Foothill has amazing faculty, staff, administrators, and programs. Program Review is about documenting the discussions and plans you have for sustaining and improving student success in your program. It is also about linking your plans to decisions about resource allocations. Thank you for taking the time to review your program and sharing your findings with the college community!

Program Review Committee Members for 2017-18:

Administrators:
- Andrew LaManque
- Paul Starer
- Teresa Ong

Faculty:
- Carolyn Holcroft
- Bruce Mc Leod
- K Allison Meezan;

Classified Staff:
- Craig Gawlick
- Jackie Brown
- Melia Arken

Elaine Kuo (Ex Officio)

Let us know how we can help you!

https://foothill.edu/staff/irs/programplans/index.php

BASIC PROGRAM INFORMATION

Department Name: NANO (Nanoscience)

Division Name: Physical Science Math and Engineering (PSME)

Please list all team members who participated in this Program Review:

Name	Department	Position
Robert Cormia	NANO	Faculty (instructor)

Number of Full Time Faculty: 1 **Number of Part Time Faculty:**

Please list all existing Classified positions: *Example: Administrative Assistant I*

Administrative Assistant (RuYu Chen)

List all programs covered by this review and indicate the program type:

NANO	☒ Certificate	☒ AA / AS	☐ AD-T	☐ Pathway
	☐ Certificate	☐ AA / AS	☐ AD-T	☐ Pathway
	☐ Certificate	☐ AA / AS	☐ AD-T	☐ Pathway
	☐ Certificate	☐ AA / AS	☐ AD-T	☐ Pathway
	☐ Certificate	☐ AA / AS	☐ AD-T	☐ Pathway

Not sure? Check: https://foothill.edu/programs/ and click to sort using the “Areas of study/Divisions” button Current pathways at Foothill College include: ESLL, NCEL, ENGL pathways (ENGL 209-110-1A; ENGL 209-1A; ENGL 1S/1T); MATH pathways (NCBS 401A/B; MATH 235-230-220-105; MATH 217-57).

SECTION 1: PROGRAM ENROLLMENT, PRODUCTIVITY, AND COMPLETION

Data for certificates and degrees will be posted on Institutional Research's website for all measures except non-transcriptable completion.

1A. Analysis of Transcriptable Program Completion Data: Please use your data to complete the following table.

Transcriptable Program	Five-year trend in degrees/certificates awarded	Comments
e.g. Associate Degree for Transfer	The number AD-Ts awarded has been steadily increasing each year, up to a high of 39 degrees awarded in 16-17	We are pleased to see this trend and believe it will continue as more students pursue AD-Ts

*according to CCCApply data

1B. Non-Transcriptable Program Data: If your program offers any non-transcriptable programs, please complete the following table. Institutional Research does not track this data; each program is responsible for tracking its own data.

Non-Transcriptable Program	Comments	Five-year trend	Rationale for program
e.g. Certificate of Proficiency in characterization	A number of students qualified for the certificate in characterization over the last five years, but not everyone requested one.	The number of completers has dropped since the peak of the program a few years ago	This program helps students achieve positions as interns, technicians, as well as enhancing career opportunities.

The 2017-18 College Strategic Objectives (E^2SG) operationalize the college's 3 EMP goals and include:

Equity– Develop an integrated plan; identify goals for alignment with equity, student success, and basic skills; and focus on efforts to integrate with enrollment strategies (access, retention, and persistence) to close equity gaps while increasing enrollments at the same.

Enrollment Growth – Achieve more than 1.5% FTES growth at 500 productivity (+/- 25) with attention to integrating equity efforts related to enrollment, CTE, and Sunnyvale Center.

1C. Course Enrollment: Enrollment is a count of every student who received a final grade (A, B, C, D, F, P, NP, W) in your program's courses. It also serves as an indicator for program viability. Please use your program review data to examine your course enrollment trends and check the appropriate box below.

The link to the program review data tool can be found on the Employee tab of the portal: myportal.fhda.edu (Program Review Application).

5-year Enrollment Trend: ☐ Increase ☐ Steady/No Change **X Decrease**

Our college goal is to increase enrollment by 1.5% FTES this year. What steps might you take to increase the numbers of students enrolling in your courses? Steps might include cross department collaborations, actions to increase retention, service learning projects, support for student clubs, participation at recruitment events, examination of pre-requisites, review of assessment results, etc.

We are currently working with the San Francisco Bay Area chapter of the IEEE, as a future "gold member" to promote our program at various one-day workshops in the next year, and especially before spring quarter. Faculty Cormia also does a number of in-class presentations at Palo Alto High School in winter to help recruit students for the fall semester. Outreach at Gunn High School has been more difficult, but we are active in PAUSD's Authentic Advanced Research program (aar.pausd.org)

1E. Productivity: Productivity is a measure of students served per full-time equivalent faculty and is a factor in program viability. Please use your program review data sheet to examine your productivity trends and check the appropriate box below.

5-year Program Productivity Trend: ☐ Increase ☐ Steady/No Change x Decrease

The college productivity goal is **500 (+-25)**. There are many factors that affect productivity (i.e. seat count/ facilities/accreditation restrictions, curriculum, etc.). Please discuss factors that may be affecting your program's productivity trends and any plans you have for addressing the trends, especially if they are declining.

Enrollment has always been low in the nanoscience program, and across the country nanotechnology programs have dwindled in size. We have considered having just two or three courses in the program, as science electives, where they seem to have more traction in high schools. In spring 2017 a new (revised) course was added to integrate the three advanced courses in the program, but it was offered on return from sabbatical, and did not enroll as strongly as hoped. In winter 2018 faculty Cormia will work with engineering clubs to increase awareness for the program, and coordinate with faculty Sarah Parikh (engineering lead) to promote nanoscience in engineering classes, including demonstrations in the microscopy lab (AFM and SEM) and also through tours of NASA Ames. We continue to look for funding for workforce training at NASA-Ames.

SECTION 2: COURSE COMPLETION & STUDENT ACHIEVEMENT

2A. Institutional Standard: This percentage represents the lowest course completion (success) rate deemed acceptable by the College's accrediting body (ACCJC). The institutional standard during the year for which this program review is being written (2016-17) is **57%**.
Please check the appropriate box:

Program Level Course Completion: **x Above Standard** ☐ At Standard ☐ Below Standard

If your program's course completion (success) rates are below the institutional standard (see above), please discuss your program objectives aimed at addressing this.

The majority of students (two-thirds and greater) complete the course with a satisfactory effort. The primary reason students don't complete the course is being underprepared for the technical content, and underestimating the amount of time required for written assignments. Younger students keep up with assignments better, but lack the technical knowledge and experience that mature students have.

2B. Institutional Effectiveness (IEPI) Goal: This percentage represents an aspirational goal for course completion (success) rates; all programs should strive to reach/surpass this goal. The IEPI goal for which this program review is being written (2016-17) is **77%**.
Please check the appropriate box:

Program Level Course Completion: ☐ Above Goal **X At Goal** ☐ Below Goal

If your program's course completion (success) rate is **ABOVE** the IEPI goal, please share your thoughts about why/how this is so (we hope to learn from your effective practices!).

Successful course completions are right near the 75-80% mark, and the primary reason for lower success is not completing the course, a combination of getting behind in homework, including final projects, etc.

2C. Course Success Demographics: Please examine the **"**Disproportionate Impact data by year**"** shared with your department and discuss actions you are taking, or plan to take, to address any achievement disparities identified in your program. If you are uncertain about actions faculty can take, please take a look at Appendix A.
https://foothill.edu/staff/irs/programplans/docs/appendix-a.pdf

Demographics can be a bit tricky in this program. The majority of Caucasian (white) students are older, already have a college degree, and somewhat familiar with advanced technology. Hispanic students tend to be younger, with less experience in technology. There are significantly more men than women in the program, and there isn't a strong correlation with success by gender, except that women (like men) with a college degree tend to do better. Additionally, the large number of high school students, with significantly higher diversity, tends to skew the results, as high school students are much more motivate to complete the course (especially dual enrollment)

Be sure to include the resources you need to implement or sustain your action plans in Section 3.

A brief prepared for Andrew La Manque to address enrollment is included in this report.

2E. Faculty Discussion: Course-Level Outcomes: Please share examples of how assessment and reflection of course-level Student Learning Outcomes (CL-SLOs) has led to changes in curriculum or teaching.

SLOs are very important in developing curriculum and assessment tools. Course level SLOs have focused on two big ideas, structure => property relationships, and the integration of process => structure => properties => applications, and process => structure => properties => characterization. This was the core idea funded by the National Science Foundation in 2009, and is embedded in materials engineering, as well as nanoscience courses. The course level SLOs are both difficult and complex, especially for younger students. Understanding material structure, material properties, and methods of processing and characterization take maturity and experience in technology, and instruction for degree holders is much different than instruction for AS students. As a result, the day to day instruction in NANO10 (nanoscience) for high school students is different that the instruction for advanced courses. A new course, NANO62, Nanomaterials Engineering, was developed specifically to provide a condensed curriculum for integrated materials engineering of high performance materials and novel structures.

