October 1, 2009

TO:       Paul M. DeLuca, Jr.
          Provost

FROM:    Paul S. Peercy
          Dean

RE:     Madison Initiative for Undergraduates Phase 1 Proposal Submission

Attached you will find the following Phase 1 MIU proposals from the College of Engineering, which I fully support:

- Nanotechnology Education: Bridging Technology and Society; Wendy Crone, lead author

- Planning a New Approach to Recruitment, Retention and Educational Program Enhancement of Engineering Undergraduates Through an Interdisciplinary, Cross-Cutting Honors Program; Tom Kuech, lead author

Thank you for your consideration of these proposals.

Attachments
Madison Initiative for Undergraduates
Phase I Proposal

Nanotechnology Undergraduate Education:
Bridging Technology and Society

Proposed by
Wendy C. Crone, Professor
Department of Engineering Physics
College of Engineering
crone@engr.wisc.edu
608-262-8384

Introduction
Nanotechnology offers an exciting array of future careers for today’s students, and it is imperative that we offer our undergraduates proper training and educational opportunities in this emerging interdisciplinary field in order to successfully prepare them to enter this burgeoning market and workforce. Following a National Nanotechnology Initiative Societal Implications workshop in 2003, Mihail Roco and William Bainbridge remarked upon the exciting projections concerning the future market of nanotechnology: “According to industry experts, within 10 years nanotechnology could be used in nearly half of all new products, from handheld computer devices to cancer and other disease treatments; renewable energy sources; lightweight multifunctional components in cars and airplanes; agents for environmental remediation; and water filters that remove viruses, contaminants, and salt for entire cities.” Even in slow economic times, funding for nanotechnology is growing. Lux Research recently reported that “Nanotech funding reached $18.2 billion in 2008, as government spending ballooned to $8.4 billion, corporate funding edged to $8.6 billion, and VCs provided $1.2 billion.” This growth is expected to produce hundreds of thousands to millions of jobs in the short term. To fulfill these projections, we will need individuals trained in nanotechnology at all educational levels, from associate degrees to PhDs, and in all disciplines of engineering.

Our students at the University of Wisconsin-Madison (UW) have already demonstrated awareness of nanotechnology and a keen interest in the topic, which became especially evident in Fall 2006 on the College of Engineering campus. Instructors of our InterEng 101: Contemporary Issues in the Engineering Profession freshman course added a special lecture on nanotechnology because, out of a class of 250 students, 31% had selected nanotechnology as their focus area (students chose from five topics: energy, health care, sustainability, nanotechnology, or globalization).

Students are not the only group with a growing interest in nanotechnology; employer demand for students with an understanding of this field is also expected to increase. According to the UW College of Engineering’s current database of industry employers, many of the companies that recruit our undergraduates have a vested interest in nanotechnology. The top ten employers for the college have consistently included Accenture, Cargill, GE, Kimberly Clark, and 3M over the last five recruiting seasons (2005-07). Small Times Magazine has featured these companies in nanotechnology-focused articles, including “GE nano lab announces direct pathway to ordered nanostructured ceramics” and “Nanotech starch may be cardboard’s new glue.” According to Jack Uldrich, a Motley Fool investment advisor, “Most of the cutting-edge research and development of practical applications for nanotechnology are being pursued by Fortune 100 companies like Intel (Nasdaq: INTC), GE (NYSE: GE), Hewlett-Packard (NYSE: HPQ), 3M (NYSE: MMM), and DuPont (NYSE: DD).” In addition to these large companies, startup companies also engage in a significant amount of nanotechnology research and development. Local, Madison-area nanotechnology companies such as Platypus Technologies, nPoint, Imago Scientific Instruments, Bruker AXS, and Mad City Labs have hired our graduates.

