Nanoscience and Molecular Engineering (NME)

Undergraduate Option Programs in Engineering

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Why?

- Program Goal

> ***Incorporation of modern and emerging science fundamentals and engineering aspects, involving nanoscale and molecular principles, into engineering curricula.***

- Educational Objectives
  - **Link macroscopic phenomena to nanoscale and molecular principles**;
  - Provide **early and continuous educational experiences** that foster cross-fertilization with core curricula;
  - Enhance **multidisciplinarity** (drawing knowledge from other disciplines), **interdisciplinarity** (identifying links between disciplines that are mutually beneficial) and **transdisciplinarity** (integrating societal and ethical aspects);
  - Furnish **hands-on experiences** through laboratory and independent research;
  - Offer a learning environment in which **younger students are influenced by the experience of older students**.

When?

- Program Background and Effect

With the recognition of the enormous potential of bottom-up rational engineering of materials, systems and devices, the importance for teaching engineering students nanoscale principles and molecular engineering aspects have become increasingly important.

2011: Initiated the **Option Degree Program in Nanoscience and Molecular Engineering**, with an NSF *Nanotechnology Undergraduate Education* (NUE) grant.

2012: Established the **NME Option Network**.

2014: NME program has grown to over **200 enrolled students** and has been **adopted by five engineering departments** on campus. It has influenced undergraduate curricula, such as in Chemical Engineering that has adopted nanoscale and molecular engineering principles into its core educational program. It has given rise to a **Ph.D. program in Molecular Engineering** at UW.

Where?

University of Washington

- Housed initially in **Chemical Engineering**, the NME degree option has been adopted in **Bioengineering**, **Electrical Engineering**, **Material Sciences & Engineering**, and **Mechanical Engineering**.
- Today, the NME Option Program Network is jointly **administered by Chemical Engineering and the Molecular Engineering & Sciences Institute at the University of Washington**.

Requirements

- NME Option programs are **19-21 credit programs** (depending on the department). They are offered close to credit neutral, by **directing elective and research credits towards the NME goal**.
- Within the NME Network we require **one fundamental core course** at the beginning of the program, and **three consecutive seminars distributed over three years** that involve all students.

What?

- Learning Activities and Materials
  - **Interdisciplinary Introductory Core Course "Molecular and Nanoscale Principles"** (NME 220) (sophomore year)

    This course **goes *far beyond* the show-and-tell approach** taken in conventional introductory courses in this field. It introduces students to macroscopic limits of material properties involving:

    - ❖ molecular structures considering underlying quantum-mechanics and thermodynamic constraints,
    - ❖ interaction forces,
    - ❖ molecular transport properties
    - ❖ cooperative and nanoscale phenomena, and
    - ❖ device and process technologies.

Learning Activities & Materials (cont.)

- **Seminar on "Nanoscience and Molecular Engineering"**
  NME 221/321/421 (sophomore to senior years)

  It provides **a venue for NME students to interact, lowers barriers to connect to research labs,** and allows **younger students to benefit from the experiences of older students**.

  As sophomores, students hear about on-going NME research from faculty at UW and research conducted by NME seniors, and obtain access to labs to find independent research opportunities. They hear from upperclassmen about societal/ethical aspects.

  As juniors students learn how to plan and tackle research challenges, put their work into the framework of others, and to present and interpret data. They critically assess contemporary societal and ethical issues.

  As seniors, they are acting role models for the younger students, sharing their research experiences by emphasizing research objectives and motivations, and are addressing research hypotheses and how they were tested.

What Works?

Students, very early on, **critically access conventional theories**

- The students improve critical thinking abilities and appreciation for material that originally seemed “academic”.
- Nanoscience and Molecular Engineering is better integrated into the core educational program by offering it earlier.

Integrated laboratory experiences and lab module developments

- Hands-on experiences are provided to NME students by all network participating departments in *NME-module-expanded* laboratory courses, and through independent research opportunities.

Prognosis?

Impact: The impact of the program is assessed quarterly via student evaluations, and yearly, through departmental peer reviews, assessments by the UW Center for Engineering Learning & Teaching, and the NME Option Network assessment. Student interest and program growth has also been a parameter for the impact of the program.

Scale-up: The program has grown to **over 200 students with five departments** involved. Further growth at the UW requires more departments to join. Scale up beyond the UW has not been attempted thus far.

Current Challenges: Further growth at the UW would require more departments to join. It is restricted by the number of students who can access the core course NME 220 and the seminar, which would require more resources.

FOEE:

We seek input from FOEE on **how the NME effort could be multiplied beyond the UW, involving other institutions with concerted national effort.** The NME program has shown to be quite successful. Besides providing students with valuable fundamental input towards modern engineering, it has also contributed to the establishment of a Ph.D. Program in Molecular Engineering.