2E. Faculty Discussion: Program-Level Outcomes: Please provide examples of what is being done at the program-level to assist students in achieving your Program-Level Learning Outcomes, degree/certificate completion, and/or transferring to a four-year institution (e.g. review of progress through the program, "career days"/open houses, mentoring, education pathways (clear, structured academic program maps (suggested courses for each term) for all academic programs), etc.). If your program has other program-level outcomes assessments (beyond SLOs and labor market data), discuss how that information has been used to make program changes and/or improvements.

While the initial focus of the program was to provide certificates for cohorts of students interested in a complete introduction to the field of nanotechnology, the primary focus of our nanotechnology program today is helping students advance their career interests. This is primarily for two "logically opposed" observations. First, the AS degree certificate provides a very well-rounded education, especially for AS degree students, that leads to transfer, continuation of an engineering degree, but not an immediate job. Second, the education (instruction) and especially electron microscopy training provided at NASA-Ames, can provide the "just in time" skills needed to freshen a resume, and position a degree holding student for employment, or career advancement. We have a number of very successful students who took one or two classes, and were "ready" for opportunity. With that in mind, the program might consider having one elective course (nanoscience), one career course (nanomaterials engineering) and more hands-on training, at Foothill (SEM/AFM) and NASA (FE-SEM/TEM).

Please attach Course and Program-Level Outcomes (Four Column Report from TracDat).
Contact the Office of Instruction if you need help.

If your department has a Workforce/CTE program, please complete Section 2F.
If your department does not have a Workforce/CTE program, please skip to Section 3.

2F. Workforce/CTE Programs: Refer to the program review website for labor market data.

What is the regional five-year projected occupational growth for your program? 2% CAGR 2017-22

What is being done at the program-level to meet/adjust to the projected labor market changes?

Nanotechnology is a broad field of high specialized skills, from materials development (R&D) to pilot manufacturing, including sophisticated processing equipment, and the field of materials characterization. We maintain an advisory board including analytical labs, and tour three labs each quarter. Lab tours have led to interviews and job placement, as well as business opportunities for student / entrepreneurs. We are thinking of developing more hands-on training in processing tools.

What is being done at the program-level to assist students with job placement and workforce preparedness?

We are building an internship program with USRA (University Space Research Association) that could be a mechanism to place more of our students into technical positions, and develop more of a workforce centric thinking within PSME. Our students really desire and value technical training, and especially something that will make their career and academic resume shine.

Be sure to include the resources you need to implement or sustain your action plans in Section 3.

SECTION 3: SUMMARY OF PROGRAM OBJECTIVES & RESOURCE REQUESTS

3A. Past Program Objectives: Please list program objectives (not resource requests) from past program reviews and provide an update by checking the appropriate status box.

Increase enrollment at Foothill	Year:2015	☐ Completed	X Ongoing	☐ No Longer a Goal
Increase enrollment at PAUSD	Year: 2015	☐ Completed	X Ongoing	☐ No Longer a Goal
Develop more hands-on activities	Year:	☐ Completed	X Ongoing	☐ No Longer a Goal
Develop an internship program	Year:	☐ Completed	X Ongoing	☐ No Longer a Goal
Increase program awareness	Year:	☐ Completed	X Ongoing	☐ No Longer a Goal

Please comment on any challenges or obstacles with ongoing past objectives.

Enrollment challenges are constant, in both the Foothill as well as PAUSD programs. Outreach is critical. Students are pressured to transfer, which makes taking a science elective less desirable.

Please provide rationale behind any objectives that are no longer a priority for the program.

All objectives are still active, although we may not be pushing as hard on the high school STEM Camp

3B. Current Program Objectives and Resource Requests: Please list all new and ongoing program objectives based on discussion in Sections 1 and 2, including your objectives to eliminate any achievement disparities in course success for student subgroups (Section 2A). If additional resources are needed, indicate them in the table below. Refer to the Operations Planning Committee (OPC) website for rubrics and resource allocation information.

Resource Request	Program Objective	Implementation Timeline	Progress Measures	Resource Type Requested*	Estimated cost
	Example: Offer 2 New Courses to Meet Demand	*Winter 2016 Term*	*Course Enrollment*		

Support workforce investment (SWP)	Build awareness for research in materials jobs	Winter – Spring term	NANO62 Course enrollment	Ensure SWP funding for workforce	$15-$20K

*Resource type should indicate one of the following: One-time B-budget; Ongoing B-budget augmentation; Facilities/Equipment; New faculty/staff.

3C. Faculty/Staff Position Requests: Please describe the rationale for any new faculty or staff positions your program is requesting:

No new faculty requests

3D. Unbudgeted Reassigned Time: Please list and provide rationale for requested reassign time.

3E. Please review any resource requests granted over the last five years and whether it facilitated student success.

SECTION 4: PROGRAM SUMMARY

4A. Prior Feedback: Address the concerns or recommendations made in prior program review cycles, including any feedback from the Dean/VP, Program Review Committee (PRC), etc.

Concern/Recommendation	Comments
Enrollment decline	Working with IEEE/AVS for better outreach
Lack of certificate completions	Analysis of SLOs, and shift to science elective
Tie-in to specific jobs	May reflect the diversity of the job market
Uncertain value high school program	High school course doesn't fit directly into NANO program

4B. Summary: What else would you like to highlight about your program (e.g. innovative initiatives, collaborations, community service/outreach projects, etc.)?

The nanoscience program at Palo Alto and Gunn High School continues to be of interest to students as a science elective, and properly positioned and promoted, could also be at Foothill College as well. The larger four-course certificate program at Foothill is probably not as effective in helping students find employment as a smaller, focused program in core skills (fabrication, characterization) with a general overview of nanostructures and advanced materials. The combination of NANO62 (nanomaterials engineering), NANO53 (nanocharacterization), and hands-on training on electron microscopes at NASA-Ames might be the proper size for this program, with an emphasis on smaller cohorts. Finding a means of recruitment and selection of candidates for such a program has been a challenge, as outreach through traditional avenues (IEEE and AVS) has heretofore not been effective. That said, embedding our program deeper into the local IEEE chapter, as planned for 2018, might be more effective recruitment.

SECTION 6: FEEDBACK AND FOLLOW-UP

This section is for the Dean/Supervising Administrator to provide feedback.

6A. Strengths and successes of the program as evidenced by the data and analysis:

Nanotechnology is a unique program not found commonly at community colleges. In fact, nanotechnology is seldom a separate department even at a 4-year college or a university. However, the field of nanotechnology is at the cutting edge of science. Foothill College is home to modern instrumentations in microscopy that are crucial to such a program. Students that gain expertise in these instruments will be well positioned for advanced work in research laboratories in this area.

6B. Areas of concern, if any:

There are several concerns related to this program:

1. Enrollment has been < 100 during the last five year period and productivity has been < 200, far below the college standard of 500 ± 25.
2. The partnership with Palo Alto Unified School District where some of the classes have been taught has not provided significant additional enrollment. As identified in this document, this is due to the fact that the Nano classes are considered as an elective and the students in this school are already under pressure to complete several other classes that few seem to be able to fit the Nano classes into their schedule.
3. Besides dual enrolled students, there needs to be an interest among Foothill College students for this program. This demand has not been amply demonstrated.
4. No certificates or degrees have been awarded, which is consistent with the low enrollment in the required courses.

6C. Recommendations for improvement:

The long-term sustainability of this program will require a substantial increase in enrollment.

1. While other programs have the advantage of having parallel majors in the same field, which leads to a sustained student-interest, Nanotechnology does not. Therefore the recruitment strategies must be as uniquely different as the program itself is.
2. A program that provides students a set of skills on the sophisticated instrumentation found at our college, providing hands-on experience that will lead to job placement in technical areas is necessary to draw students to the program.
3. Partnerships with other research facilities, such as USRA (discussed here) or universities that engage students in Nanotechnology at the undergraduate level could potentially draw students towards introductory classes in this program.

6D. Recommended Next Steps:

☐ Proceed as Planned on Program Review Schedule
☒ Further Review / Out-of-Cycle In-Depth Review

This section is for the Vice President/President to provide feedback.

6E. Strengths and successes of the program as evidenced by the data and analysis:

6F. Areas of concern, if any:

6G. Recommendations for improvement:

6H. Recommended Next Steps:

☐ Proceed as Planned on Program Review Schedule

☐ Further Review / Out-of-Cycle In-Depth Review

Upon completion of Section 6, the Program Review document should be returned to department faculty/staff for review, then submitted to the Office of Instruction and Institutional Research for public posting. Please refer to the Program Review timeline.

