Spring 2021

Nan Yi: Professor of Chemical Engineering

Erin Trainer
University of New Hampshire

INQUIRY journal

www.unh.edu/inquiryjournal 2021

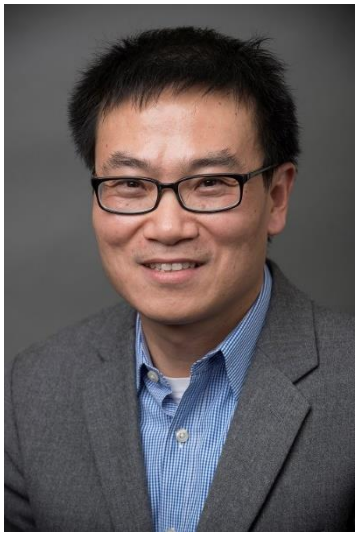
Mentor Highlight

Nan Yi

—Erin Trainer

Nan Yi is an assistant professor in the Department of Chemical Engineering at the University of New Hampshire. Below is a correspondence with Dr. Yi about his own research and mentoring experiences with undergraduate students.

Inquiry: What is your research focus? Did your undergraduate studies point you toward it? What interests you most about it?



Nan Yi

My research focuses on the development of robust catalysts for chemical production. Specifically, I am interested in transforming small molecules, such as methane, carbon dioxide, ethanol, and glycerol, through direct catalytic approaches into platform chemicals. My research goals are: (1) to design efficient catalysts capable of breaking chemical bonds and assembling atoms into products under mild conditions (low temperature and atmospheric pressure) and (2) to understand the reaction pathways at the molecular level with the aid of spectroscopy. I am also interested in STEM education. Therefore, I have worked with science teachers from local schools to develop science activities in order to enrich high school students' learning experiences in chemical science subjects.

While I pursued my undergraduate degree in chemical engineering, I conducted research in my junior and senior years to model the process of scrubbing ammonia in urea production. I enjoyed building equations based on material and energy balance and writing computer codes to solve multivariable differential equations. My research experience in college reinforced my appreciation for the use of fundamental knowledge to solve industrial-scale problems and defined my passion toward energy production and environmental protection. Eventually, I chose hydrogen production as my Ph.D. research topic and received a Ph.D. in chemical engineering.

Catalysis science has always fascinated me, because a majority of chemical and biological processes in nature are related to catalysis. Catalysis science is the place where knowledge of chemical science, math, and engineering collide to decode the mysteries of nature and to answer the social challenges we face as a community. When it comes to climate change, carbon dioxide and methane emerge as two major greenhouse gases. Catalysis science empowers our efforts to decrease the emission of greenhouse gases through catalytic conversion of carbon dioxide and methane into valuable chemicals, including hydrogen and fuels.

Inquiry: What is the purpose of a mentoring relationship? What should the student and you gain from it?

As a research mentor, I acknowledge the unique experience each mentee brings into my research lab. I adjust my mentoring approach accordingly to ensure students improve their knowledge and research skills with necessary oversight. This individual, tailored mentoring approach enables students to maximize their research outcomes, because they are able to apply their strengths to solve problems while also improving their developmental areas. In addition to fostering critical thinking, students improve other skills, such as effective communication and working collaboratively.

Mentoring undergraduate researchers also allowed me to gain insight on how students apply their learnings from the classroom to solve problems. Importantly, I identified real gaps between lecture objectives and problem-solving skills. I utilized that useful information to modify lecture content, so students can see better connections and clear transitions from fundamentals to practical applications.

Inquiry: Please describe one or two memorable mentoring experiences or mentees.

A good mentor/mentee relationship is not one-directional but one in which we collaborate and learn from each other. My first UNH mentee realized this ideal model. I wanted this mentee to refresh the material learned during his chemistry courses, so I asked him to synthesize materials following a procedure for which I thought I knew the expected results. After a few attempts, he told me that something "strange" happened, because he could not validate my idea. After we reviewed his notes and repeated his approach together, we finally realized that our unexpected results were normal and were published decades ago. I like to mention this story to new mentees, so they realize that everyone can add value and have good ideas. Additionally, this is a reminder that nobody knows the answers in research, and we need to think freely and have confidence as researchers.

One of the most rewarding parts of mentoring is seeing others realize their potential. I have been fortunate to work with motivated undergraduates and to assist them in applying their research trainings to secure jobs or to attend graduate schools. One student received several acceptances and became the first UNH chemical engineering to attend MIT. I vividly remember his first research experience as a UNH Summer Undergraduate Research Fellowship (SURF) awardee. He built his research plan, asked for feedback, and planned experiments weeks ahead. Therefore, he was able to run two to three different experiments at the same time to maximize his research progress. This mentee had a true passion for research and exemplifies the potential of motivated undergraduate researchers.

Nan Yi with one of his many students. *Photo credit: Jeremy Gasowski.*

Inquiry: Please describe any difficulties or problems you have had in mentoring undergraduates. *Time management*. The first assignment I give to undergraduate researchers is to integrate research trainings into their weekly schedules. Undergraduates need to prioritize course studies, then develop an individual rhythm for lab training activities, including attending weekly group meetings, reading papers, and working in the lab. Managing time effectively is challenging, because students have limited spare time during the semester. It always takes time to complete a set of experiments in order to experience a sense of accomplishment through the successful completion of work. Without allocating enough time to research, students do not see immediate outcomes. Short-term setbacks can frustrate students, and some students may develop a

negative feedback loop in which early discouragement leads to disinterest. Improving time management is common in each stage of research training.

Developing ownership. When undergraduate researchers start a research project, they often feel a sense of accomplishment through the operation of instruments safely and independently and through the collection a set of experimental data. However, it is common for students to feel intimidated when asked to analyze data, because they are worried that they don't have the knowledge to complete the analysis and consider themselves as assistants to graduate students. Undergraduate researchers easily underestimate their creativity. I like to work with undergraduate researchers to review their results and ask questions to get them to think of the meaning behind their original experimental results. I discuss different options to plot data and build tables and encourage them to try different approaches to present their results. Eventually most students are able to effectively analyze their results and become confident in owning the project.

The pandemic brought unexpected challenges to everyone, particularly undergraduates who received summer research fellowships. When UNH operated under limited/restricted mode, students had limited access to lab space. Students were concerned that limited lab time might stymie their progress. I decided to build a "virtual laboratory" to continue their research training. We had Zoom meetings three times per week. During each meeting, we discussed one or two papers thoroughly. In addition to summarizing the highlights/findings, we also commented on how the paper was constructed and written, analyzed how authors designed experiments to investigate hypotheses, and built connections between the discussed literature and their own projects. I was impressed by students' commitment and the amount of preparation they did before each discussion. Our lab work was impeded by COVID-19. However, students realized that research training includes a spectrum of activities. They were able to improve their critical thinking and practice communication skills. Importantly, students designed experiments for the future when they were able to return to the lab.

Inquiry: What advice or tips would you give a faculty member new to undergraduate mentoring?

Remind students the purpose of research: to seek answers to unknown questions. Nobody knows the answer before extensive studies. Students often approach research training as a lab course. They expect either their research advisor will know the solutions, or that they will get the solution after just a few tries. Some undergraduate researchers who have good academic records may feel uneasy with this uncertainty, because this perspective of research is different from their approach to course studies.

Trust students' research competence. I personally believe that each undergraduate researcher can do exceptional work when they discover their passions. Once they identify their research projects and feel comfortable working independently, I meet with them individually on a weekly basis. This meeting enables them to explain their progress but also allows them to talk about their doubts and questions. These meetings also help students build their confidence toward being a researcher instead of an operator.