Academic Research Funding Strategies, LLC

How to Write A Winning CAREER Proposal

Seminar presented March 2, 2012

Handout Package

By Lucy Deckard

Academic Research Funding Strategies, LLC

http://academicresearchgrants.com

LDeckard@academicresearchgrants.com

Helpful Resources for CAREER on the Web

NSF Solicitation and other Info

http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=503214&org=NSF&sel_org=NSF&from=fund – CAREER page

http://www.nsf.gov/publications/pub_summ.jsp?WT.z_pims_id=503214&ods_key=nsf11690 - CAREER solicitation

http://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf11038 - CAREER FAQ

http://www.nsf.gov/bfa/dias/policy/outreach.jsp - Presentations by NSF program officer at the most recent NSF Regional Grants Conference (including CAREER Presentation)

Successful CAREEER proposals on the web

http://serc.carleton.edu/NAGTWorkshops/earlycareer/research/NSFgrants.html - 5 funded CAREER proposals related to Geosciences

http://valis.cs.uiuc.edu/~sariel/papers/01/career/career.pdf

http://www.math.uic.edu/~bshipley/career.education.pdf

Other CAREER Resources

http://books.google.com/books?id=FUrGpiV0EKAC&printsec=frontcover&dq=ZJ+Pei+CAREER&source=bl&ots=hHbqJvN1TH&sig=zO2_EKfU0iie8WTUaDNgOANaEAo&hl=en&ei=Gee5S8TzNoG88gam-5ThBw&sa=X&oi=book_result&ct=result&resnum=3&ved=0CBAQ6AEwAg#v=onepage&q=&f=false – Short book by Z. J. Pei, "NSF CAREER Proposal Writing Tips." Some of the info from previous year awardees is out of date, but still very useful information

Resources for Education

http://www.eric.ed.gov/ - Education Resources Information Center

http://www.nae.edu/Activities/Projects/CASEE/EntryPortals.aspx - National Academy of Engineering portal

http://www.nap.edu/catalog.php?record_id=11463 – National Academies Press, Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future (2007)

http://www.cur.org/publications.html - Council on Undergraduate Research, Publications page

http://naples.cc.sunysb.edu/Pres/boyer.nsf/ The Boyer Commission on Educating Undergraduates in the Research University, REINVENTING UNDERGRADUATE EDUCATION: A Blueprint for America's Research Universities (1998) – *old, but classic*

Handout #3

Developing Education Components for NSF Proposals:

An Interview with Dr. Jeff Froyd, Research Professor and Director of Faculty and Organizational Development in the Office of the Dean of Faculties at Texas A&M University

(This article was published in Texas A&M University's Funding Newsletter May 1, 2009, M. Cronan, ed., but some information, including weblinks has been updated.)
By Lucy Deckard

Dr. Froyd has been PI or co-PI on numerous NSF-funded projects that either focused primarily on engineering and science education or included large education components. He served as Project Director for the NSF-funded Foundation Coalition, which extensively reworked the first-year and sophomore-year engineering curricula. Dr. Froyd has also served as a reviewer for proposals to NSF's Engineering Education and Centers Division in the Engineering Directorate

Q: What strategic advice would you give a new faculty member who is developing an education component for a CAREER or other NSF proposal?
A: An important thing to do when planning an education component, particularly for CAREER proposals, is to think about what will differentiate your proposals from those of others. What is your distinctive educational contribution? For example, you may propose to develop a new graduate course. That's fine, but many other people are going to propose the same thing – what will make your proposal stand out from all the others? One thing you can do to make your proposal distinctive is to include a strong assessment plan that will allow you to add to the body of knowledge in STEM education. Another thing you can do is develop a plan that describes the materials (text, videos, exercises, projects, problems, etc) that will allow others to implement what you have done more easily.

Q: How should a PI go about developing an assessment plan?
A: First, think in terms of your goals for your educational component, and describe to yourself evidence that would help you to determine if they were met. For example, if you want to improve student learning in a course, how do you recognize when they have mastered the material? You would say that they need to "understand" the material. That's a good start, but understanding is an internal mental state and we cannot observe understanding yet. So, ask yourself what you might observe to convince yourself that a student has understood the material. What things would you look at?

There has been a lot of work done on developing instruments to assess things such as critical thinking and cognition, and there are efforts funded by NSF and the Lilly Endowment to collect assessment information and tools and to make them generally more available. For example, the Wabash National Study focuses on assessing Liberal Arts Education, but much of this information can also be applied to STEM. You can find information on their outcomes and assessment instruments for different outcomes on their website [http://www.liberalarts.wabash.edu/study-instruments/].

In cases in which you want to compare influences of your intervention, one place to start is where you have multiple sections of an undergraduate course. Then, you might collect data with assessment instruments that would allow you to compare how students perform in one or more sections that experienced the educational innovation, with students from other sections that did not experience the educational innovation. This is pretty easy if the sections already have common exams. If they don't, you might collaborate with a faculty member teaching another section to give common exams. Another option is to compare student performance in a version of a course with student performances in previous years.

Often, you may need to involve others with expertise in assessment who can advise you on the use of a particular assessment instrument. In most universities, you'll find faculty members with that expertise in the College of Education and Human Development. Exactly who you recruit will depend on what you're trying to assess. For example, if you want to look at critical thinking, you would reach out to one group of people; if you need a survey instrument, you would reach out to people with expertise in surveys. If the assessment requires more qualitative research, you'll want to reach out to folks who are experts in qualitative research methods.

If you are writing a CAREER proposal, this may be tricky since only the PI can be funded at the faculty level. However, you can ask a faculty member with this expertise to serve as an advisor to you on your CAREER project. They would then give you a letter of collaboration for your proposal. If a significant amount of effort might be involved, you could offer to provide part-time support for one of their graduate students, who would help you with your assessment.

