

## Project Summary

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**Intellectual Merit** - The goal of this pedagogical research proposal is to educate undergraduate students at the University of New Mexico (UNM) about the history and current state of Nanoscience and Nanotechnology (NS&NT) via hands-on approaches in order to produce an informed citizenry and competitive work force for the 21<sup>st</sup> century. Three junior faculty members and one research professor of engineering education from two engineering programs are employing their collective knowledge in NS&NT to develop new experiments and pedagogical methods that will be institutionalized across UNM's School of Engineering (SOE). The hands-on approach is essential to successful communication of the material to UNM's students. For example, the co-PI's will create lectures on atomic structure and deformation and then use drinking straw (atoms) models to do mock-up nanoindentation experiments in-lecture to demonstrate slip-planes and dislocations. Students will then go to lab and use a nanoindenter having understood the concepts in lecture. Courses on NS&NT will be available during every year of their degree (Freshman – Senior). Though the courses dedicated to NS&NT will be optional, the co-PI's will place NS&NT modules in core courses in both the Mechanical Engineering (ME) and Electrical & Computer Engineering (ECE) disciplines causing all students in those majors to have exposure to NS&NT material.

Succinctly, the objectives of this proposal are the following:

- 1) Create a program in NS&NT for undergraduates at UNM, NM STEM Educators, and local high school seniors. This will be accomplished by offering undergraduate courses in UNM's SOE at every level – freshman through senior years. The freshman course is for undergrads, STEM Educators, and high school students. During the sophomore and junior years, the undergraduates go to their respective curriculums where they encounter NS&NT modules in their core courses in ME and ECE. Finally, in the senior year the ME and ECE curricula merge again by cross-listing of 3 courses in which nanosystems are designed, created, and characterized in the laboratory.
- 2) Institutionalize NS&NT into the UNM-SOE curriculum by creating a *concentration in NS&NT* at the Bachelor of Science level for those students who have taken 3 courses in NS&NT.
- 3) Fuse NS&NT education with research from the co-PI's NS&NT Research. Evident by the investigators' own experience, this approach appeals to the large community of minority students at UNM's SOE, thereby cultivating a cultural exchange that will result in an increase in minority graduates with hands-on NS&NT research experience for undergraduates (REUs) in the state of New Mexico.

**Broader Impact** - This project will institutionalize nanotechnology into UNM-SOE's curriculum by creating a concentration in this area. In this proposal, 4 new courses are created and lecture/lab modules are added to 3 existing courses. These new developments will be in addition to the course and lecture/lab modules from a prior NUE award; 2 of the 4 co-PI's were a part of a previous award. Considering the past and proposed work, a critical mass will have been reached to offer this concentration which is supported by the Dean of UNM SOE's office. Between the two leading departments of the project (ME and ECE) more than 328 *undergraduate students* will be exposed to the NS&NT material. *Out of that number, 158 students are minorities (mostly Hispanic and Native Americans) and 44 are female students.* This approach, while familiarizing New Mexico students with NS&NT, does not strain the curriculum of the two lead departments nor does it financially burden the students.

The co-PI's efforts of training students in the proposed courses will yield students that have a working knowledge of NS&NT and become valuable research assistants even as undergraduates. Therefore, the co-PIs will hire students to perform research in their laboratories where cutting edge NS&NT research is occurring. The co-PIs already have strong record of hiring undergraduate students in nanotechnology research – 8 students and 9 papers. These undergraduate students will participate in regional and international conferences on NS&NT as well as co-authoring peer-reviewed publications.

K-12 Shareable Content Objects (SCOs) will be developed and presented by the minority undergraduate students who constructed them. The co-PI's have identified the great benefit of having undergraduates whose ethnicity matches that of the audience. In addition to the SCO effort, the co-PI's will present components of the NS&NT material developed at 2 to 4 STEM Educator Workshops per year and show the participants how to adapt these into STEM high school courses. The co-PI's plan to impact approximately 100 teachers over the course of two years who in turn will impact several hundred students at local / rural public schools and from New Mexico's Native American Reservations.