Assessment: Course Four Column

NANO

Department - Nanotechnology (NANO)

Mission Statement: Provide technicians training for students and working professionals practicing nanomaterials engineering

NANO 10:INTRODUCTION TO NANOTECHNOLOGY

Course-Level SLOs	*Assessment Methods*	*Assessment Findings/Reflections*	*Action Plans*
Applications - students will describe the industrial applications of nanotechnology, with specific instances (applications) in semiconductors, high performance materials, (and suggested) energy, food, water, computing, and medicine - assessment by written evaluation. **Course-Level SLO Status:** Active **Start Date:** 09/01/2011 **End Date:** 01/01/2013	**Case Study/Analysis -** Students write a midterm assignment studying an application of nanotechnology including analysis of an industrial application, a company working in that area, and the technical approach taken to solve that problem. **Target for Success:** Ability to communicate a problem space (industrial application) and why it is important, the reason behind the technical approach taken, and how a company will bring this particular solution into the market place. **Notes:** Deep Web and company research, degree holding students do vert well on this assignment	**Year This Assessment Occurred:** 2015-2016 **Result:** Target Met Case study analysis by students was excellent, far exceeding expectations (04/25/2016) **Resource Request:** N/A **GE/IL-SLO Reflection:** N/A	
		Year This Assessment Occurred: 2015-2016 **Result:** Target Met Students successfully completed a case study analysis of a key application in nanotechnology. Students with four-year degrees were able to complete the task with ease, while younger (typical) students struggled a bit. In addition to essays, we will consider having a final class presentation (as conducted by Jill Johnsen in winter 2011). A combination of essay and class presentation would help other students benefit from individual research. (04/25/2016) **Resource Request:** N/A **GE/IL-SLO Reflection:** N/A	**Action Plan:** Bring more 'current news' into the course, focus on applications and the PNPA rubric (NSF-ATE 0903316) that integrates processing => structure => properties => applications. Have more in class student presentations on writing assignments one and two, and have more in class discussions about current nanotech news. (12/16/2012)
		Year This Assessment Occurred: 2015-2016 **Result:** Target Met Students made excellent presentations about applications of nanotechnology in a class presentation that was accompanied by a written paper. This project continues to be important in developing a broader understanding of nanoscience applications. (04/25/2016) **Resource Request:** N/A **GE/IL-SLO Reflection:** N/A	

Assessment: Program Four Column

Program (PSME - NANO) - Nanoscience AS/CA

PL-SLOs	Assessment Methods	Assessment Findings/Reflections	Action Plan
Nanoscience / Nanotechnology Competency - Technicians will apply foundational nanoscience principles to understanding and further learning about nanostructures, properties, and engineering solutions (read and apply literature, seminars, and webinars). Demonstrate through written assignments (diagrams etc.), term papers, and class presentations. Use PNPA as a way to read and learn from technical writing articles **SLO Status:** Active **Year(s) to be Assessed:** End of Quarter **Start Date:** 01/01/2012 **End Date:** 01/01/2013	**Case Study/Analysis -** Students use case studies in nanoscience (research) and nanotechnology (commercial applications) to demonstrate an understanding of the relationships between processing => structure => properties => applications, and how scientists and engineers leverage structure => property relationships for nanomaterials selection, and how new fabrication methods produce novel nanostructures with unique / tailored properties. **Notes:** Assessment for this begins in NANO50, and especially NANO51. It is an integrative approach to learning, and connects NANO50, 51, 52, 53, and 54, through nanostructures, which is the pedagogy outlined in NSF-ATE award 0903316.	**Year This Assessment Occurred:** 2017-2018 **Result:** Target Met Students have really progressed on this PLO, with the ability to conduct excellent research, and tie it into materials structures, processes, and characterization. Students have also done far better than ever imagined in tying together advanced applications and novel material structures. (02/02/2018) **Resource Request:** N/A **GE/IL-SLO Reflection:** Critical thinking	
		Year This Assessment Occurred: 2015-2016 **Result:** Target Met Students continue to use case studies effectively throughout NANO51 (applications) NANO52 (structures) NANO53 (Characterization) and NANO54 (fabrication) to describe the use of the PNPA rubric in integrated materials engineering. In NANO10 (Nanoscience) younger students have used the PNPA rubric to show the integration path from structure-properties to fabrication-structure to characterization of structure and process optimization. (12/01/2016) **Resource Request:** Funding of electron microscopy training at NASA-ASL (MACS facility)	
		Year This Assessment Occurred: 2014-2015 **Result:** Target Met Students have used case studies effectively throughout NANO51 (applications) NANO52 (structures) NANO53 (Characterization) and NANO54 (fabrication) to describe the use of the PNPA rubric in integrated materials engineering. In NANO10 (Nanoscience) younger students understand this	

PL-SLOs	Assessment Methods	Assessment Findings/Reflections	Action Plan
		if we spend time on it (12/07/2015) **Resource Request:** N/A **Resource Request:** N/A **GE/IL-SLO Reflection:** N/A **GE/IL-SLO Reflection:** N/A	
		Year This Assessment Occurred: 2012-2013 **Result:** Target Met Over the course of the last year students have displayed the ability to do nanoscience research and specifically nanostructures, based on the integrated engineering model of structure => properties, processing, and characterization. As mentioned in recent SLO reflections, students with degrees have a MUCH easier ability to do this than younger students, which may reflect maturity in college level research and writing, not just the science foundation for nanoscience. Encouraging students to do more literature reading, not just websites and current events, may be an effective approach to more in-depth application of nanoscience principles in advanced materials engineering. (12/04/2013) **GE/IL-SLO Reflection:** N/A	
		Year This Assessment Occurred: 2011-2012 **Result:** Target Met Students in NANO50 and especially NANO51 have exhibited proficiency in both analysis of nanotechnology methods for developing new products and processes (NANO50 and NANO51 midterm writing assignment) and developing their own approaches to nanomaterials engineering of new products and processes. (03/13/2012) **GE/IL-SLO Reflection:** Students use research and writing skills, analysis and critical thinking to understand how nanoscience is being applied to a real commercial/industrial applications, and exhibit very good writing and presentation skills in both the midterm and final assignments for NANO50 (Nanoscience) and NANO51 (Nanotechnology). At least 75% of students do these assignments very well.	
Nanomaterials Engineering - Technicians will develop effective engineering plans for developing	**Class/Lab Project -** Students will demonstrate an understanding of effective nanomaterials engineering	**Year This Assessment Occurred:** 2017-2018 **Result:** Target Met	

PL-SLOs	Assessment Methods	Assessment Findings/Reflections	Action Plan
materials engineering solutions for industrial applications (using PNPA). These include applying characterization skills to elucidating structure=> property relationships, process optimization (for desired properties) and consistent material manufacturing. Demonstrate through term projects (diagrams etc.), engineering lab experiments, and class presentations, **SLO Status:** Active **Year(s) to be Assessed:** End of Quarter **Start Date:** 01/01/2012 **End Date:** 01/01/2013	practice through class lab projects where they will design / describe / document a path from processing => structure => (characterization) => properties => applications. **Notes:** This assignment demonstrates a working understanding on the PNPA rubric (integrated nanomaterials engineering) from NSF-ATE Nano-technician award 0903316	This has proven much more difficult, mostly as we lack good fabrication facilities. In a more advanced program with access to fabrication tools, and faculty with deeper fabrication experience, this PLO can probably be met, but ideally, it needs a hands-on laboratory. (02/02/2018) **Resource Request:** N/A	
		Year This Assessment Occurred: 2015-2016 **Result:** Target Met Students develop a working plan to develop an advanced material for a new application, e.g. a thin film for solar PV, or a nanoparticle for energy storage. They consider the current state of the art for a material, current fabrication methods, and design a processing path to reach a specific structure, with specific properties. This PLO is only accomplished after taking NANO54, however in spring 2016 we will be offering NANO62, advanced materials engineering, which is an integrated / advanced course comprising components from NANO52, NANO53, and NANO54. We believe the integrated pedagogy will be effective for achieving this PLO. (12/01/2016) **Resource Request:** Funding of electron microscopy training at NASA-ASL (MACS facility)	
		Year This Assessment Occurred: 2014-2015 **Result:** Target Not Met This SLO requires students to participate in a laboratory course with access to equipment. In NANO54, we discuss engineering plans, but this is somewhat difficult to provide effective instruction for. We are rethinking this in our program redesign during Winter Qtr 2016, and over a proposed sabbatical for Robert Cormia. (12/07/2015) **Resource Request:** Need hands-on experience with process tools **Resource Request:** Need hands-on experience with process tools	
		Year This Assessment Occurred: 2012-2013 **Result:** Target Not Met Student success in this ability was strongly correlated with experience in science and engineering. As in previous reflections, the majority of students with science and engineering degrees and industry/workforce experience	