Q: If a PI seeks to involve faculty who are experts in assessment, will this fit into their own research agendas?
A: Often times it does fit into their agenda, and in that case it can be collaborative project that will advance their research. Other times, they can connect you with experts who may not consider it part of their research but who can participate as practitioners: maybe a graduate student or others in their community who would be willing to participate on a part-time basis. For example, in a recent project I was working on, a faculty member in the Department of Statistics helped us to find a statistician in the community who helped us with our data analysis.

Q: What are examples of things a PI could do to develop a strong dissemination plan?
A: The PI needs to answer NSF's question: What comes out of this education component? It might be the production of materials – curricula, course materials, lab manuals, software, etc. which are posted on a website – that enable others to implement the same educational innovation. It might be in the form of published papers describing what was done and documenting its effectiveness (which brings us back to assessment).

I think you also have to ask yourself what do other faculty members really want. Too often, faculty members focus on what they want to make available instead of asking themselves what they might want from faculty members who are working on educational projects in which they are interested. For example, a faculty member might make available text resources that describe how they organized the material or how they explained specific concepts. Faculty members may be looking for this type of material, but on the other hand, they may be looking for activities that students can do: projects, experiments, or simulations. A popular site, http://nanohub.org/ , got started as a site for faculty members to share simulations at the nanoscale, but now the site has incorporated social networking elements because faculty members wanted to interact about how they were using the simulations and what other things could be developed.

An Open Education Resource (http://www.oercommons.org/) movement is growing in the education community, and it can provide good avenues to disseminate course materials and tools. For example, Rice University has the "Connexions" project [http://cnx.org/], where you can post your materials, and people can try them out and review them. This brings the added benefits of peer review. The PI could commit in his or her proposal to put these resources where other people can access them and use them and then provide feedback. This approach fits well with a movement that's starting within NIH and NSF to require that data generated by funded projects be posted in a publicly accessible way.

Q: Are there particular educational innovations that interest NSF?
A: In NSF's Division of Undergraduate Education, the solicitation for their Transforming Undergraduate Education in STEM (TUES) program often provides insight into things in which they are interested; check out what has been funded in that program, and look at resources on that page *[go to http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5741&org=DUE&from=home and click on "Abstracts of Recent Awards Made" near the bottom of the page.]* It is crucial that you know what educational innovations have already been tried in a discipline and which have been more widely adopted. In some subject areas, there have been numerous innovations, while in others, very little has been tried.

In the Division of Graduate Education, their main program is IGERT, but there are also a lot of ideas that are being discussed behind the scenes about where they see graduate education headed. I'd recommend talking to the program directors in that division to get their thoughts.

Q: What about technology-assisted learning?
A: There is a lot of interest in technologies that provide rapid feedback or allow collaboration among students, but, like any tool, there are right ways and wrong ways to use these technologies. Folks will say they want to use a particular technology in their classroom, but the question is, "why?" The educational goal should come first, and the technology should serve that goal rather than vice versa.

Student Response Systems (such as clickers) are an interesting method to provide more rapid feedback to students (see the review article by Fies and Marshall, Journal of Science Education and Technology, 2006). Another method is online homework questions. Getting feedback even just 2 or 3 days later can be discouraging, and everyone – not just students – appreciates more rapid feedback. (Think about how it feels to get reviews back on a proposal 6 months after you've submitted it.)

Online homework can generate problems with randomly varying numbers (here at Texas A&M, we use systems such as "Blackboard" (http://www.blackboard.com), but it's still a challenge to generate questions that require graphs or chemical equations for balancing that use varying numbers. Online homework has been developed for some popular subjects such as first-year physics or calculus, but is not necessarily available for other subjects, so a PI could propose to pull together material and develop online homework for a new area. A project might involve pulling material together and putting it on-line for a new area. You could also assess the effectiveness of using these rapid-response approaches.

Also, just knowing if the answer is right or wrong is not always the most valuable way to help students learn. Formative feedback helps students to discover where they are making mistakes. Researchers have discovered that there are a number of patterns of mistakes, and those can then be used to reveal what students are doing wrong. Software is being developed that can then help students to understand what conceptual errors they are making based on their wrong answers.

Another possible direction for a particular subject is to develop what is called a "concept inventory." A concept inventory is a collection of carefully developed concept questions. Each concept question poses a scenario and asks students something about what will happen without asking students to generate numbers or formulas. Research on concept inventories has shown that subjects can successfully complete a course, even earn an A, but lack conceptual understanding of the subject. The best known concept inventory is the Force Concept Inventory developed by Hestenes and Halloun (http://modeling.asu.edu/R&E/FCI.PDF) for the introductory physics mechanics course. Developing and validating an entire concept inventory would be beyond the scope of a CAREER proposal, but some initial work toward that goal might be proposed as part of a CAREER. For example, a researcher might propose to develop a set of concept questions dealing with several key concepts. For emerging fields, even identifying key concepts would be a substantive contribution. However, to do that kind of project, a PI would definitely need to engage people with expertise in developing concept inventories.

What about labs?

One promising innovation is to use a set of approaches that are variously called inquiry-based, problem-based or project-based approaches. There has already been a lot of research on these kinds of approaches, so be sure to read the literature so that you can build on existing knowledge. I wrote a white paper discussing promising approaches in this area for the Board of Science Education of the National Academies [http://www7.nationalacademies.org/bose/Froyd_Promising_Practices_CommissionedPaper.pdf].

An inquiry-based example for a lab might be to get the students to design the experiment. The students work together to formulate the exact question and figure out a method to address the question. However, any time you pose more complex learning tasks, you must provide support and feedback. If you include this in your proposal, then be sure to figure out: what is my contribution in this area? Is it the materials, a curriculum, a lab manual?

