An Integrated Multidisciplinary Nanotechnology Undergraduate Education Program at the University of New Mexico

**BENEFITS**
- Training students that have a working knowledge of NS&NT and become valuable research assistants early in their undergraduate education.
- K-12 Shareable Content Objects (SCOs) will be developed and presented to high school teachers and students.
- Familiarizing New Mexico students with NS&NT without straining the current curriculum with departments and financially burdening the students.
- Between the two leading departments of the project (ME and ECE) 62% 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.
- Components of the NS&NT material developed will be presented at STEM Educator Workshops.

**TARGET AUDIENCE**
- UNM undergraduate students
- High school teachers and students
- STEM educators
- CNM students

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**NEED:** “Educating undergraduate students at the University of New Mexico (UNM) and New Mexico (NM) STEM educators about the basic concepts, techniques, applications, and the current state of Nanoscience and Nanotechnology (NS&NT), in order to produce an informed citizenry and competitive workforce in this emerging field”

**APPROACH:** Development of lecture/laboratory modules for undergraduate students (UG), courses devoted to NS&NT training STEM educators and involving the UG in NS&NT research.

1. Creating a program on NS&NT for undergraduates at UNM and NM STEM educators.
   - Creation of 4 new courses dedicated to different aspects of Nanoscience and Nanotechnology (NS&NT).
   - Including NS&NT modules in core courses in both the Mechanical and Electrical Engineering programs.
   - Developing teaching modules for K-12 and the teaching of STEM Educators using undergraduate assistance.

2. Institutionalize NS&NT into the UNM-SoE curriculum.
   - A concentration in NS&NT will be available to students who complete 3 NS&NT courses across the School of Engineering.
   - Every year on courses will be available to attract more students to this concentration.

3. Fuse NS&NT education with research from the co-PIs’ NS&NT Research.
   - Hiring undergraduate students to participate in research activities as research assistants.

* Three junior faculty members and one research professor of engineering education from two engineering programs, Mechanical Engineering (ME) and Electrical & Computer Engineering (ECE), have employed their collective effort to institutionalize NS&NT in UNM’s School of Engineering:

**Dr. Zayd C. Leseman (Associate Professor of ME)**
- Research: Physics of nano/micro-materials, adhesion of micro/nanomaterials, length scale effects in thin films, Phononic Crystals and alteration of the electrical, magnetic, and thermal properties.

**Dr. Mani Hossein-Zadeh (Assistant Professor of ECE)**
- Research: High-Q optical microresonators, Nanophotonic, Microwave photonics and Plasmonic engineering.

**Dr. Matthias W. Pleiße (Research Associate Professor of ME)**
- Research: Semiconductor nanostructures, Nanotechnology, Thin Film, Molecular beam epitaxy, Nanoscale and microscale component fabrication.

**Dr. Claudia C. Luhrs (Assistant Professor of ME)**
- Research: Nanoscience and materials, membrane synthesis pathways for their preparation, characterization of their crystal structures, properties and reactivity, production of nano-sized metal particles, nano-scale ceramic materials and metal/ceramic composites.

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**OUTCOMES**

What have we learned?

- Even with minimal background is it possible to introduce advanced concepts in NS&NT? Especially fabrication and characterization techniques that do not require advanced mathematical background are easily understandable and accessible.

- Ensuring the undergraduate student to do research projects on the subject not only exposes them to the ongoing studies and teaching opportunities it helps the transition from say, a well defined textbook material to using scientific information as they get involved in research projects.

- Including students in development of new experiments for labs improves the self-confidence, design skills and in the meantime improves the course for the following year.

- Once the students are exposed to the application of the material they have learned in the classroom they can also see the connections and the feedback from the other courses (as one of the emerging fields with significant national investments) they may pay more attention to fundamental research.

- Undergraduate students can help in different aspects of the research projects with instructive and productive experiences from which they can learn the skills and in many cases they are more excited about the subject.

- Due to lack of background and bias undergraduate students can think out of the box and be very creative.

- Involving undergraduate helps the graduate students to develop their mentoring and teaching skills and prepares them for academic positions.

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**APPENDIX 1:** Development of shareable content (SCOs) modules for undergraduate education.

**Survey for ME461 (Nanomaterials)**
- **Objective:** The level of your knowledge about nanoscience and nanotechnology (NS&NT) in the course.
- **Questions:**
  1. Did you feel that NS&NT topics covered in this class were relevant?
  2. Did you find that the course contents are directly relevant to your future career?
  3. Do you think that NS&NT is a subject that should be taught in other engineering disciplines?
- **Example:**
  - 82% Male
  - 28% Female
  - 6. Future trends in nanotechnology
  - 5. Impact of nanotechnology in society
  - 2. Methods used to generate nanomaterials

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**Survey for ECE 370: Introduction to ModernBlooming Technology**
- **Objective:** To assess the level of your knowledge about nanoscale and nanotechnology (NS&NT) before taking the course.
- **Questions:**
  1. Before taking this course what do you know about nanotechnology?
  2. What is your opinion about the NS&NT course from this class?
  3. Do you think that NS&NT will be a part of your future career?

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**Survey for ECE 371 (Materials and Devices)**
- **Objective:** To assess the level of your knowledge about nanoscale and nanotechnology (NS&NT) after taking the course.
- **Questions:**
  1. Before taking this course what do you know about nanotechnology?
  2. What is your opinion about the NS&NT course from this class?
  3. Do you think that NS&NT will be a part of your future career?

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**Survey for ECE 407: Introduction to Modern Blooming Technology**
- **Objective:** To assess the level of your knowledge about nanoscale and nanotechnology (NS&NT) before taking the course.
- **Questions:**
  1. Before taking this course what do you know about nanotechnology?
  2. What is your opinion about the NS&NT course from this class?
  3. Do you think that NS&NT will be a part of your future career?

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**Survey for ENG 100: "Introduction to Nanotechnology"**
- **Objective:** To assess the level of your knowledge about nanoscience and nanotechnology (NS&NT) before taking the course.
- **Questions:**
  1. Before taking this course what do you know about nanotechnology?
  2. What is your opinion about the NS&NT course from this class?
  3. Do you think that NS&NT will be a part of your future career?

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**Example of a success story!**

- **Trevino (ECE):** she obtained a NSF Fellowship (UNM) Project title: “Design, fabrication and implementation of a Michelson Interferometer for ME and ECE”.
- **Trevino:** as she has obtained a NSF Fellowship she is currently working on the fabrication of an interferometer which can be measured down to 500 nm. This interferometer is currently used in ME undergraduate curriculum.
- **ZL’s studies:** in her recent paper, Zayd Leseman’s Group (mostly Hispanic and Native Americans) and (ME and ECE) more than 328 undergraduate students have been involved in thin films, Phononic Crystals and alteration of the electrical, magnetic, and thermal properties.
- **Lundt,** she developed the nanotechnology Undergraduate Education (NUE) in Engineering (Grant# EEC-1042062).