which this proposal has been/will be submitted. None

Support: X Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Synthesis Study: Development of an Electronic Detection and Warning System to Prevent Over-height Vehicles from Impacting Overhead Bridges

Source of Support: Indiana Department of Transportation/Joint Transportation Research Program

Total Award Amount: $30,000 Total Award Period Covered: 01/01/08-12/31/08

Location of Project: Purdue University

Person-Months Per Year Committed to the Project.	Cal:	Acad:	Sumr:
		2.5%	2.5%

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

Investigator: Joseph V. Sinfield	Other agencies (including NSF) to which this proposal has been/will be submitted. None

Support: ☐ Current X Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Distributed Raman Spectroscopic Monitoring of Macro-nutrients in the Geoenvironment

Source of Support: Purdue Research Foundation

Total Award Amount: ~$27,000 Total Award Period Covered: 1 year

Location of Project: Purdue University

Person-Months Per Year Committed to the Project.	Cal:	Acad:	Sumr:
		0	0

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

H. Current and Pending Support - Adams

(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: Robin Adams

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: CLT: Center for the Advancement of Engineering Education (CAEE)

Source of Support: NSF

Total Award Amount: $10,173,321 Total Award Period Covered: 1/1/03 – 12/31/07 (no cost extension 12/08)

Location of Project: University of Washington; Sub-budget Purdue University

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1 week

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Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: CAREER: Intentional Serendipity, Cognitive Flexibility, and Fluid Identities: Cross-Disciplinary Ways of Thinking, Acting, and Being in Engineering

Source of Support: NSF

Total Award Amount: $495,830 Total Award Period Covered: 08/01/08 – 07/31/13

Location of Project: Purdue University

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 3 weeks

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Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: ERC: Capacity Vitalization of Megacities

Source of Support: NSF

Total Award Amount: $16,250,000 Total Award Period Covered: 08/01/08 – 07/31/13

Location of Project: Purdue University

Person-Months Per Year Committed to the Project. Cal: Acad: 10% Sumr: 1 month

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Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: COLLABORATIVE RESEARCH: Expanding and sustaining research capacity in engineering and technology education: Building on successful programs for faculty and graduate students

Source of Support: NSF

Total Award Amount: $963,976 Total Award Period Covered: 7/1/08-6/30/11

Location of Project: Purdue University

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 2 weeks

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

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H. Current and Pending Support - Yadav

(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: Aman Yadav	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:

Preparing Students for Global Careers in STEM

Source of Support: National Science Foundation

Total Award Amount: $931, 339 Total Award Period Covered: 3 years

Location of Project: Purdue University

Person-Months Per Year Committed to the Project. Cal: 0.25 Acad: 0.0 Sumr: 0.0

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Engineering Research Center for Capacity Vitalization of Megacities Institutional Configuration

Source of Support: National Science Foundation

Total Award Amount: $15,000,000 Total Award Period Covered: 5 years

Location of Project: Purdue University

Person-Months Per Year Committed to the Project. Cal: 0.25 Acad: 0.0 Sumr: 0.0

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Online Science “Fair”: An Online Learning Environment to Support Scientific Understanding of Students with Disabilities

Source of Support: Office of Special Education

Total Award Amount: $487,677 Total Award Period Covered: 2 years

Location of Project: Purdue University

Person-Months Per Year Committed to the Project. Cal: 1.0 Acad: 0.0 Sumr: 0.0

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Classroom Links to Vocabulary & Phonological Skills

Source of Support: Institue of Educational Sciences

Total Award Amount: $1,738,508 Total Award Period Covered: 4 years

Location of Project: Purdue University

Person-Months Per Year Committed to the Project. Cal: 0.25 Acad: 0.0 Sumr: 0.0

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

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55