Q: NSF places a lot of emphasis on involving undergraduates in research. Are there any innovative approaches to that?

A: Involving undergraduates in performing research is an excellent way to get them interested in conducting research, but it doesn't scale up easily. What do you do if you have 50 undergrads? How do you deal with that? Some people have been working on models that allow a faculty member to expose large groups of undergrads to research. One approach is to have students work in groups, perhaps mentored by graduate students or postdocs. Chris Quick in the College of Veterinary Medicine here at Texas A&M has developed a program in which tens of undergraduate students can participate. More information can be found in a paper he and others have published [http://www.ncbi.nlm.nih.gov/pubmed/18539852?ordinalpos=4&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DefaultReportPanel.Pubmed_RVDocSum].

Also, if you have a large number of undergrads, you may not want to put a lot of freshmen in front an expensive piece of lab equipment, but you could explain what it does and how it works and then have the student work on data generated by the instrument. This approach is an example of engaging students in inquiry-based learning, a type of teaching that engages students in authentic reasoning and thinking using typical tools, models or data generated by research. Bruce Herbert in Geology & Geophysics at Texas A&M has done a great job incorporating inquiry-based learning into one of his courses in a way that is similar to undergraduate research and allows Dr. Herbert to integrate his scientific research with his teaching. Another innovative approach is to expose undergraduates to a topic and then ask them to come up with research ideas. You can get the students working on sorting through the ideas, and some gems may emerge in that process.

Steve Balfour has taught over 200 students in an introductory psychology course at Texas A&M, and he created a website where students wrote and posted papers about topics in introductory psychology. The technology supporting the web site allowed the papers to be peer reviewed, and the original contribution and the peer reviews served as indicators of student learning. One student in the course generated a PhD-quality research question. Other professors have students create Wikis that are a synthesis of work in an area and have peers (other students) evaluate them. The quality of the material generated could be used for assessment. Remember that encyclopedias are high quality both because of who writes the articles but also because of the review and revision process. Working together in this way can be a valuable experience for students.

Q: Are there common mistakes that PIs should try to avoid when developing an education component for an NSF proposal?

A: One common mistake, which I discussed earlier, is proposing an education component that is not distinctive or innovative, so that there is really nothing that makes their idea stand out from what everyone else is proposing.

A second common mistake is to try to do it alone. Invest the time to talk to people rather than repeating mistakes hundreds have already made. A good place to start here at Texas A&M is our Center for Teaching Excellence [http://cte.tamu.edu/]. The CTE gives individual consultations as well as workshops, and you can even call them up and request a workshop on a particular topic if you don't see it on the schedule, and if there's enough interest they will develop one. Many other universities have similar faculty development centers.

A third common mistake is proposing an education innovation without knowing what has already been done in the area. This is another place where support from other people can help.

Handout #3

Finally, PIs may make a mistake proposing an educational component without asking themselves if this is something they are really interested in doing. If they are funded and then have to invest time and energy in a project that they really don't believe in, it can suck the life out of them. Pick something that really matters to you.

Q: What about outreach to K-12 students?
A: I'm really not an expert in K-12 outreach, but I will offer one piece of advice: think systemically. If you want to have a strong impact on K-12 education, I think it's most effective to influence the teachers, not just the students. By influencing a 5^{th} grade teacher, you will affect all the classes of 5^{th} graders that will come through that teachers' classroom. You could also work with PTOs and parents. There's also a movement to start putting engineering in the high schools and to increase the number of science classes most high school students take. If we want to entice more students to pursue science and engineering, these high school educational experiences need to be really good. This could be an opportunity faculty to reach out and help high schools. The College of Education and Human Development has quite a few researchers who work in K-12 science and math education and the College of Science has experts in mathematics and science education. They can be very helpful in advising you on how to plan and execute a K-12 education plan and in helping you to connect with schools.

Handout #4

CAREER PROJECT SUMMARY EXAMPLE AWARDED 2006

Jairo Sinova, Department of Physics, Texas A&M University

SECTION A- SUMMARY: This five year career-development plan (CDP) is an integrated research, education, and outreach program that focuses on the study of spin-dependent phenomena in semiconductors at multiple length scales. This CDP has four main goals:

1. To develop a theory of spin transport and accumulation in spin-orbit coupled systems where spin manipulation is possible solely by electrical means. This study, which encompasses the spin-Hall effect, will address key issues such as disorder scattering, generalized drift-diffusion equations, and interaction effects. Several approaches combining analytical and computational techniques at different length scales will be utilized;
2. To obtain a systematic theory of the anomalous Hall effect and anomalous transport that treats on an equal footing both extrinsic and intrinsic mechanisms responsible for the effect. This study will also merge different approaches to resolve the contradictory results obtained through microscopic and phenomenological approaches which ultimately should be linked, forming a consistent theory;
3. To further extend the theory of magneto-transport and magneto-optics in diluted magnetic semiconductors (DMS) to include nano-structures and hybrid systems and explore new phenomena such as tunneling anisotropic magneto-resistance;
4. To implement an educational plan which incorporates and develops a new teaching initiative in the upper-division undergraduate curriculum, involves undergraduates in research, promotes student international collaborative research, exposes the field of spintronics to the general public, and provides a resource web-site for DMS studies.

Intellectual merit of the proposed activity: The proposed research plan addresses fundamental questions essential to advancements in the semiconductor spintronics field (SeS). We propose to develop a spin-transport theory for systems with intrinsic and extrinsic spin-orbit coupling using a variety of models and approaches at multiple length scales in order to connect the physical insights obtained through each approach into a unified cohesive picture of spin-transport in semiconductors. At the nanoscale it is possible to explicitly address the effects of disorder on decoherence and spin-accumulation. This microscopic approach must ultimately be linked to the macroscopic length scale as it was done successfully in charge transport theory. Some of these approaches will involve non-equilibrium Green's function calculations, phenomenological model calculations, and first principles calculations. The PI has ongoing collaborations with leading experimental groups at Hitachi-Cambridge, SUNY Buffalo, U. of Würzburg, and U. of Nottingham. This CDP extends naturally a highly fertile line of leading research by the PI which has generated many publications by his group in top ranked journals and has been featured in wider audience journals (Physics Today, February 2005).