PL-SLOs	Assessment Methods	Assessment Findings/Reflections	Action Plan
		were able to demonstrate detailed approaches to engineering experiments, while only a few of students, and almost always the better students, were able to develop good engineering plans. Students with internships, even informal ones, had much better thought and planning of Design of Experiments (DoE). Emphasis on workforce education may be a better route to enhancing this learning outcome. (12/04/2013)	
		Year This Assessment Occurred: 2011-2012 **Result:** Target Met Majority of students develop very thoughtful engineering approaches to product or process development as evidenced in written assignments and PowerPoint presentations. Key items assessed for include the linkage between process => structure => properties => applications. Other methods of demonstrating mastery of engineering knowledge includes the thoughtful/effective selection of tools and methods for processing, characterization, and structure => properties. Students who master this assignment typically have good reading, research, and writing skills, and also bring in working experience from industry experience. (03/13/2012) **GE/IL-SLO Reflection:** Students who master this assignment typically have good reading, research, and writing skills, and also bring in working experience from industry experience. These skills undoubtedly were built on extensive previous college courses. However, there is significant variation in practicing complete grammar in writing.	
Nanotechnician Competency - Technicians will support fundamental R&D, process development, characterization (including QA/QC FA etc.) and consistent / good manufacturing practice (in all sizes of high technology firms). Demonstrate through internship and work experience. **SLO Status:** Active **Year(s) to be Assessed:** End of Quarter	**Field Placement/Internship -** Students will demonstrate an ability to effectively practice the integrated nanomaterials engineering method (PNPA rubric) in a working / research environment. Students will practice processing/fabrication, characterization, and working to develop/optimize a fabrication/processing method. Could be capstone experience in a laboratory, internship, or incumbent	**Year This Assessment Occurred:** 2017-2018 **Result:** Target Not Met Very few students have achieved this, as internships have been difficult for fabrication. However, a few have, and demonstrated the ability to work in cutting edge research facilities. In addition, a greater number of students have found internships in characterization, which they've done very well, and beyond expectation. (02/02/2018) **Resource Request:** N/A	
		Year This Assessment Occurred: 2015-2016 **Result:** Target Not Met	

PL-SLOs	Assessment Methods	Assessment Findings/Reflections	Action Plan
Start Date: 01/01/2012 **End Date:** 01/01/2013	working experience. **Notes:** This is the final step in the nanomaterials engineering methodology (PNPA rubric) showing competency in fabrication, characterization, process engineering, or QA/QC. Completes the work statement for NSF-ATE award 0903316 (Scenario Based Nano-technician Training). Students may also submit projects from work experience.	In previous years we were able to place interns at NASA-ASL (Advanced Studies Lab) where they received microscopy training, and working in advanced materials engineering. This year, with UC Santa Cruz pulling out of the ASL/MACS facility, we were only able to train three students in the use of microscopes, and additionally couldn't support the materials development (experiments) for the three students (12/01/2016) **Resource Request:** Funding of electron microscopy training at NASA-ASL (MACS facility) **Resource Request:** Funding of electron microscopy training at NASA-ASL (MACS facility)	
		Year This Assessment Occurred: 2014-2015 **Result:** Target Not Met We placed two students into paid positions during this time period, but lack internships to help other students practice knowledge and learn OJT skills. We need to fund more internships at NASA-ASL. This is part of a proposed sabbatical for Robert Cormia in 2015-16 (pending approval by the sabbatical committee). (12/07/2015) **Resource Request:** We need to fund (more) internships at NASA-ASL **Resource Request:** We need to fund (more) internships at NASA-ASL	
		Year This Assessment Occurred: 2012-2013 **Result:** Target Not Met A limited number of students were able to effectively demonstrate this competency, and as with previous SLO/PLOs, the better students, and working professionals, almost always had success, while younger students did not. This may be a more advanced concept/competency that requires field experience. (12/04/2013)	
		Year This Assessment Occurred: 2011-2012 **Result:** Target Not Met About half of students, all of whom are currently employed, have exhibited integration of nanoscience and nanotechnology knowledge and skills in their work, as evidenced in a final reflective assignment in NANO53 and NANO54. However, for those students who were not already employed, have had a more difficult time reporting	

PL-SLOs	Assessment Methods	Assessment Findings/Reflections	Action Plan
		how they applying knowledge and skills as current practice. We are developing new assignments to learn better how 'technician' skills are practiced outside of the workplace, as in short/informal internships. In this respect, as our goal was 80 to 90% of students practicing lab skills, we rate this assessment finding as 'target not met' in quantity, but met (mostly) in quality. (03/13/2012) **GE/IL-SLO Reflection:** Practice of good laboratory work skills includes good work habits, safety awareness, and application of the scientific method. Institutionally, we have a strong commitment to local industry to provide a skilled workforce, ready to work.	

Course-Level SLOs	Assessment Methods	Assessment Findings/Reflections	Action Plans
		Year This Assessment Occurred: 2015-2016 **Result:** Target Met At both Palo Alto HS and Gunn HS, students were able to identify the applications of nanotechnology, principally through group projects. Target was met in 2014/2015. (04/25/2015) **Resource Request:** N/A **GE/IL-SLO Reflection:** N/A **GE/IL-SLO Reflection:** N/A	
Field of Nanotechnology - students will describe the field of nanotechnology from a historical perspective, and emergent / convergent from physics, materials science and engineering, semicondutors and electronics, biology and chemistry - assessment by written evaluation **Course-Level SLO Status:** Active	**Discussion/Participation -** Weekly writing assignment **Target for Success:** Ability to communicate the history and contest of Nanotechnology, as integrative of but also distinct from chemistry, physics, and materials science **Notes:** Data collected in ETUDES	**Year This Assessment Occurred:** 2014-2015 **Result:** Target Met Students at both Palo Alto and Gunn HS were mostly able to define the field of nanoscience and nanotechnology, however in our after school venue at Gunn HS, this was a more difficult task. We'll add more videos and perhaps guest speakers. (06/30/2015) **Resource Request:** N/A	
		Year This Assessment Occurred: 2013-2014 **Result:** Target Not Met We didn't assess for this, as we didn't spend too much time on the subject. We did ask one question in a weekly writing assignment. (01/01/2015) **Resource Request:** N/A	
		Year This Assessment Occurred: 2011-2012 **Result:** Target Not Met Students had only a weak understanding of nanoscale phenomenon as distinct (or integrative) of chemistry, physics, and biology. (12/05/2011) **GE/IL-SLO Reflection:** This assignment gave a lot of students difficulty, especially if they have not completed a college level chemistry, physics, and/or biology course. It is important to lay a foundation for nanoscience as distinct (or integrative) of other sciences. We did work on vocabulary (mesoscale phenomenon).	**Action Plan:** Increase use of Wikipedia nanoscience and discussions of atomic and molecular geometry, environments, and local properties (surface, electronic, etc). Develop a more rigorous approach to nanoscience concepts including self-assembly, supramolecular chemistry, band gaps, and atomic and molecular interactions. (12/16/2012)
Material Engineering - students will describe the material engineering and application challenges in energy, food, water, computing, and medicine - assessment by written	**Discussion/Participation -** Weekly writing assignment **Target for Success:** Ability to communicate the need for new materials and materials engineering	**Year This Assessment Occurred:** 2014-2015 **Result:** Target Met At both Palo Alto and Gunn HS students were able to articulate the need for advanced materials in the key application areas of energy, food, water, computing, and	

Course-Level SLOs	Assessment Methods	Assessment Findings/Reflections	Action Plans
evaluation. **Course-Level SLO Status:** Active	solutions in the field of energy, food, water, computing, and medicine. **Notes:** Follows the Foresight Institute. Data is collected in ETUDES.	medicine, through group projects and presentations. However, we didn't assess for an understanding of all of the application areas. Will need to reword the assignment. (06/30/2015) **Resource Request:** N/A **Resource Request:** N/Ahttps://foothill.tracdat.com/tracdat/faces/assessment/observations/editObservation.jsp#	
		Year This Assessment Occurred: 2013-2014 **Result:** Target Met We did spend time discussing the application of materials science and engineering in nanoscience and especially nanotechnology. Students described materials engineering problems as best they could, this SLO will require more effort in 2015. (01/01/2015) **Resource Request:** N/A	
		Year This Assessment Occurred: 2011-2012 **Result:** Target Met Most students were able to describe the materials challenges in energy, water, medicine, and computation. Most students clearly understood there were materials development challenges in these areas, and nanomaterials engineering would lead to novel properties in addressing many of these issues. (12/05/2011) **GE/IL-SLO Reflection:** A good simple SLO, and one lecture in class addressed the topic perfectly.	**Action Plan:** Continue to emphasize the grand challenge applications of nanotechnology, especially energy, water, medicine, and societal impacts. This area continues to be the most interesting for students, and especially younger 'traditional' students. (12/16/2012)
Nanoengineering - students will describe how nanotechnology and nanoengineering are practiced in industry, including thin film deposition, particle size, distribution, and surface area, grain boundary engineering, lattice dimension / strain - students will describe the material engineering and application challenges in energy, food, water, computing, and medicine - assessment by written evaluation. **Course-Level SLO Status:** Active	**Discussion/Participation -** Weekly writing assignment **Target for Success:** Ability to communicate how nanotechnology and nanomaterials engineering is used in industry, and specifically the technical approaches to solving problems in application development. **Notes:** Data collected in ETUDES	**Year This Assessment Occurred:** 2014-2015 **Result:** Target Met The student learning outcome for nanoengineering was much stronger at Palo Atlo HS than at Gunn HS. This was most likely because of the different venue (period 5/7 at Palo Atlo vs after school at Gunn) (06/30/2015) **Resource Request:** N/A	
		Year This Assessment Occurred: 2013-2014 **Result:** Target Not Met We didn't spend as much time on this subject as we had hoped to. Advanced materials engineering concepts are probably too difficult for high school students. (01/01/2015) **Resource Request:** N/A	
		Year This Assessment Occurred: 2011-2012	