These factors point to a critical need on the UW campus for further coordinated training opportunities in nanoscale science, engineering, and technology (NSET). Although a number of key courses have already been established in engineering and physical science departments, a broadly-accessible
coordinated curriculum has not been provided to students. Further, courses that integrate NSET and societal implications are missing from current course offerings at the undergraduate level. A group of faculty, including Wendy Crone, (Engineering Physics), Naomi Chesler (Biomedical Engineering), Kristyn Masters (Biomedical Engineering), David Shaffer (School of Education), and Kevin Turner (Mechanical Engineering) were recently awarded a Nanotechnology Undergraduate Education (NUE) grant from the National Science Foundation which provides funding ($200k over 2 years) to develop a Nanotechnology Certificate that would be open to all undergraduate engineering and physical science majors. This would allow our students to enhance the strong disciplinary foundation gained through their major by obtaining additional specialized training associated with nanoscale science, engineering, and technology (NSET) in the form of a certificate with completion of their bachelor's degree. In order to complete the certificate program and graduate with the Nanotechnology Certificate, in addition to the Bachelor of Science degree of their major, students would select from a list of courses designed to train them in key NSET concepts and be required to complete an introductory survey course as well as an innovative capstone course on nanotechnology for a total of 18 credits.

An Introduction to Nanotechnology and Society Course for Undergraduates
In addition to providing this more comprehensive certificate experience, we have the opportunity to provide an introduction to technology experience for a broader range of students via a course we plan to develop on: Introduction to Nanotechnology and its Societal Implications. The training in NSET must address societal, ethical, economic, and environmental implications in order for it to be a well rounded experience. This course will provide an aspect of that training as well as an opportunity for students in disciplines outside of engineering and physical sciences to engage with technology concepts. A similar undergraduate course on Nanotechnology and Society, involving students from engineering, physical sciences, social sciences, and humanities, was developed several years ago by Profs. Wendy Crone and Clark Millar and taught several times at UW-Madison prior to Prof. Millar’s departure from UW. That work, summarized in a journal paper that includes significant assessment results9, was developed under prior NUE funding from the NSF. There is also an invited paper outlining strategies for developing cutting-edge curriculum9 and a book chapter on “Introducing Nanotechnology and Society Issues into the Classroom” coauthored by Prof. Crone.

We anticipate offering the new course on Introduction to Nanotechnology and its Societal Implications through our Interdisciplinary Engineering (InterEng) timetable designation, which "provides a home for courses that are applicable to the majority of engineering disciplines and for which expertise exists in the college, but that do not fit neatly into any single academic department within the college." Additionally, we will seek crosslisting of the introductory course with the other programs such as the Science, Technology and Society (STS) timetable designation. Given the recent experience of a new introductory course on Introduction to Society’s Engineering Grand Challenges, we anticipate that our Introduction to Nanotechnology and its Societal Implications course will draw a diverse audience. The preliminary data from the first two semesters of the Grand Challenges course shows the highest percentage of women of any introductory engineering course taught in our college over the past five years (29%) and has also attracted high percentage of non-engineering students (28% of the 97 students in Spring 2008, 22% of the 144 students in Fall 2008).9

What is currently missing on campus is a faculty member who would complement the expertise already on campus in the areas of communication, education, and policy on NSET. This new faculty member will act as a bridge between the traditional scientific communities in NSET and the communities in education, social science, humanities, and/or the arts. The ideal candidate would have a multi-faceted professional training and scholarly work, which integrates knowledge, techniques, and practice from both sets of communities. The placement of the individual would be in a traditional engineering or physical science department (such as what occurred with the Energy Policy Cluster) or in an education, social science, humanities, or arts department. The core of their teaching efforts would be connected to the Nanotechnology Certificate program through the Introduction to Nanotechnology and its Societal Implications course currently envisioned and other undergraduate and graduate level courses at the interface of technology and society.
The Proposed Nanotechnology Certificate Program

The objectives of the proposed certificate support the general goal to promote the development of graduates who are well-versed in nanoscale science, engineering, and technology (NSET) concepts and the societal implications of technology. The courses and certificate will impact the education of hundreds of future engineers and will help to develop a future workforce with a fundamental understanding of NSET concepts and liberally educated students with the tools to understand the intersections between technology and society.

A new introductory survey course and new a capstone course specific to the certificate will be required for all students enrolled in the Nanotechnology Certificate Program and the introductory course will be open to students from all disciplines. The strength of the introductory course will be its interdisciplinary nature, both in the student body and the concepts addressed. In the prior offerings of Nanotechnology and Society in the late 1990’s, sections were filled to capacity and populated by a range of students from engineering, science, social science, and humanities majors.

