



## **NSF-NUE: Using Nanotechnology to Engage Students from High School through Graduate School**

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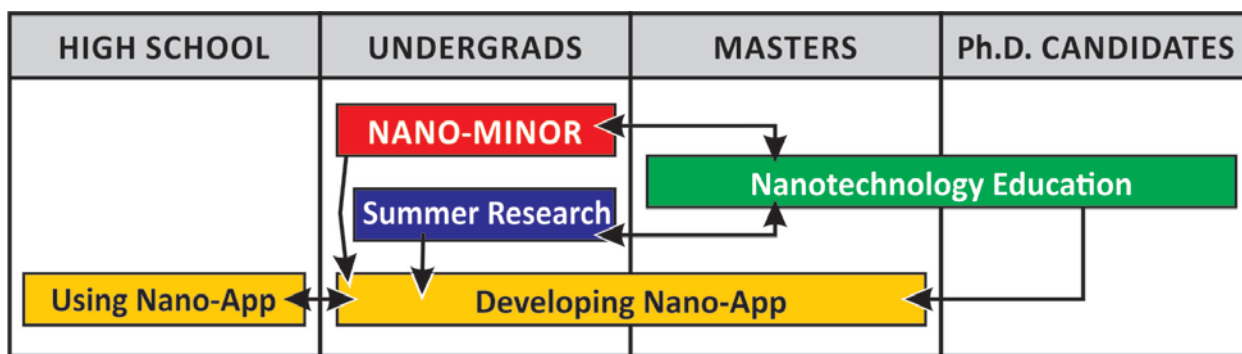
Nanotechnology is expected to create millions of new jobs and generate ~ \$1 trillion in product revenues worldwide by 2015.<sup>1,2</sup> Research and development in nanotechnology is likely to change completely the design, analysis, and manufacturing for a wide range of engineering products. Nanotechnology, however, is still mostly a topic for graduate schools whereas undergraduate programs that focus on nanotechnology remain sporadic.<sup>3</sup> Our NSF-NUE award will build a multidisciplinary, cross-campus educational program that integrates nanotechnology to the undergraduate curricula in science and engineering. Our educational program in nanotechnology will also reach out to high school (K9-K12) and graduate students.

In the development of an educational program for introducing nanotechnology to undergraduate (UG) students majoring in STEM at the New Jersey Institute of Technology (NJIT), we considered the following:

- a. Multidisciplinary and Interdisciplinarity of nanotechnology: nanometric entities and the nanoscale mechanisms associated with them are not exclusive to one or a few disciplines, nor to one or a few departments, but they extend beyond the limits of traditional fields of knowledge and beyond the borders of traditional academic curricula.
- b. Research-driven field: nanotechnology is a hot research topic, the instruction of which has been typically confined to graduate school and to those who pursue research careers. As a result, the development of courses on nanotechnology for UG students is challenged by a constantly evolving body of knowledge.
- c. Little flexibility of the UG curricula: STEM (Science, technology, Engineering, and Mathematics) students at NJIT have very structured curricula that leave scarce room for electives, especially during the freshman and sophomore years. The development of new programs has, therefore, to fit into existing courses or be kept on hold until the junior and senior years.
- d. Strong nanotechnology research at NJIT: more than 30 faculty members from multiple departments on campus have a focus on nanotechnology within their research lines. External funding for nanotechnology at NJIT stands at ~ \$1,000,000 per year.