Course-Level SLOs	Assessment Methods	Assessment Findings/Reflections	Action Plans
		Result: Target Met Most students were able to find industry applications of nanotechnology that they could relate to. Most had one or two areas where they understood how nanotechnology was used, such as in an iPod, a computer, energy, or nano-medicine. (12/05/2011) **GE/IL-SLO Reflection:** Straightforward and led to the midterm writing assignment, which probably reinforced this SLO. Need to measure how many application areas they learn by the end of the course.	**Action Plan:** Continue to develop tours as a method to communicate the importance of materials engineering in local industry. Develop laboratories that are related to the tours. (12/16/2012)
Nanostructures - students will identify ten key nanostructures, how they are prepared, and why they are important in nanoscience and materials engineering - assessment by written evaluation. **Course-Level SLO Status:** Active	**Discussion/Participation -** Weekly writing assignment **Target for Success:** Students will identify and define ten key nanostructures and why they are important in nanotechnology. Can including structure => property relationships as well as industry applications **Notes:** data collected in ETUDES	**Year This Assessment Occurred:** 2014-2015 **Result:** Target Met Palo HS students were able to identify nearly ten structures, while Gunn HS students were only able to identify six to eight. The level of detail/recall was better for Palo Alto HS, again a reflection of the more academic setting for this course. (06/30/2015) **Resource Request:** N/A	
		Year This Assessment Occurred: 2013-2014 **Result:** Target Met All students did very well in identifying ten or more key nanostructures. We did spend a significant amount of time on this. This is a key SLO for NANO10 / nanoscience. (01/01/2015) **Resource Request:** N/A	
		Year This Assessment Occurred: 2011-2012 **Result:** Target Not Met Most students were able to identify about 5 nanostructures at most, and not without considerable help from the course notes and Wikipedia. (12/05/2011) **GE/IL-SLO Reflection:** It might be either too early to ask them to do this, or it could be that it takes iterative passes through this content to begin to master nanostructures.	**Action Plan:** Do more reinforcing drills associated with nanostructures, including week to week vocabulary, and looking for names of structures in the weekly assignments. (12/16/2012)
PNPA Rubric - students will learn and apply the PNPA rubric to key application and product engineering challenges - as a method for applying the engineering method to advanced materials engineering - assessment by	**Research Paper -** Final writing assignment **Target for Success:** Ability to integrate the PNPA rubric into an industry application (nanotechnology or area of research	**Year This Assessment Occurred:** 2014-2015 **Result:** Target Not Met We reworded the final writing assignment, and actually removed this as a goal in our two offerings of NANO10. It would have required too much effort, especially at the end of the course when we were running out of time. We do	

Course-Level SLOs	Assessment Methods	Assessment Findings/Reflections	Action Plans
written evaluation. **Course-Level SLO Status:** Active	(nanoscience). Demonstrate understanding of processing => structures => properties => applications **Notes:** data collected in ETUDES	introduce PNPA at a number of points in the class, and across the NANO program, students do master this concept. (06/30/2015) **Resource Request:** N/A	
		Year This Assessment Occurred: 2013-2014 **Result:** Target Not Met We didn't spend time on the PNPA rubric in NANO10 in fall 2014, but we might in 2015. This SLO requires that we work through the nanostructures carefully and explain how each set of properties relates to structure, and how properties are developed for applications. The fabrication component of PNPA is most difficult. (01/01/2015) **Resource Request:** N/A	
		Year This Assessment Occurred: 2011-2012 **Result:** Target Not Met Most students were only vaguely aware of PNPA and could not find an immediate use for the rubric. (12/05/2011) **GE/IL-SLO Reflection:** We will need to spend much more time on this in NANO51 beginning in winter 2012	**Action Plan:** Need to spend 5 to 10 minutes at the beginning of each lecture with the PNPA rubric as applied to a specific topic/application (semiconductors, nanocarbon, etc.) (12/16/2012)
Properties Relationships - students will apply theory of atomic, electronic, and material structure to Modeling and Simulation, Engineering, and Structure - Properties Relationships. **Course-Level SLO Status:** Active	**Discussion/Participation -** weekly writing assignment **Target for Success:** Ability to describe how particular properties emerge from molecular/electronic structures etc., and a general understanding of structure => property relationships. **Notes:** data collected in ETUDES	**Year This Assessment Occurred:** 2014-2015 **Result:** Target Not Met This SLO was way too challenging for students given the limited amount of time that we have in this class. We'll probably bolster our molecular modeling demonstration and lab, with an emphasis on visualization of molecular structure and chemical bonding. (06/30/2015) **Resource Request:** N/A	
		Year This Assessment Occurred: 2013-2014 **Result:** Target Met We tested this SLO for properties of nanocarbon, and students did pretty well on it. However, many students didn't have enough a foundation in chemistry to apply to the process/concept of extending physical properties from atomic/molecular structure. We may try this a bit more in 2015. (01/01/2015)	
		Year This Assessment Occurred: 2011-2012 **Result:** Target Not Met Most students had a rough idea of structure => property relationships, especially if they previously had studies	**Action Plan:** Discuss properties of structures throughout the presentation of a structure => application, such as particle size,

Course-Level SLOs	Assessment Methods	Assessment Findings/Reflections	Action Plans
		materials, or taken chemistry past organic. For students with only one college course this was a stretch for them to articulate. (12/05/2011) **GE/IL-SLO Reflection:** Degree holding students had a clear advantage in articulating structure => property relationships. This topic may require a number of lectures for students to master.	surface area, electronic and thermal properties, etc. Also follow and reflect on why (how) some students understand this, and others do not. Attempt to correlate prior experience with materials science, etc. (12/16/2012)
Fabricating Nanostructure - students will identify the primary process tools for fabricating nanostructured materials, how they work, and where they fit into both academic research and industrial laboratories and manufacturing. **Course-Level SLO Status:** Active	**Discussion/Participation -** weekly writing assignments **Target for Success:** Ability to identify basic approaches to nanofabrication from a tools and process perspective. May integrate a notion of key nanostructures, properties, and applications. **Notes:** data collected in ETUDES	**Year This Assessment Occurred:** 2014-2015 **Result:** Target Not Met This SLO was also too challenging for a younger student without any understanding of tools used in industry. We also had very little time to work on this. However, we did have a field trip at Gunn HS to a thin film facility (Southwall Technologies) that was quite memorable. We'll scale back the fabrication tools SLO. (06/30/2015) **Resource Request:** N/A	
		Year This Assessment Occurred: 2013-2014 **Result:** Target Not Met We didn't spend time on this topic which might be a bit advanced for high school students. We might try an acronym approach to help students learn these terms. (01/01/2015) **Resource Request:** N/A	
		Year This Assessment Occurred: 2011-2012 **Result:** Target Not Met Students were able to grasp thin films and semiconductors, but topics including nanochemistry were a little challenging for over half the group. (12/05/2011) **GE/IL-SLO Reflection:** Degree holders especially with chemistry, physics, biology, and some industry experience did reasonable well. Students with minimal science struggled with this.	**Action Plan:** Develop more interesting laboratory tours that students can use to identify processing equipment, such as Stanford Nanofabrication Facility (SNF). (12/16/2012)
Characterization Tools and Methods - students will identify the primary process tools for characterizing nanostructured materials, how they work, and where they fit into both academic research and industrial laboratories and manufacturing	**Discussion/Participation -** weekly writing assignment **Target for Success:** Ability to identify typical instruments and methods used in characterizing nanomaterials, nanostructures, and elucidating structure property	**Year This Assessment Occurred:** 2014-2015 **Result:** Target Met We spent a lot of time on this SLO at both Palo Alto and Gunn HS, and also had a tour of Stanford University's nanocenter. Students did quite well on this, as measured by their identification of tools, spectra, and ability to name/identify acronyms. (06/30/2015)	

Course-Level SLOs	Assessment Methods	Assessment Findings/Reflections	Action Plans
(QA/QC). **Course-Level SLO Status:** Active **Start Date:** 09/01/2011 **End Date:** 01/01/2013	relationships. **Notes:** data collected in ETUDES	**Resource Request:** N/A	
		Year This Assessment Occurred: 2013-2014 **Result:** Target Met We spent a significant amount of time on this topic and it really paid off. High school students mastered this topic through lecture, field trips, and in class exercises. (01/01/2015) **Resource Request:** N/A	
		Year This Assessment Occurred: 2011-2012 **Result:** Target Met Surprisingly students did a pretty good job with this assignment - and were able to articulate both the names and functions of tools, and additionally materials that could be analyzed with each method. (12/05/2011) **GE/IL-SLO Reflection:** Success of this SLO might be due in part to the experience of the faculty in these tools and methods. This might be a case of both knowledge and enthusiasm rubbing off on students.	**Action Plan:** Continue to reinforce characterization tools in discussion of structures, properties, and process development and optimization. This could simply be 'time on task'. (12/16/2012)
Emergent and Converget Nanotechnology - students will identify and discuss the current challenges to nanotechnology and nanoengineering in policy, education, funding, legal, and environmental applications and identify and discuss the future emergent and convergent areas of nanotechnogy, including quantum computing, synthethic biology, and IT/MEMS (nanorobotics) **Course-Level SLO Status:** Active	**Discussion/Participation -** weekly writing assignment **Target for Success:** Describe the convergence of nanotechnology, biology, physics, etc., and the legal and policy implications of nanotechnology. Identify where funding of research is needed. **Notes:** data collected in ETUDES	**Year This Assessment Occurred:** 2014-2015 **Result:** Target Not Met We will eliminate this SLO as we ran out of time to cover the advanced fields in nanoscience and nanotechnology. We'll replace it with easier topics (3D printing), nanomedicine, and only a slight coverage of synthetic biology. (06/30/2015) **Resource Request:** N/A	
		Year This Assessment Occurred: 2013-2014 **Result:** Target Met We ran out of time in NANO10 at Palo Alto High School and hence didn't spend time on this topic. However, we will spend time on the topic at Gun High School in 2015. (01/01/2015) **Resource Request:** N/A	
		Year This Assessment Occurred: 2011-2012 **Result:** Target Met We are just beginning our discussion of this topic. Hopefully there will be enthusiasm in learning about future technology goals of nanotechnology, and how policy and investment can accelerate development of new nanomaterials / engineering innovation.	**Action Plan:** Spend more time throughout the class discussing grand challenge problems, the rapid growth of semiconductors, and the potential for nanomedicine and energy. (12/16/2012)