The Nanotechnology Certificate Program will appeal to a large portion of the student base of engineering and physical science majors. The question “How likely would you be to enroll in the Nanotechnology Certificate program if it requires 18 credits beyond your BS course requirements?” was posed to Freshman students enrolled in Introduction to Engineering in Spring 2008 (n=83). The results showed that 21.7% of students reported being somewhat and 10.8% very likely to enroll for the 18 credit option (the interest jumped to 28.9% and 25.3% respectively when they were told that 6 credits could overlap with their BS course requirements). The UW College of Engineering has an average undergraduate enrollment of just over 3,000 students and grants approximately 600 BS degrees per academic year. Given our prior data we might expect as much as 10% of students – 60 students per year – to complete the certificate. While this might not be the most conservative estimate of the number of students who would actually complete all requirements for the Nanotechnology Certificate, our prior data from two surveys suggest strong interest and support the idea of developing such a program. Furthermore, many students may select to complete portions of the coursework in the Certificate to fulfill technical elective requirements. The Introduction to Nanotechnology and its Societal Implications course is expected to be widely popular.

Although we currently have a Nanoengineering Focus Area in the new bachelor of Engineering Physics (EP) undergraduate degree program, this track is not appropriate for the majority of engineering students because of its research-oriented focus. The new EP undergraduate degree is designed to provide graduates with highly developed skills in emerging technological areas, and one such focus is Nanoengineering (approximately half of the 25 majors in this program have chosen the Nanoengineering Focus Area). The program has a rigorous curriculum and a 6-credit research project. Students need to be academically strong and highly motivated to work effectively within a research group, so the program has a high GPA requirement of 3.5 for admission. The traditional capstone design project is replaced by a research project equivalent to the requirements for Honors in Undergraduate Research. The proposed Nanotechnology Certificate is seen as complementary to the existing degree focus area.

The Nanotechnology Certificate will draw students from every discipline in engineering and the physical sciences. These students will be provided with an opportunity to devote their attention to a selection of courses that will give them a clear introduction to the field of nanotechnology and the key concepts that will build a foundation for future work or study in this field. Our goal is to have the certificate enhance students’ majors in a complementary way while providing a foundation in the underpinnings of nanotechnology.

The preliminary plan for the Nanotechnology Certificate involves an 18-credit series of courses that address the foundational issues of nanotechnology. The plan includes an introductory survey course on nanotechnology and society, followed by a series of technical courses, and ending in a capstone course that will use case studies to draw together concepts. We have based the draft course requirements on “The Big Ideas of Nano” work done at the University of Michigan through the NSF-funded National Center for Learning and Teaching (NCLT) in Nanoscale Science and Engineering. However, a key portion of the work planned for this project involves engaging students in the process of developing case studies
and then doing the required research to implement those case studies as professional practice simulations for use in developing educational games for NSET.

In the draft of course requirements, five theme areas were identified:

A. Societal, ethical, economic, and environmental implications, including both the scientific and market potential of the field
B. Size and scale, size-dependence of properties, including nanostructured materials and biological interactions with nanostructured surfaces
C. Thermal dynamics of small systems, colloidal science, and interfacial engineering
D. Quantum mechanical and electronic properties
E. Nanomanufacturing and incorporation of nanotechnology into systems

Several existing courses on our campus will meet many of the requirements identified above. Additionally, the modification of additional existing courses, institutionalization of existing special topics courses, and creation of two new courses (including the Introduction to Nanotechnology and its Societal Implications) will establish a program through which students can fully develop their understanding of the foundations of NSET.

Evaluation Plan for the Courses and Certificate Program
There will be a variety of assessment and evaluation efforts associated with the proposed work. Initially, we will survey our freshman students to gauge the level of interest in the Nanotechnology Certificate and their likelihood of selecting and completing the program given a range of requirement levels. This preliminary and further survey information will help us to gauge whether the requirements we envision will be acceptable to a reasonable number of students. Additionally, students in the first offering of the Introduction to Nanotechnology and its Societal Implications course will be surveyed to determine which particular nanotechnology application areas are of greatest interest to assist our selection of case study topics for the capstone Nanotechnology Seminar: Analysis and Impact course.