Broader impact of the proposed activity: The greater tunability of materials properties in semiconductors gives SeS devices richer scientific and technological possibilities than their metallic counterparts and may resolve current obstacles such as dissipation of heat at the nanoscale. This CDP evaluates SeS systems as a technological alternative.
The educational and outreach component of this CDP focuses on four segments: (1) Incorporation, further development, and assessment of several Paradigms of Physics (PP) module courses at Texas A&M University (TAMU) in coordination with their developers at Oregon State University. The PP program consists of several short module-like-courses, taught during the junior year, that focus on key paradigms that cut across several branches of physics. This allows students to better connect many interwoven ideas in different subfields. (2) Direct undergraduate involvement in the group's research projects. (3) Enhancement of graduate education, through student participation in international collaborative research including visits to international experimental groups. (4) Outreach activities to increase public awareness of spintronics and its broad impact in society, including public lectures and the development of a website describing spintronics research at TAMU at a general level. In addition a website dedicated to the specialized DMS research community will be further developed. The PI believes strongly in mentoring underrepresented students and diversity will be encouraged in the research group. The PI is currently advising two Hispanic graduate students and two undergraduate students.

Comment [LMD1]: Concise description of the area of research

Comment [LMD2]: Educational goal included with research goals

Comment [LMD3]: Goals described early in the summary in enough detail to be meaningful

Comment [LMD4]: New knowledge generated

Comment [LMD5]: Why it's significant

Comment [LMD6]: Brief overview of methodology

Comment [LMD7]: Collaborations and resources are part of intellectual merit

Comment [LMD8]: Describes the PI's credentials – also part of intellectual merit

Comment [LMD9]: Technical broader impacts.

Comment [LMD10]: Strong educational broader impacts described with some specifics.

Comment [LMD11]: Addresses diversity

Handout #5

Example CAREER Introduction and Overview Section, Awarded 2007

Jaime Grunlan, Department of Mechanical Engineering, Texas A&M University

CAREER: Tailoring Nanoparticle Dispersion and Microstructure Using Stimuli-Responsive Polymers

Project Description

1. Overview and Significance of Proposed Project

The ultimate **goal** of this project is to precisely tailor the microstructure of high aspect ratio nanoparticles in both liquid suspensions and solid polymer composites. Despite all of the promise that particles such as carbon nanotubes hold, lack of microstructural control during processing remains a significant hurdle to their widespread use.[1-3] In the proposed work, a high level of control over the process will be demonstrated through the use of stimuli-responsive, water-soluble polymers to control the extent to which the particles are stabilized and dispersed. Polymer-particle interactions will be weakened or strengthened by increasing or reducing viscosity through adjustment of a given stimulus (e.g., pH, temperature, or light) to enhance processability. An external stimulus will modify the degree of ionization and/or shape of a given polymer, which will in turn alter the degree of non-covalent interaction between the nanoparticles and the polymer, as shown in Figure 1. In addition to the novelty of using stimuli-responsive polymers to control nanoparticle organization, there are two important traits to this research. By focusing on an aqueous environment and water-soluble polymers, this work promotes the use of environmentally benign materials. Furthermore, polymer-particle interactions are non-covalent, allowing the intrinsic properties of the particles to be preserved. The heavily aggregated and fully exfoliated (dispersed) states shown in Figure 1 are the microstructural extremes. Intermediate microstructures will also be possible with the appropriate choice of polymer and stimulus. The questions motivating this research are: to what degree can we tune polymer-inclusion interaction through non-covalent means? What are the effects of the interactions on the final composite microstructure and properties? How can we use our findings to engineer polymer structures optimizing microstructural control of these nanoparticles? The goals of this study correlate well with the mission of the Materials Processing and Manufacturing (MPM) Program within the Design and Manufacturing Innovation (DMI) Organization.

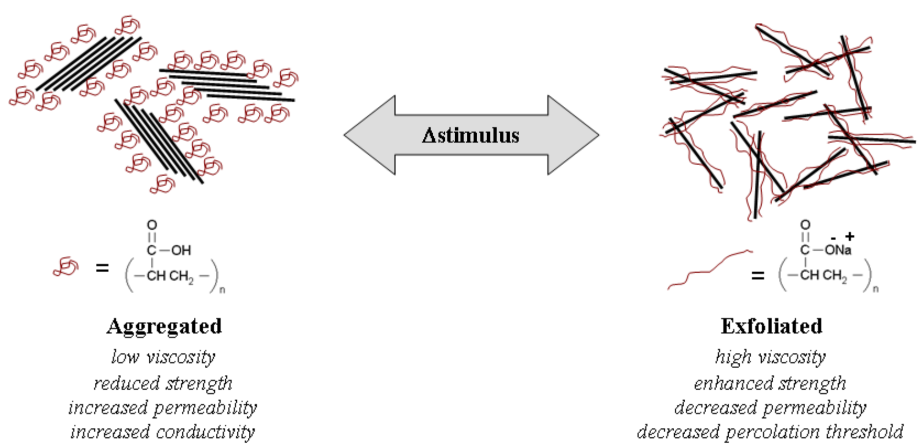


Figure 1. Schematic showing the change in nanoparticle microstructure resulting from a change in stimulus supplied to the water-soluble polymer matrix. This has been demonstrated for single-walled carbon nanotubes and poly(acrylic acid), where low pH results in an aggregated microstructure due to a coiled polymer that poorly interacts with the nanotubes (see Ref. 4). Other stimuli-responsive polymers (e.g., temperature and light) are expected to produce similar microstructural changes and produce the

types of macroscopic behaviors listed here.