(12/05/2011)
GE/IL-SLO Reflection: Work in progress

NANO 51:APPLICATIONS OF NANOTECHNOLOGY

Course-Level SLOs	*Assessment Methods*	*Assessment Findings/Reflections*	*Action Plans*
Fundamental Concepts of Nanoscience - What are (some of the) fundamental tenants of nanoscience? (Emergence of properties at scale, self-assembly, surface area effects, and emergence of nanosystems). **Course-Level SLO Status:** Active **Start Date:** 01/01/2012 **End Date:** 01/01/2013	**Exam - Course Test/Quiz -** weekly writing assignments and midterm/final writing assignments **Target for Success:** Describe key ideas / concepts in nanoscience and how / why they are important in nanotechnology. Three key ideas are self-assembly, surfaces, and emergence of properties at scale. **Notes:** data collected in ETUDES	**Year This Assessment Occurred:** 2015-2016 **Result:** Target Met Students in this class were similar to previous classes in having a diversity of knowledge and skills. This course did perform slightly better in describing the fundamental tenants of nanotechnology, especially size, surface area, and self-assembly. The class may have been more prepared. We also talked more about nanotechnology applications. (04/25/2016) **Resource Request:** N/A **GE/IL-SLO Reflection:** N/A	
		Year This Assessment Occurred: 2015-2016 **Result:** Target Met Students used the PNPA rubric effectively in preparing final assignments, however, as noted in many other reflections, students with four-year science and engineering degrees performed far better than students with minimal science foundation. The PNPA rubric continues to be a strong pedagogical tool in NANO. (04/25/2016) **Resource Request:** N/A **GE/IL-SLO Reflection:** N/A	
		Year This Assessment Occurred: 2015-2016 **Result:** Target Met Students continue to do well with the fundamental concepts of nanoscience, however we see a striking difference between students that have completed a year of chemistry and physics compared to those who have not. This isn't unexpected and suggests that we should try to recruit from science courses. In fall 2016, we did notice that a number of younger and more prepared students mastered this SLO much better. (04/25/2016) **Resource Request:** N/A **GE/IL-SLO Reflection:** N/A	
		Year This Assessment Occurred: 2015-2016 **Result:** Target Met Students did very well with fundamental concepts of self assembly and surface area effects, however emergence of properties at scale, and emergence of nanosystems, were	**Action Plan:** Have students present and discuss a fundamental nanoscience concept as a group. For the four tenants mentioned here, group projects would likely

Course-Level SLOs	Assessment Methods	Assessment Findings/Reflections	Action Plans
		more difficult. As in previous classes, students who had an understanding of atomic structure and one year of physics and chemistry did much better than students who were studying nanotechnology concurrently with chemistry and physics. (04/25/2016) **Resource Request:** N/A **GE/IL-SLO Reflection:** connects to the four C's research and analysis (but not computation skills)	encourage more research, and especially discussion, and ensure better understanding of each topic. (12/16/2012)
Key Nanostructures used in Nanotechnology - What are the 10-20 key nanostructures used in industry? (Apply PNPA to each in a top-level manner) (fullerenes, nanotubes, thin films, and dendrimers) **Course-Level SLO Status:** Active **Start Date:** 01/01/2012 **End Date:** 01/01/2013	**Exam - Course Test/Quiz -** weekly writing assignments and midterm/final essays **Target for Success:** Describe ten to twenty key nanostructures and how and why they are used in industry. Include a description of PNPA processing => structures => properties => applications, and how PNPA is used in industry / nanomaterials engineering. **Notes:** data collected in ETUDES	**Year This Assessment Occurred:** 2013-2014 **Result:** Target Met Students continue to do well on nanostructures - reflecting the time that we invest in this topic. (01/01/2015) **Resource Request:** N/A	
		Year This Assessment Occurred: 2013-2014 **Result:** Target Met Students mostly did well on this assignment, but there were a range of responses to different structures, which I interpret as having familiarity in chemistry and chemical structures. The PNPA rubric works well for nanocarbon, silicon, surface coatings, and particles, a little more challenging with quantum dots, dendrimers, etc. Students seem to gravitate to a particular structure. (01/20/2014) **Resource Request:** None **GE/IL-SLO Reflection:** N/A	
		Year This Assessment Occurred: 2012-2013 **Result:** Target Met Students used the PNPA rubric effectively in preparing final assignments, however, as noted in many other reflections, students with four-year science and engineering degrees performed far better than students with minimal science foundation. (01/25/2013) **Resource Request:** N/A	
		Year This Assessment Occurred: 2011-2012 **Result:** Target Met Most students were able to learn ten structures by the end of the course, but mostly by 'class', meaning nanocarbon, and within that perhaps graphene, graphite, CNT, fullerenes, etc. and dendrimers and biomolecules, but within a class, not a strong level of detail or ability to draw out a structure. Students who had an understanding of	**Action Plan:** As mentioned in NANO10 and NANO52, having exercises to reinforce memorization of structures is very important. Drawing structures, making models, and identifying the types of bonds and material properties continues to be the primary approach.

Course-Level SLOs	Assessment Methods	Assessment Findings/Reflections	Action Plans
		atomic structure and one year of physics and chemistry did much better than students who were studying nanotechnology concurrently with chemistry and physics. (01/01/2012) **Resource Request:** none	(12/16/2012)
Fundamental Applications of Nanotechnology - What are the fundamental problems addressed and industries using nanoscience and nanoengineering? Use PNPA, and how does it relate to the actual hands-on practice of nanomaterials engineering? **Course-Level SLO Status:** Active **Start Date:** 01/01/2012 **End Date:** 01/01/2013	**Case Study/Analysis -** midterm/final writing assignment **Target for Success:** Describe fundamental problems in industry requiring novel materials / properties, and how / where nanomaterials engineering is used to find solutions to those problems. Integrate PNPA: processing => structures => applications => properties into the discussion of nanomaterials engineering for application development. **Notes:** data collected in ETUDES	**Year This Assessment Occurred:** 2013-2014 **Result:** Target Met The case studies for NANO51 in fall quarter 2014 were superb! We were quite amazed with the applications students chose for their final projects. These included energy storage, nanomedicine, advanced computing, transportation, atomic physics, and even computational modeling. (01/01/2015) **Resource Request:** N/A	
		Year This Assessment Occurred: 2013-2014 **Result:** Target Met A number of students had exceptional assignments addressing material properties, applications, and novel approaches to (unmet needs) in technology, especially health. However, the engineering of the solutions was a challenge for them to consider, as they have very little hands-on experience with fabrication. (01/20/2014) **Resource Request:** None **GE/IL-SLO Reflection:** N/A	
		Year This Assessment Occurred: 2012-2013 **Result:** Target Met Students used the PNPA rubric effectively in preparing final assignments, however, as noted in many other reflections, students with four-year science and engineering degrees performed far better than students with minimal science foundation. (01/25/2013) **Resource Request:** N/A	
		Year This Assessment Occurred: 2011-2012 **Result:** Target Met Students did very well tying applications to nanomaterials engineering and especially researching applications of particular nanomaterials. In both weekly assignments and the final project, students found interest in nanomedicine, clean energy technology, and transportation to drive their studies. There was no significant difference in ability to tie	**Action Plan:** Following NANO10 approach, students will apply the PNPA rubric in discussing nanoscience news and research, and especially nanomaterials engineering solutions in the the 'grand challenge' fields of energy, water, medicine, and computation. (12/16/2012)

Course-Level SLOs	Assessment Methods	Assessment Findings/Reflections	Action Plans
		applications to properties, however students with a four-year degree were much better able to develop lengthy and in depth assignments. (01/01/2012) **Resource Request:** none **GE/IL-SLO Reflection:** research and analysis	