Some of the existing courses included in the draft course requirements plan have been evaluated beyond the standard university teaching evaluation form (for example Micro & Nano-Scale Mechanics”), but others have not. We are currently in the process of assisting course instructors in developing a thorough assessment plan for their courses that will focus on learning goals of the course as well as critical nanotechnology concepts identified by the development of case studies toward a professional practice simulation. The instructors will use these results to identify issues concerning understanding of concepts, breadth and depth of coverage, and effectiveness of teaching methods. Once this has been developed for a particular course, it can be revisited every time the course is taught with minor modifications, allowing for continuous improvement.

Beyond the more traditional survey techniques, several of the courses will incorporate reflective writing assignments asking students to evaluate information, draw inferences, identify cause and effect, and draw comparisons with examples from the literature.” Reflective practice is a core component of numerous theories of learning in that it contributes to the process of making meaning.” This type of exercise will help students to respond to new concepts, make connections with their prior knowledge, comment on the future potential of nanotechnology, and imagine where the technology might progress in the future. Not only does this technique improve a student’s critical thinking and technical writing abilities, it also helps the instructors to assess the depth of understanding of the course material.

In the future, both of the new courses, Introduction to Nanotechnology and its Societal Implications and Nanotechnology Seminar: Analysis and Impact, will be heavily evaluated with pre and post tests to measure student achievement relative to the learning goals established for the courses. Special attention will be paid to the integration of knowledge from the five themes (A-E). We have experience in conducting and analyzing such detailed assessments and the ability to conduct assessments with an independent evaluator through our NSF funding. This allows us to maintain confidentiality of student responses and ensure that bias is not introduced in the interpretation of results.
Proposed Faculty Position

The core of this proposal is a new faculty member who would complement the expertise already on campus in the areas of communication, education, and policy on NSET. This new faculty member will bridge the traditional scientific communities in NSET and the communities in education, social science, humanities, and/or the arts. The ideal candidate would have a multi-faceted professional training and scholarly work, which integrates knowledge, techniques, and practice from both sets of communities.

Several different modalities can be envisioned which would fill the current gap in teaching:

1) a NSET scientist with additional research interests related to communication, education, or policy;
2) an education researcher with published research connected to NSET; or
3) a scholar in the social sciences, humanities, or arts with published works connected to NSET.

Identifying a pool of potential candidate and the search process itself will require campus members from several colleges and schools, including but not limited to the College of Engineering, College of Agriculture, College of Letters and Sciences, La Follette School of Public Affairs, School of Journalism and Mass Communication, and School of Education. There are a number of good sources for individuals described above, including the Center for Nanotechnology and Society at Arizona State University and the AAAS Fellows Program. The ultimate tenure home of the individual could be either in a traditional engineering or physical science department (such as what occurred with the Energy Policy Cluster) or in an education, social science, humanities, or arts department. The core of their teaching efforts would be connected to the Nanotechnology Certificate program through the Introduction to Nanotechnology and its Societal Implications course currently envisioned and other undergraduate and graduate level courses at the interface of technology and society.

Budget Justification

The ongoing cost of this position is the faculty line requested. An estimate of starting salary and fringe benefits is given in the budget below. The position would be advertised for an Assistant Professor. One-time costs related to the search process and the startup package for the individual hire are also given. A request of 50% of these costs is presented in the budget below, the remaining funds will be derived from the schools and colleges participating in the hiring process. The startup package is estimated based on 2 months of summer salary for the first year, one RA position for 2 years, and flexible funds to begin research activities.

Budget

<table>
<thead>
<tr>
<th>Recurring Costs</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faculty Salary</td>
<td>$85,000</td>
</tr>
<tr>
<td>Fringe Benefits</td>
<td>$29,325</td>
</tr>
<tr>
<td></td>
<td><strong>$114,325</strong></td>
</tr>
</tbody>
</table>

One Time Costs (50% of expected)

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interviewing Travel</td>
<td>$3,000</td>
</tr>
<tr>
<td>Startup Package</td>
<td>$125,000</td>
</tr>
<tr>
<td></td>
<td><strong>$128,000</strong></td>
</tr>
</tbody>
</table>


Personal communication from Mark Mastalek, Director of the Engineering Leadership Center, College of Engineering, University of Wisconsin - Madison to Wendy Crone, 8/25/06.


Eman Zeki, Student Services Coordinator, College of Engineering, University of Wisconsin - Madison to Wendy Crone, 9/5/08.