The issues presented above will be addressed with the overall **objective** of understanding the range and sensitivity of microstructural control that can be achieved using stimuli-responsive polymers. In general, stronger polymer-nanoparticle interaction should result in a better dispersed microstructure with the properties highlighted in Figure 1. Weaker interactions will generate more bundled nanotubes or nanowires, resulting in a different set of properties. In an effort to balance breadth and depth of research, three model nanoparticles and three classes of stimuli-responsive polymers will be evaluated. **The significance of our approach** is that *materials could be engineered with precisely tailored performance by tuning the microstructure of the particles during manufacture*. This is a new way to process nanoparticles that will allow suspension and solid composite properties to be tailored for a given application. For example, forcing nanoparticles into a heavily aggregated state in a liquid mixture will produce lower viscosity and result in energy savings during processing. On the other hand, the ability to fully exfoliate nanoparticles in a polymer composite with strong polymer-particle interactions is vital for achieving the significant enhancements in mechanical behavior predicted by theory. Figure 1 shows a list of behaviors and characteristics associated with the two extreme states of dispersion, but other particle-specific properties will also be examined in this work (e.g., electrical conductivity, optical effects, dielectric constant, etc.). **The novelty of our approach** is that *one state of particulate dispersion could be used during processing in a liquid with a completely different microstructure induced just prior to the final dry composite formation*. **The outcomes of this research should provide the necessary framework for tuning the properties of aqueous suspensions and hybrid materials containing high aspect ratio nanoparticles.**

Handout #6

Example Preliminary Results overview paragraph…

A number of preliminary studies performed by the PI and her lab demonstrate the feasibility of the proposed project. In summary, these results are: (a) integration of the proposed microscope system has already been started and is feasible (Figure 3); (b) the PI has demonstrated the ability to image live cells using contact mode AFM (Figure 4), and to conduct quantitative topography measurements using AFM cell images (Figure 5); (c) the PI has been able to conduct quantitative measurements of receptor-ligand adhesion forces (Figure 6); (d) the PI has successfully imaged fluorescent live cells (Figure 7); (e) accurate alignment of cell images using AFM and optical methods was demonstrated (Figure 8); This work is briefly described below:

Handout #7

Example CAREER Research Plan overview paragraph, Awarded 2007

Jaime Grunlan, Department of Mechanical Engineering, Texas A&M University

4. Research Plan

This research plan has three phases, with each focused on a specific stimulus (pH, temperature,or light) that will be used to control nanoparticle microstructure. Three experimental tasks will be performed within each phase: (1) polymer synthesis and characterization, (2) suspension preparation and characterization, and (3) polymer composite preparation and characterization. Many of the model stimuli-responsive polymers we will use are not available commercially and will need to be synthesized by my students or with the help of a collaborating group. Professor David Bergbreiter's group in Chemistry at Texas A&M University [74,80] and Professor Xin Wei's group in Chemistry at Texas Southern University [115-116] will provide assistance with polymer synthesis in the form of consultation and hands-on laboratory assistance. Each polymer's molecular weight and stimuli-responsive behavior will be characterized prior to mixing with the model nanoparticles. Singlewalled carbon nanotubes, provided by Carbon Nanotechnologies (Houston, TX), will be the most used particles, but we will also study differences in microstructural control when silver nanowires (provided by Prof. Xia at Univ. of Washington) and CdS nanowires (provided by Prof. Regev at Ben Gurion University in Israel) are used instead of SWNTs. Nanoparticle chemistry and polymer responsiveness are expected to play a significant role in the range of microstructures that can be achieved. The characterization techniques summarized in the table below will be used in each phase of this project. Professor Dale Schaefer's group at the University of Cincinnati will help with light scattering experiments [117] and the Characterization Facility (CharFac) at the University of Minnesota will provide cryo-electron microscopy assistance [118] Phase One is an in-depth study of pH-responsive control of nanoparticle microstructure and will take three years to complete. Phases Two and Three are proof of concept studies that will take approximately one year each to complete.

CAREER: Development of 'Smart' Structural Nanocomposites Based on Interfacial Coupling and Local Field Enhancement