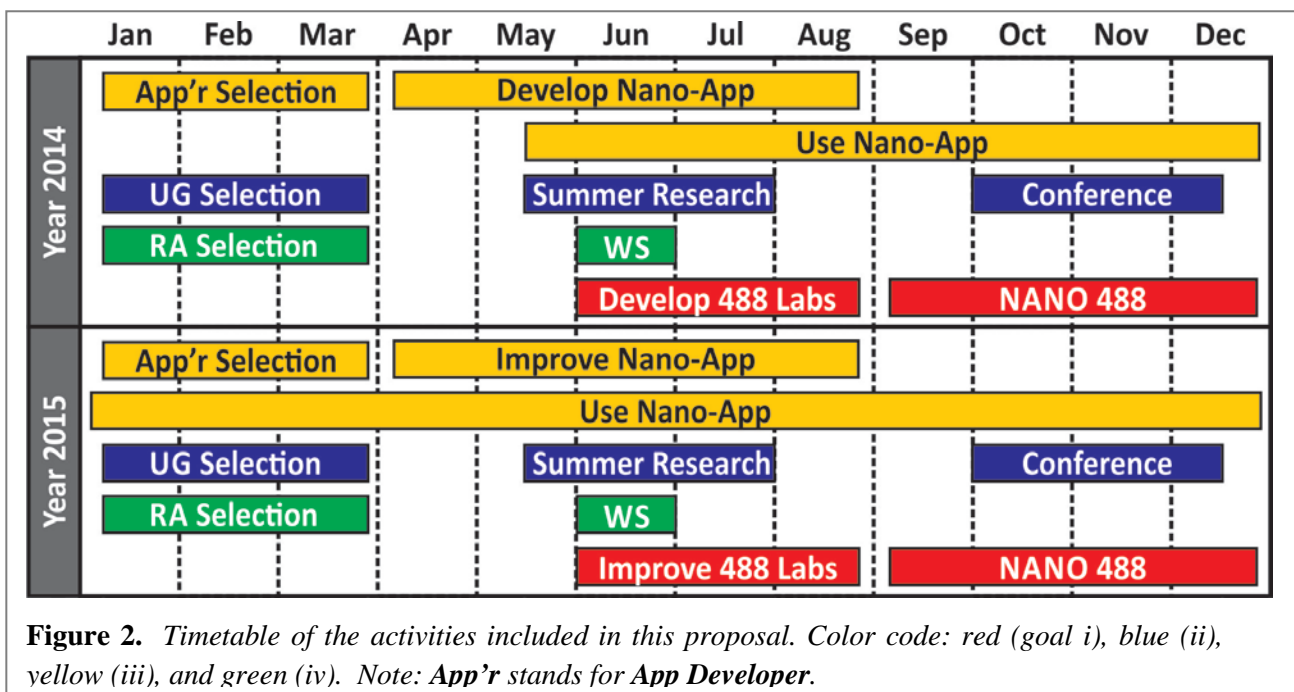
In response to those challenges, ours is an integrated educational program that provides three routes for undergraduate STEM students (i – ii), one for graduate students (iii), and one for high-school students (iv) to access nanotechnology:

- (i) To develop a new 15-week course (NANO488) course that will introduce UG students to basic concepts of nano-technology through a series of lectures and hands-on sessions; students will be able to take this course as an independent elective or as part of the minor in nanotechnology recently approved at the New Jersey Institute of Technology. The new course NANO 488 has also been approved as a technical elective for all engineering and science majors.



**Figure 1.** Goals of this project as they relate to the different student groups involved with them. Color code: red (goal i), blue (goal ii), yellow (goal iii), and green (goal iv).

- (ii) To develop a nanotechnology-oriented summer research program for undergraduate students at NJIT, which will offer 5 students per year the chance to take further their interest for nanotechnology. The strength of nanotechnology research at NJIT creates multiple openings for undergraduate students to explore this field beyond their coursework and will also make it possible to maintain this program after the NUE funding expires. Students will receive additional career-developing activities and networking opportunities through the cross-campus summer research programs—e.g., poster and abstract preparation workshops, and end-of-the-summer poster showcase—as well as the possibility to present their results in a regional or national conference, if their abstract gets accepted. These research experiences will complement the students’ learning during the courses, and the public display of their results will magnify the visibility of the nanotechnology curriculum inside and outside NJIT.
- (iii) To develop a program that will train graduate researchers in educational strategies for effectively teaching and mentoring in nanotechnology. Ten graduate researchers will design, prototype, and test the 10 hands-on lab sessions of the NANO488 course that will introduce students to nanotechnology. The graduate researchers will develop the lab sessions in collaboration with the PI and co-PIs or senior personnel. The lab sessions will serve as practice for the graduate students to exercise the implementation of good teaching practices. Typically, graduate students (even those with teaching assistantships) lack the experience of designing educational activities, as these are usually designed by senior instructors/faculty members, whereas teaching assistants are only responsible for the implementation. This training will provide graduate students the educational training that they will need as they progress in their careers, especially if they plan to secure an academic job.
- (iv) To develop a multi-platform nanotechnology educational app—i.e., an app that will be able to run on tablets, computers, and smart phones—that will familiarize K9-K12 students with the nano-scale dimensions. This *nanoApp* will address the difficulty that most students have to visualize the size of nanometric items, since these are much smaller than the ones students see every day.<sup>4,5</sup>



**Figure 2.** Timetable of the activities included in this proposal. Color code: red (goal i), blue (ii), yellow (iii), and green (iv). Note: *App'r* stands for *App Developer*.

The development and implementation of this set of four goals will span the two years of the award (Figure 2). We expect the four main activities (i: nanotechnology minor; ii: nano-summer program, iii: RA nano-education training; and iv: nanoApp use) developed in this proposal to remain active/in use beyond the two years of this proposal.

The four goals of this award aim at taking nanotechnology from the research labs at NIT into multiple educational settings: from high schools (K9 - K12) to undergraduate and graduate schools. Implementation of the goals of this award will bring together resources and supports from all levels of NJIT as well as from local industry in order to provide students with a holistic access to the field of nanotechnology. This program is designed to have the greatest impact in both ethnic and gender minorities because NJIT is a core of diversity—within the heart of a city with mostly African and Latin American population. With an undergraduate student population at NJIT of 33% underrepresented minorities—African-American and Hispanic—and 25% women, the educational program included in this NSF-NUE award will have a remarkable impact in introducing minorities to nanotechnology.

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