TEACHING PROPOSAL

Each applicant is expected to propose a teaching plan that has promise to improve science education. Although this is an opportunity to share the philosophy and principles that guide you as a teacher-scholar, you must include concrete examples of what you have done and plan to do. Your plan needs to be substantive and must demonstrate a long-term commitment to your role as a teacher. Teaching proposals are screened initially by the Research Corporation staff, and only those that pass this screening process are submitted to peer review of the teaching and research, giving equal weight to both.

STATEMENT OF THE PROBLEM, SIGNIFICANCE OF THE PROBLEM, AND PLAN OF PROCEDURE (State clearly the problems or issues you wish to address and how they relate to any ongoing work. Carefully outline the importance of your plan and the impact it may have on your students, especially undergraduates. A viable approach should be given, including examples from your own experience and/or from the literature. Indicate ways in which the completion of this work has a broader impact.)

EDUCATION PLAN SUMMARY: The educational and outreach plan involves three key areas.
(1) Implementation, assessment, and further development of several courses of the Paradigm of Physics (see below) program utilizing formative assessment tools: I became aware two years ago of a new and exciting program called Paradigm of Physics (PP), developed at Oregon State University (OSU).[35,36] The PP program focuses on restructuring and improving significantly the upper-division undergraduate curriculum. It consists of teaching several intense module-like courses designed to explore single themes and key paradigms that cut across the different branches in physics, e.g. oscillations, periodic potentials, spin and quantum measurements, etc., during the junior year. The senior year follows a more conventional but coordinated curriculum. This 'nailing down' of key concepts common to a variety of subjects allows students to better understand and see the connections in the different areas of physics and to develop better interdisciplinary skills. Several of these module courses, which are in an advanced but not fully completed phase, will be implemented and assessed at Texas A&M University (TAMU) in coordination with the original developers at OSU. This final development of the courses will be done though formative assessment[37] techniques such as Calibrated Peer Review (CPR),[38] which seamlessly integrates writing, training in assessment for students, and web-based peer review. I have already used CPR in introductory physics classes.
(2) Integration of undergraduates in research: Participation of undergraduates in research is often neglected in undergraduate education. In agreement with the Boyer Commission report,[39] I strongly believe that research is a fundamental part of a complete undergraduate education. Undergraduate involvement and extensive mentoring will be an integral part of my research projects, as described below.
(3) Promotion of the nano-science field and its impact on society through public lectures and web-page development for the general public involving undergraduates in its development: Outreach activities to increase the awareness of the nano-science field are part of this program in the form of public lectures and the development of a website describing spintronics and nanotechnology research at TAMU at a level accessible to the general public. Undergraduate students will be involved in the development of the website and delivering of the lectures.

I-Paradigm of Physics course implementation and development at TAMU:

Motivation and concept: Over the past decade, intensive research in the cognitive sciences has radically changed the general understanding of teaching and learning. Key studies in general education, such as the National Research Council reports on 'How people learn',[37] and in introductory-courses physics-education[40] have established several important factors needed in efficient student learning: (1) active learning vs. simple note-taking; (2) a spiral approach that revisits common themes at increasingly more advanced cognitive levels; (3) exploring specific examples prior to going into the general theory; (4) group activities and peer instruction; and (5) a clear focus of the courses objectives with a philosophy that "less is more".[35]

Most traditional upper-division curricula depart from some or all of these principles. As a consequence, upper division undergraduates often struggle to grasp and connect the many interwoven ideas that cut across different branches of physics. In trying to apply the same principles of efficient scientific learning as the ones used in modern introductory curricula, a new upper-division curriculum has been developed at Oregon State University (OSU).[35,36]

TEACHING, continued

This new curriculum, called the paradigms of physics (PP), consists of teaching several intense short courses/modules designed to explore single themes and key paradigms, e.g. oscillations, periodic potentials, spin and quantum measurements, etc. This focus on key concepts that cut across the fields and are common to a variety of subjects allows students to better understand and see the subtle connections in the different areas of physics. This understanding enhances their development of better interdisciplinary skills.

Plan of implementation: Some of these paradigm courses are now fully developed and available to other institutions while others are still being developed and are at different stages of readiness to be shared with other institutions. My first response upon learning about this program was one of "where was this when I was around?" and I have been advocating for the eventual implementation of the paradigm program at TAMU.