NANO 52:NANOMATERIALS & NANOSTRUCTURES

Course-Level SLOs	Assessment Methods	Assessment Findings/Reflections	Action Plans
Key Nanostructures used in Nanotechnology - What are the key 10 to 12 nanostructures used in nanotechnology, and what are their composition and structure. Why are they important and what industries use them to solve what types of problems? **Course-Level SLO Status:** Active **Start Date:** 01/01/2012 **End Date:** 01/01/2013	**Exam - Course Test/Quiz -** weekly writing assignments and midterm/final writing assignment **Target for Success:** Describe ten to twelve key nanostructures in terms of their elemental composition, molecular and electronic structures, and how/why they are important in nanoscience and nanotechnology. Integrate PNPA (fundamental structure => properties) **Notes:** data collected in ETUDES	**Year This Assessment Occurred:** 2015-2016 **Result:** Target Met Students are capable of identifying a dozen key nanostructures, the key properties and applications, and how the materials are fabricated and characterized. (07/01/2016) **Resource Request:** N/A **GE/IL-SLO Reflection:** N/A	
		Year This Assessment Occurred: 2014-2015 **Result:** Target Met Students still struggle with keeping over a dozen nanostructures at the tip of their tongue, but do have detailed knowledge of a few key nanostructures. It may not be realistic to have so many structures committed to memory. (06/30/2015) **Resource Request:** N/A **GE/IL-SLO Reflection:** Not applicable **GE/IL-SLO Reflection:** N/A	
		Year This Assessment Occurred: 2014-2015 **Result:** Target Met Students are able to describe a dozen or more key nanostructures, their key properties, how to process/characterize, and structure property relationships. (06/30/2015) **Resource Request:** N/A **GE/IL-SLO Reflection:** N/A	
		Year This Assessment Occurred: 2014-2015 **Result:** Target Met Students are able to describe the ten nanostructures reasonably well, although students who lack a good chemistry foundation have challenges with molecular bonding. The addition of a molecular/crystal modeling exercise helped significantly. (06/30/2015) **Resource Request:** N/A **GE/IL-SLO Reflection:** N/A	
		Year This Assessment Occurred: 2014-2015 **Result:** Target Met Students developed a good understanding of structures	**Action Plan:** As practiced in NANO51, each week do a quick drill on key nanostructures, and in NANO52, add

Course-Level SLOs	Assessment Methods	Assessment Findings/Reflections	Action Plans
		throughout the course, with an observation that students who used broader references than Wikipedia tended to develop deeper understandings of structures and related properties. Also, students who had completed more than one year of chemistry had a much better (easier) ability to learn structures and structure => property relationships. The project based assessment for this SLO continues to be very effective. (06/30/2015) **Resource Request:** N/A **GE/IL-SLO Reflection:** N/A	atomic and molecular composition, and makes sure to discuss industries that use particular materials, to solve (address) particular applications. The PNPA rubric is a useful for connecting structure => composition => properties. (12/16/2012)
Structure => Property Relationships - How do properties arise from key nanostructures? Using the systems archetype model: networks of atoms, systems of physics, and emergence of properties at scale. **Course-Level SLO Status:** Active **Start Date:** 01/01/2012 **End Date:** 01/01/2013	**Exam - Course Test/Quiz -** weekly writing assignment **Target for Success:** Ability to describe fundamental interactions (physics) at the level of molecular and electronic structure that lead to the emergence of properties, and specific structure => property relationships. Ideally integrate the nanopatterns pedagogy of networks of atoms => systems of physics => and emergence of properties at scale. **Notes:** data collected in ETUDES	**Year This Assessment Occurred:** 2015-2016 **Result:** Target Met Students show through weekly assignments they understand how structure leads to properties, using the newer nanopatterns pedagogy. There is a division between younger students and students with degrees. Younger students with less materials experience have a more difficult time with this concept, while students with degrees in chemistry, physics, and engineering are more able to understand and apply this method. (07/01/2016) **Resource Request:** N/A **GE/IL-SLO Reflection:** N/A	
		Year This Assessment Occurred: 2014-2015 **Result:** Target Met This SLO is met by students with a good chemistry foundation, however for students without advanced chemistry, this can be a little difficult. We may need to add new curriculum for this SLO. (06/30/2015) **Resource Request:** N/A **GE/IL-SLO Reflection:** N/A	
		Year This Assessment Occurred: 2013-2014 **Result:** Target Not Met Most students still struggle with structure => property relationships, even as we have added more content to this discussion. We still use a new pedagogy of networks of atoms, systems of physics, and emergence of properties at scale. (10/10/2014) **Resource Request:** N/A **GE/IL-SLO Reflection:** N/A	
		Year This Assessment Occurred: 2011-2012	**Action Plan:** Develop a laboratory

Course-Level SLOs	Assessment Methods	Assessment Findings/Reflections	Action Plans
		Result: Target Met About half of the students were able to accurately describe material properties including electrical, optical, magnetic, mechanical, and thermal. While almost all students could name at least one property, most had difficulties naming three properties. Students with at least one year of physics and chemistry did MUCH better than students without such preparation. Students with a bachelors degree in science had 80% or better probability of developing a good understanding of structure => property relationships. (07/01/2012) **Resource Request:** none	demonstration where students can see how specific properties are measured, and how those properties (mechanical, thermal, and electric etc) relate to composition, bonding and structure, and 'emergence of properties'. (12/16/2012)
Characterization and Fabrication of Key Nanostructures - What are the primary fabrication and characterization tools for the key 10 - 12 nanostructures used in nanotechnology? **Course-Level SLO Status:** Active **Start Date:** 01/01/2012 **End Date:** 01/01/2013	**Exam - Course Test/Quiz -** midterm/final writing assignments **Target for Success:** Ability to describe process and characterization tools and methods for fabricating and characterizing key nanostructures. Ideally integrate PNPA rubric: process => structures => properties => applications that tie tools to structure => properties. **Notes:** data collected in ETUDES	**Year This Assessment Occurred:** 2015-2016 **Result:** Target Met Assigning fabrication and characterization techniques to each nanostructure is an advanced concept / skill and is the focus of evolving NANO52 into NANO62. Students are generally able to assign fabrication and characterization tools to a small number of nanostructures, usually nanocarbon, silicon, thin films and surfaces, and perhaps one other they make the focus of their final project. NANO62 (Advanced Materials Engineering) will be a test to see if the majority of a class can learn the fabrication and characterization tools for each structure. (07/01/2016) **Resource Request:** N/A **GE/IL-SLO Reflection:** N/A	
		Year This Assessment Occurred: 2014-2015 **Result:** Target Met Students performed very well on this assignment, some with just one year of chemistry, if they paid attention to the lectures and followed the required reading. (06/30/2015) **Resource Request:** N/A **GE/IL-SLO Reflection:** N/A	
		Year This Assessment Occurred: 2013-2014 **Result:** Target Met Students are doing better in this key topic, and probably because we have more content added to these modules, and that the faculty teaching have a better understanding of these topics. A focus on applications for material	

Course-Level SLOs	Assessment Methods	Assessment Findings/Reflections	Action Plans
		properties helps. (10/10/2014) **Resource Request:** N/A **GE/IL-SLO Reflection:** N/A	
		Year This Assessment Occurred: 2011-2012 **Result:** Target Met 80% of students were able to describe typical characterization tools and methods for process develop and support, and elucidation of structure => properties relationships . Students with a year or more of chemistry were able to describe in better detail how characterization tools are used for describing structures in terms of atomic position, chemical bonding, and electronic properties, and especially students with a degree in science or engineering degrees. (07/01/2012) **Resource Request:** none **GE/IL-SLO Reflection:** research and analysis	**Action Plan:** Use the PNPA-2 rubric integrating fabrication, characterization, structure and properties for as many class discussions and examples as possible. Students should also describe the PNPA-2 model for each structure in their weekly assignments. (12/16/2012)

NANO 53:NANOMATERIALS CHARACTERIZATION

Course-Level SLOs	Assessment Methods	Assessment Findings/Reflections	Action Plans
Structure Characterization Tools - What combination of instruments are used to characterize the composition, chemistry, and structure of a material? **Course-Level SLO Status:** Active **Start Date:** 09/01/2011 **End Date:** 12/30/2015	**SLO Assessment Results**	**Year This Assessment Occurred:** 2017-2018 **Result:** Target Met In fall 2017 we spent more time on characterization tools, including in-class exercises for selecting characterization tools. Students improved their understanding of each of the tools, and families of tools. (01/21/2018) **Resource Request:** Perkins funding for microscopy training **GE/IL-SLO Reflection:** Critical thinking is a large part of this SLO, and the maturity of this class enhanced their performance in this learning outcome, as did the emphasis on class exercises.	**Action Plan:** Continue to develop class exercises (01/21/2018)
	Exam - Course Test/Quiz - weekly writing assignments and midterm/final writing assignment or project **Target for Success:** Describe the selection and use of characterization tools to determine composition, chemistry, structure of a material, to support process development, and FA/QA/QC of nanomaterials and devices. **Notes:** data collected in ETUDES	**Year This Assessment Occurred:** 2015-2016 **Result:** Target Met We spent a LOT of time on characterization tools, using both drill and discussion, and it appears to have paid off, especially for students with some materials engineering experience, and/or a prior course (NANO52 Nanostructures) in the program sequence. That said, it appears to simply take time to absorb the various tools, and the scenario based curriculum approach appears to be effective here. In fall 2015, the students had a very strong background in materials engineering and were able to apply new knowledge of the tools to their projects and interests. (01/01/2016) **Resource Request:** N/A **GE/IL-SLO Reflection:** N/A	
		Year This Assessment Occurred: 2015-2016 **Result:** Target Met Students were able to describe the correct approach by instrument class (image, surface, structure, organic, elemental etc) but not as specific within a class of instruments (e.g. SEM/TEM, or AFM/STM) but were able to articulate why you would use a particular type of instrument, or at least why a particular tool was needed. In smaller groups where longer discussion was possible, we were able to describe the choice and approach of a particular tool in materials characterization and failure analysis. Learning the names of tools was a little cumbersome. In fall 2015 this trend continued, and but a	