Zoubeida Ounaies

5. EDUCATION PLAN

5.1 Background and Objectives

Many engineering educators understand that the primary mission of their instruction is to educate the future leaders of the profession and prepare them for the yet to be determined challenges of a technology-driven, internationally competitive world. Consequently, most engineering students are expected to understand and retain complex engineering concepts, relate new concepts to previous knowledge, and see the "big picture." Central to the goals of both educators and students is that the learning be meaningful and long-lasting. The PI shares this interest in the improvement of learning and learning environments, especially for students of diverse backgrounds and limited experience levels. The PI's interests and motivation for the education plan focus on ways to improve student learning while simultaneously working to expand and diversify the traditional base of science and engineering students. Goodman et al. (2002), in summary of a similar concern of many engineering education reformers, note, "the interests, socialization, and experiences of women (and other underrepresented groups) are often at odds with traditional engineering structures. These populations tend to flourish, on the other hand, in settings that emphasize hands-on, contextual, and cooperative learning." Recent literature in support of innovative pedagogies suggests that a combination of learner-centered and discovery-based curriculum models promotes learning for students who do not respond to traditional behaviorist instructional approaches (Voss et al., 2002; Ellis et al. 2003). Moreover, the incorporation of a visual approach to teaching and learning through the use of concept maps, videos, and in-class demonstrations, is useful for a wide variety of students, especially those who are either visual or holistic learners and need to see the "big picture" in order to understand where they and their present learning fit within the larger context of the assignment or curriculum. Such visual, holistic, discovery-based and learner-centered approaches are also successful pedagogical strategies for students who excel through traditional linear and verbal strategies because information is simultaneously presented sequentially and supported by the inclusion of text to present content. A research-based model for the design of learning environments guides the educational plan for the proposed project (Bransford et al., *How People Learn*, 2000). Published by the National Academy of Science, *How People Learn* (HPL) is a theoretical framework that synthesizes research and practice from the learning sciences to create a simple yet powerful heuristic for addressing fundamental principles of learning that are important for teachers and curriculum developers to follow as they design effective instructional environments. HPL, was also adopted as the theoretical framework for the design of the VANTH project. The VANTH engineering research center is an NSF-funded collaborative project among Vanderbilt, Harvard, MIT, Northwestern, and the University of Texas at Austin, and is dedicated to the transformation of "bioengineering education to produce adaptive experts by developing, implementing and assessing educational processes, materials and technologies that are readily accessible and widely disseminated" (see http://www.vanth.org). These NSF-sponsored projects use research findings from the learning sciences to support the development of educational designs that focus on HPL principles that engage students' prior understanding, enhance their development of connected, factual and conceptual frameworks for understanding, and develop self-monitoring and reflection skills that enhance learning (Donovan et al., *How Students Learn*, 2005). Dr. Carol Stuessy, a collaborator who will advise the PI on the design, implementation, and assessment of the educational plan, serves as an academic consultant for the VANTH project and is a co-director of ITS at Texas A&M University.

In summary, the PI's education **objectives** and associated tasks are:

- (1) **Mentoring and Outreach** to increase the participation and success of underrepresented and underprivileged groups in science and engineering by implementing a mentoring and outreach program, which includes a one-week summer workshop focused on emerging areas in material science.
- (2) **Curriculum Design** using videos, hands-on activities, demos, and research visuals in an undergraduate "principles of materials engineering" course and a graduate "multifunctional materials" course.
- (3) **Scholarly Evaluation of curriculum design and outreach activity** to assess and evaluate the proposed graduate and undergraduate courses and the educational outreach pilot project in order to determine their

effectiveness and improve their ongoing implementation, in collaboration with colleagues in the College of Education at Texas A&M University.

5.2 Preliminary results and Prior Education Accomplishments

In graduate school, the PI served as a mentor in one of the first early intervention programs aimed at attracting girls ages 11-14 to science and engineering. At NASA LaRC, the PI served as research advisor and mentor to high school juniors and seniors (Central Virginia Governor's School for Science & Technology) and undergraduate students through the LARSS program. The LARSS program is a summer scholars program at NASA LaRC, a 10-week program available to juniors, seniors, and first-year graduate students. LARSS' objective is to encourage students to pursue graduate degrees by exposing students to the professional research resources and facilities at LaRC. Most of the students who worked with the PI presented posters and oral presentations based on their research, in regional and national conferences and workshops. The PI has publications with research students, where the students appear as co-authors or are acknowledged for contributing essential results to the published study. The PI encourages the students to display their own insights into the research projects. As a result, the students have been successful in their research pursuits, publishing and being recognized at national conferences with awards for their work (2 first place poster competitions at the National Educator's Workshop, one 3rd place finish for ASME/SPIE Best Student Paper).

The PI has always sought opportunities for the students to not only get experience and training in research but to also present their research findings to a broad audience. The PI served in the organizing committee of the National Educator's Workshop: Experiments in Materials Science and Engineering (NEW) for the past three years, and since then, has encouraged her students to participate in the conference. NEW is largely targeted at secondary and college-level educators in Materials Science.

Three years ago, the PI initiated a poster presentation session, where undergraduate and graduate students could present their research work to a broad audience. Judges of the poster sessions were recruited from government agencies such as NASA, NIST and ONR, and from industry such as Intel and Boeing. The student poster sessions are in their third year, and have grown from 20 students to three to four times that.

In the last three years, the PI has supervised seven graduate students and six undergraduate students. Of the six undergraduate students, two have since been accepted to graduate school and three have applied to graduate schools in biomedical engineering, mechanical engineering and material science and engineering. The PI has also enjoyed a fruitful collaboration with a colleague at a university in South Korea, Dr. Jaehwan Kim, professor and director of the EAPap Research Center. Through this international collaboration, two of Dr. Kim's students spent the summer in the PI's lab, collaborating with the PI's students on a joint effort aimed at exploring the piezoelectricity inherent in the biopolymer Cellulose, and developing flexible conducting electrodes based on CNT/PANI. This on-going collaboration has resulted in three conference proceedings papers (Kim et al., 2005; Yoon et al., 2005; Kim et al., 2005) and a manuscript in preparation for a journal publication.

In summary, preliminary and prior education accomplishments include:

- training and mentoring undergraduate and graduate students in scholarly research and exposing them to interdisciplinary research
- empowering undergraduate and graduate students to become independent scientists and engineers by involving them in national scientific meetings
- outreach to high school students to encourage them to consider careers in science education
- exposing students to international collaborations through a student exchange with Inha University