In order to jumpstart such a program at TAMU, I propose the following plan which utilizes existing programs currently in place at TAMU (e.g. CPR) to further develop the module paradigm courses and which will benefit the undergraduate students immediately:

1. I have attended a workshop at OSU in June 2005 for practical training on how the paradigm courses are being taught at OSU. This particular workshop focused on bridging the gap between calculus teaching in math and physics and has also demonstrated the basis of the paradigm techniques utilized in classrooms. During this visit, I also obtained information and materials regarding the other Paradigm modules which will be implemented at TAMU and have discussed several possible implementation plans which incorporate CPR within the paradigm program.
2. The Oscillations and Waves in One Dimension paradigm courses are still not fully developed and their written material remains to be finalized. I will combine these two short courses into a full semester course at TAMU and CPR will be incorporated in them in order to include the undergraduate students themselves in the development of the course. This formative assessment[37] technique has been proven very effective in course and curriculum development. This development process will be done in coordination with the team at OSU, continuously sharing materials and the different experiences.
3. After a few semesters more module courses (the center symmetric potential module and the harmonic oscillator module) will be 'polished' in a similar fashion in order to make them easily available to other faculty members at TAMU as well as to other institutions.
4. Also, given the modular aspect and flexibility of the paradigm courses, some parts of the courses can be modified as plug-in components in more traditional courses. At least one of this plug-in (a modification of the Quantum Measurements and Spin) components will be introduced into the introductory quantum mechanics course at TAMU.

II <u>Undergraduate research involvement and mentoring:</u>

Motivation and concept: Early involvement of undergraduates in research helps develop important skills that are not developed through traditional laboratory experiments taught in a class setting. From my own personal experience, I share the views of the Boyer Commission report[39] which emphasizes the need for integration of research as a necessary part of a complete undergraduate education program.

Plan of implementation: Each year two undergraduate students will be recruited to participate in the group's research. Undergraduates will be given small projects according to their skill level that will help them learn new concepts and, at the same time, be a part of the relevant research machinery of the group by teaming each with a graduate student from the group. They will attend the regular group meetings and during the summer they will be involved in a full project and will be payed during this period for summer support. For example, Adam Haecker is currently undertaking a project to compute tunneling probabilities across modulated barriers and implement this in a visual set up (for computation and visual presentations). This project will be coordinated later with the one being developed in the projects. Adam will learn, ahead of seeing it in the classroom, many quantum mechanical concepts and acquire important computing techniques. Also, emphasis will be given to recruit under-represented students.

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I enjoy tremendously the interaction with undergraduate students, whose enthusiasm and sense of awe when discovering and learning new things is quite infectious and it is thrilling to be a part of. My wonderful experience with the two undergraduate students that I am currently mentoring has motivated me to make undergraduate involvement in my group a permanent part of my career plans.

III <u>Outreach activities involving undergraduates:</u>

Many misconceptions about nano-science are prevalent in the general public, which may lead to a lack of support in popular opinion for the field. In the specific case of spintronics, the public's knowledge is severely limited. The general public has the right to expect a proper reporting of its findings and its broader impact. Such reporting must take the form of outreach activities aimed at conveying and promoting the impact of the field in society in a way which is accessible to everyone.

Given the level of commitment in the other proposed educational activities, a more modest, but still important, outreach activity plan is proposed:

1. Public lectures to high schools and community colleges titled "Spintronics: what is all the spin-fuss about?" and "Nanotechnology in the 21st century" are planned on a yearly basis. Some of these lecture series have already been given to groups of undergraduate students for recruiting purposes at TAMU with positive feedback. Undergraduate research students, with their understanding of high school students, will help improve the effectiveness of the lecture materials and demonstrations for the series. These lectures would reach on the order of 200-300 high school students per year given the number of schools and recruitment in the area.
2. A web-site will be built to disseminate the type of research that is being conducted in nanotechnology and spintonics at TAMU. This website will be accessible to persons with a high school level of physics education and will contain several interactive demonstrations that will engage visual learners. An undergraduate student will help with this web-page development.

<u>Prior accomplishments:</u>

I have demonstrated, throughout my career, a strong commitment to education and outreach activities that surpasses the normal load expected at each level. As a graduate student I was part of an undergraduate evaluation program (the Force Concept Inventory, a 29 question test designed to evaluate student's conceptual difficulties in understanding mechanics) led by Prof. Hake at Indiana University, and volunteered as an editor of the *A Moment of Science* program at the local National Public Radio station. This five minute program explains everyday physical phenomena and the science behind it at a level accessible to the general public. While at TAMU, I joined a Faculty Learning Community group which met weekly with a facilitator from the Center for Teaching Excellence during the Fall of 2003 to discuss different teaching methods and learning processes. In addition, I have started to implement CPR in my introductory physics courses. The program incorporates web-based writing and peer-review component in regular classes to improve scientific writing skills, including planning and critical evaluation, typically weak aspects of science focused students.

In addition I have mentored two undergraduate students in small research projects and will continue to maintain a constant undergraduate research component within my research group. I believe strongly in equal access to higher education in the sciences for women and minorities. This reflects on the makeup of my research group which currently includes two minority (Hispanic) graduate students. I will continue to encourage students from underrepresented groups to participate in research.