5.3 Mentoring and Outreach

The first project in the educational plan, *SMARTGirls*, will implement a multilayered mentoring program designed to encourage middle and high school girls from underrepresented and underprivileged minorities to consider careers in science and engineering and raise their level of interest in Math and Science. Girls from small, culturally isolated rural communities within an hour's distance from College Station will be recruited to participate in the program. The professional development specialist in science education at the Regional Educational Service Center, an arm of the Texas Education Agency, will assist the PI in recruiting girls from these schools. *SMARTGirls* takes advantage of numerous interdisciplinary collaborations with the College of Education and other university and community institutions, among which include the translation of the student-produced videos into educational materials that will be used in *SMARTGirls* workshops, K-12 science classrooms, university science education courses; the mentoring of pre-college and undergraduate female students by women graduate students; and the on-going assessment of the *SMARTGirls* program. All costs associated with administrative tasks, room, board and transportation for *SMARTGirls* will be covered by the local Society of Women Engineers (SWE) camp and the SENSR outreach program (College of Engineering, TAMU). Mentoring, working with teachers, recruiting teachers and *SMARTGirls* participants, program assessment through the College of Education, and all other activities associated with *SMARTGirls* will be coordinated by the PI and participating mentors. The mentors will be recruited amongst the undergraduate and graduate engineering and science students, and through SWE. Activities will vary from touring of facilities, to attending seminars given by women faculty in engineering to participating in hands-on group projects focusing on materials science, and running virtual experiments in the Immersive Visualization Center (IVC). The educational implications will have a global impact through a website and through the interaction with the teachers, as teachers will have access to demonstrations and experiments in material science targeted to middle and high school audiences. Continued communication with the participating girls will be maintained throughout the school year through e-mails with the mentors and visits by the PI and college students to the participating schools. The number of participants will vary from five to ten for the first couple of years, until enough material in terms of activities, videos, and seminars will be generated. With the continued collaboration with SWE and SENSR, the number of participants would increase to 40-50, which is the target of the SENSR program.

5.4 Curriculum design

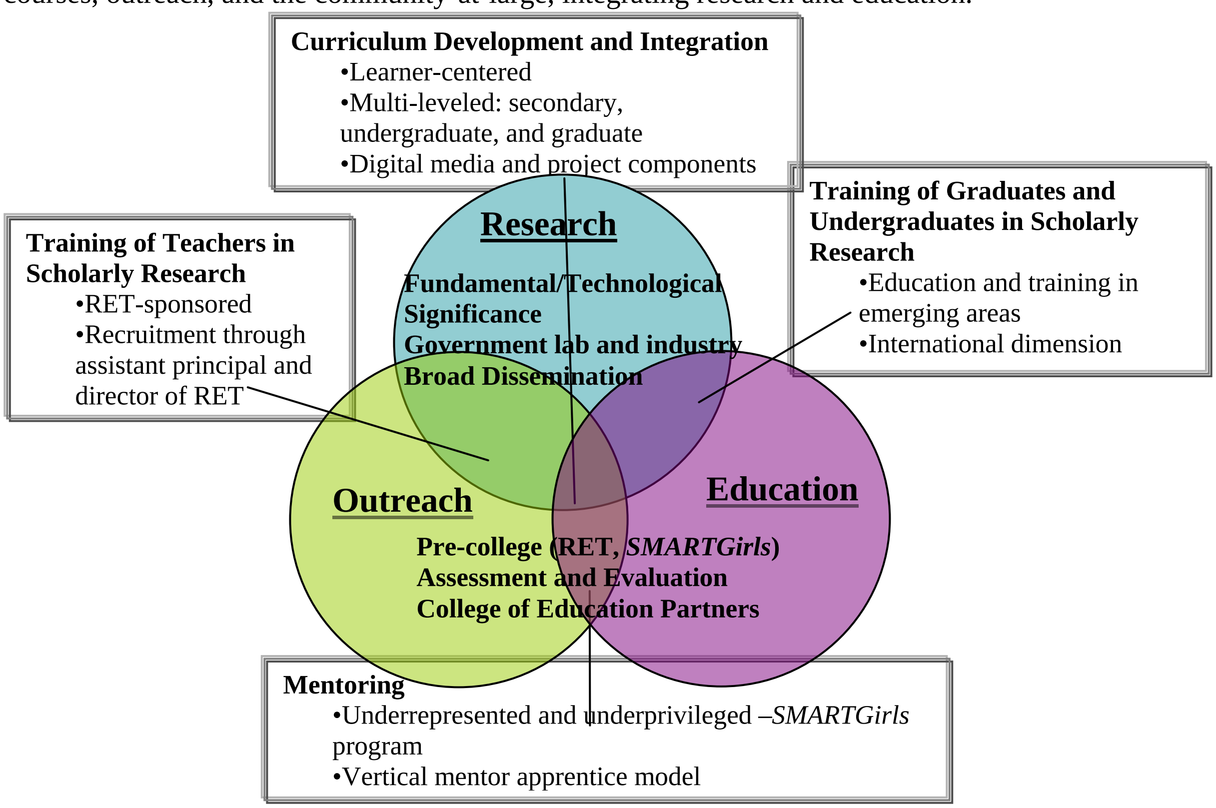
The second project is designed to update and revise an existing undergraduate course in materials and design a new graduate level course in multifunctional materials. The undergraduate course is the only material science course in the current undergraduate engineering curriculum in the PI's department. The revised course will include student-produced video case studies of their self-designed experiments, an interactive laboratory component, and the integration of the course content with other courses in the curriculum. Further, the student-produced videos will also serve as demonstration content for the revised undergraduate material science course and other courses. The video and laboratory experiments will come from a number of sources including the PI’s research, the PI’s involvement in the National Educator’s Workshop: Experiments in Materials Science and Engineering, and commercially developed educational tools. In a previous undergraduate course entitled ‘Material Science for Engineers’, the PI incorporated videos shot at the PI’s lab, scanned and downloaded graphics, and in-class demonstrations to supplement and improve upon lecture notes. The first semester the PI taught the course, students complained that they failed to see the relevance to their chosen engineering major, and had a hard time connecting all the themes together to end up with a strong understanding of structure-property-performance relationship. Once videos, microscopy, and hands-on demos were incorporating the next semester, it became evident that the students had developed better understanding of dislocations, atomic structures, and structure-property in general. Although a thorough assessment was not done at the time, students commented in the course evaluations about the animations, about the research applications, and the demos in a very positive manner. The visualization, integration of research through video and microscopy, and the laboratory experiments encourage discovery learning through hands-on or experiential training, and provide experiences beyond the traditional Mechanical or Aerospace Engineering curriculum. To better relate the course content to the rest of the curriculum, the PI will use concept maps, literally graphical representation of concepts covered in the course and how they relate to strength of materials, or statics or even heat transfer. Concept maps are not a new phenomenon in education or in engineering education. Smith (1987) argues for the importance of helping (engineering) students understand the nature and structure of knowledge and also an understanding of how humans learn if (the student’s) learning is to be meaningful. This aligns with the HPL methodology of evaluation and assessment that will be used in the proposed plan. McAleese (1998) finds that using concept maps predisposes learners to consider and make relationships among concepts.

5. 5 Scholarly Evaluation of curriculum design and outreach activity

Assessment that is congruent with the goals of the education plan is crucial to providing opportunities for feedback and revision (Voss et al., 2002). Because the revised undergraduate course and the *SMARTGirls* project are based on the principles of *How People Learn*, they offer rich contexts in which to collect data to evaluate and support such approaches for engineering education in K-12 and higher education. The proposed plan addresses the HPL heuristic by targeting interventions that use learner-, assessment-, knowledge-, and community-centered principles in their design (National Research Council, 2000; Bransford 1998). The evaluation of *SMARTGirls* will be unique to the overall evaluation of the proposal and will emphasize three key components. The first component will be an open-ended, pre-/post-questionnaire that collects a variety of demographic and academic data (the academic data will be directly tied to the learning outcomes for the program). The second component will be focused interviews and observations. Questions and observations will focus on student involvement in a variety of required and elective activities sponsored by the *SMARTGirls* program, including reflection on the efficacy of these activities. The third component of the assessment uses a model to collect data that will drive improvements for a specific activity over time (formative assessments) and to archive data on a specific activity so that it may be analyzed at a latter date if it proves significant in the overall program evaluation (summative assessments). College of Education collaborators, Dr. Carol Stuessy and Dr. Scott Slough, have extensive experience with program evaluations and will coordinate evaluation of the *SMARTGirls* program. They will also supervise a graduate student in assessing the visual tools proposed for the undergraduate course, to evaluate their effectiveness and impact in improving the quality and retention of the learning.

6. SYNERGY OF INTEGRATED RESEARCH AND EDUCATION PLANS

Structural materials with multiple functionalities have broad technological impact. The proposed plan aims to further the fundamental knowledge of these types of materials and advance our understanding of nanoinclusions/polymer interaction to control self-sensing and actuation while maintaining lightweight, strength and durability. Research content will be synergized with several courses such as Principles of Material Engineering and Multifunctional Materials. Students will acquire advantageous research experience and will achieve mentorship skills. These educational efforts will have a broad impact on teaching the next generation of the workforce to utilize modern technology for solving complex engineering problems. Two main projects in the proposed educational plan link the research and data collection central to the proposal with learner-centered curriculum and mentoring based on HPL. In broad terms, the PI's overall goals are 1) to make use of research-based effective practices in education to be a better teacher in the field, 2) to disseminate research through courses, outreach, and the community-at-large, integrating research and education.



Handout #9 – Example Department Head Letter (with comments)

17 June 200x

National Science Foundation CAREER Program
4201 Wilson Boulevard
Arlington, VA 22230

Dear Program Representative:

On behalf of the Department of Civil Engineering at Texas A&M University, I am very pleased to support Dr. John Doe's application for the National Science Foundation CAREER Award. Dr. Doe has proposed a comprehensive and innovative research and education plan that will contribute to the Department's initiatives in integrating research and education into our engineering programs.

Dr. Doe is working in an exciting research area at the boundary between various fields of science and engineering. His research proposal on the "Career proposal title" draws from laboratory methods, turbulence theory, and numerical analysis to produce results that can be used in the context of the sciences, ocean engineering and other branches of civil engineering. It addresses the basic understanding of [technical details and applications]. He is also a dedicated teacher working on enlarging the curriculum in coastal and ocean engineering and enhancing internationals cooperation with other institutions of higher learning.

The Department of Civil Engineering is fully committed to providing Dr. Doe with the support he needs to further develop his academic career. As a demonstration of the Department's commitment to his development and success, the Department will provide substantial funds, up to $xxxxx in institutional support, for the purchase of the laboratory equipment required for his proposed research. In addition, the Department will provide Dr. Doe with academic release time of 20% for nine months (one day per week) during each year of the project and one-and-a-half months of summer salary support during the first year of the project. This will allow Dr. Doe to focus his efforts during this important time. The Department will also commit to providing $xxxx per year ($xxxx maximum) in travel funding for Dr. Doe and his students and up to $xxx per year for publication costs. Most importantly, the Department will provide mentoring support for Dr. Doe through ongoing relationships with senior faculty.

I have read and I endorse this career-development plan. I attest that Dr. Doe's career-development plan is supported by and integrated into the educational and research goals of the Department and Texas A&M University. I personally commit the Department to the support and professional development of Dr. Doe. I verify that Dr. Doe is eligible for the CAREER award: as of the date of this letter, Dr. Doe holds a doctoral degree in Civil and Environmental Engineering, is untenured, has not previously submitted a CAREER proposal, and is employed in a tenure-track position at Texas A&M University.

Sincerely,

Dept. Head, etc.

Comment [LD1]: States how the proposed project supports departmental priorities

Comment [LD2]: Clearly states the research and education benefits of Dr. Doe's research. Includes details of the project that makes it clear the DH has read the proposal.

Comment [LD3]: Discusses tangible support for the PI and project. The PI's startup package can be mentioned here as institutional support.

Comment [LD4]: This section is required (see solicitation for exact wording).