Course-Level SLOs	Assessment Methods	Assessment Findings/Reflections	Action Plans
		number of more experienced students were able to apply knowledge of tools to their projects fairly well. (01/01/2016) **Resource Request:** N/A **GE/IL-SLO Reflection:** Critical thinking in context of an industrial problem.	
		Year This Assessment Occurred: 2015-2016 **Result:** Target Met Students were able to describe the appropriate tools for composition, chemistry, and structure, and had the ability (with notes) to align tools, nanostructures, and industry. Performance varied based on experience. This was clearly shown in both their middle term and final project assignment, especially in fall 2015. (01/01/2016) **Resource Request:** N/A **GE/IL-SLO Reflection:** Degree holders and especially students with industry experience were able to do this more successfully than students with minimal technician level experience. This trend continues in fall 2015 - and our workforce program has also made note of this.	**Action Plan:** Do more in class drills (discussion) asking students to quickly identify the types of tools used in an industry, to look at specific materials, to solve particular types of problems. This builds on our 5-step rubric instrument => physics => information => materials => industry problems. The rubric is rigorous but intuitive in application. (12/16/2012)
		Year This Assessment Occurred: 2015-2016 **Result:** Target Met We spent more time on this SLO in fall 2014 and fall 2015 and it paid off. We could definitely spend more time on this topic in the future, and will using more in class exercises that were very effective in helping students understand which tools are used for what types of tests, and the information gained from those analyses. Using class discussions as an instructional tool, we were able to share what other students knew about the tools, and how to use them. (01/01/2016) **Resource Request:** N/A **GE/IL-SLO Reflection:** N/A	
Property Characterization Tools - What combination of instruments are used to characterize the physical properties of materials? How are structure-property relationships determined? **Course-Level SLO Status:** Active	**SLO Assessment Results**	**Year This Assessment Occurred:** 2017-2018 **Result:** Target Not Met We didn't really spend time on this topic in fall 2017, and may delete this SLO going forward. (01/21/2018) **Resource Request:** N/A **GE/IL-SLO Reflection:** N/A	
	Exam - Course Test/Quiz - weekly	**Year This Assessment Occurred:** 2013-2014	

Course-Level SLOs	Assessment Methods	Assessment Findings/Reflections	Action Plans
Start Date: 09/01/2011 **End Date:** 01/01/2013	writing assignments and midterm/final writing assignment or project **Target for Success:** Describe key tools and methods for determining material properties (physical, electrical, optical, magnetic, etc.) and elucidation of structure => property relationships **Notes:** data collected in ETUDES	**Result:** Target Not Met We haven't spent enough time on this topic, which needs to be a goal of continued course development. Collaborating with materials engineering (ENGR45) might help. (01/01/2015) **Resource Request:** N/A	
		Year This Assessment Occurred: 2013-2014 **Result:** Target Not Met This has been a difficult SLO from the very beginning for three reasons. First, you need to understand structure-property relationships, and half the students enter this course without taking the proper prerequisites (NANO52 Nanostructures). Second, teaching physical property tools e.g. hardness, optical, magnetic, etc, takes a significant amount of time/attention that we don't have in this class. Third, getting to structure-properties through characterization tools is a bit more challenging to teach than simple 'structure-properties', but it can be done, just not easily for a wide range of materials, so as such, it has been applied sparingly. (01/20/2014) **Resource Request:** None - although a better AFM/SEM would help this activity in the laboratory **GE/IL-SLO Reflection:** N/A	
		Year This Assessment Occurred: 2012-2013 **Result:** Target Not Met We didn't spend as much time on structure-property relationships in this course, and we may want to modify this SLO. Not having tools to demonstrate measurement of material properties, and lack of experience in this area (faculty) was a hindrance. (09/20/2013) **Resource Request:** N/A	
		Year This Assessment Occurred: 2011-2012 **Result:** Target Not Met Properties measurements were much more difficult for students to assign. The IL-SLO reflection will show that lack of experience with many properties tools made this much more difficult. (12/06/2011) **GE/IL-SLO Reflection:** As noted above, lack of industry experience in physical properties made this a more difficult task for the instructor - and more time will be invested in this are as the course is taught again.	**Action Plan:** Add an additional unit on physical properties of materials, and/or combine this with a laboratory exercise measuring strength, electrical and thermal conductivity, etc. (12/16/2012)

Course-Level SLOs	Assessment Methods	Assessment Findings/Reflections	Action Plans
Approaches to Failure Analysis and Materials Characterization - What are are typical approaches to failure analysis, materials characterization, and QA/QC (for nanostructures, nanomaterials, devices and industries)? **Course-Level SLO Status:** Active **Start Date:** 09/01/2011 **End Date:** 01/01/2013	**SLO Assessment Results**	**Year This Assessment Occurred:** 2017-2018 **Result:** Target Met Through increased class exercises and activities, we were able to really make progress on this particular SLO. Again, the technical experience and maturity of this class enhanced their success significantly. Someday it would be advantageous to include cooperative work experience in this mode of learning. (01/21/2018) **Resource Request:** N/A **GE/IL-SLO Reflection:** Critical thinking is a big part of choosing an approach to materials characterization.	**Action Plan:** Develop more detailed in-class exercises for choosing approaches to materials characterization, including analysis of real data (spectroscopy) (01/21/2018)
	Exam - Course Test/Quiz - weekly writing assignments and midterm/final writing assignment or project **Target for Success:** Describe approaches to failure analysis, materials characterization, and QA/QC using specific tools for key problems/devices in targeted industries. **Notes:** data collected in ETUDES	**Year This Assessment Occurred:** 2013-2014 **Result:** Target Met We spent considerable time on this topic using in class exercises, and will continue that pedagogical approach in NANO54 (Nanofabrication) in winter qtr 2015. Students enjoy working in small groups to solve hypothetical problems in materials engineering. (01/01/2015) **Resource Request:** N/A	
		Year This Assessment Occurred: 2013-2014 **Result:** Target Met This SLO is essentially the core of the entire class, and we spend significant time on it, every week, outlining instrument and process (technique) approaches to it. This was successful for most students, but we do move from one industry to another, each week, so the pace is pretty fast, but it does reinforce the use of each tool, which is more important than specific knowledge in a given industry (which can change over time, and is best learned on the job, through immersion. (01/20/2014) **Resource Request:** None **GE/IL-SLO Reflection:** N/A	
		Year This Assessment Occurred: 2012-2013 **Result:** Target Met Most students were able to describe an approach to materials characterization or failure analysis approach, but often the detail in these assignments was directly proportional to the experience of the student with a material. There was a strong correlation between the rigor and quality of the assignment and industry experience, in	

Course-Level SLOs	Assessment Methods	Assessment Findings/Reflections	Action Plans
		addition to students having a BS/MS or other advanced degree. (09/20/2013) **Resource Request:** N/A **GE/IL-SLO Reflection:** critical thinking and communication	
		Year This Assessment Occurred: 2011-2012 **Result:** Target Met This assignment is still in progress but advanced students have already made significant progress on this. It appears that students will be very detailed in one type of industry but not so familiar with other industries. This will require more online materials to support extended learning. (12/06/2011) **GE/IL-SLO Reflection:** As noted above, most students will have good success in relating an approach to materials characterization, problem solving, failure analysis, or QA/QC in one type of industry (semiconductors, magnetic storage, thin films, biomedical devices. etc , much better than the other industries. This might require extended online material for students to use after the course is completed.	**Action Plan:** Early in the class determine which students have industry experience and have them present their use of tools for problem solving and materials characterization early in the quarter. This helps students understand how real tools are used for real problems, and especially connecting data and experimental approaches. (12/16/2012)

NANO 54:NANOFABRICATION TOOLS & PROCESS

Course-Level SLOs	*Assessment Methods*	*Assessment Findings/Reflections*	*Action Plans*
Process Tools and Techniques - What are the key process tools and techniques used to fabricate nanomaterials and nanostructures? **Course-Level SLO Status:** Active **Start Date:** 01/01/2012 **End Date:** 01/01/2013	**Exam - Course Test/Quiz -** weekly writing assignments and midterm/final writing assignment or project **Target for Success:** Describe key process tools and techniques for fabrication of nanomaterials and devices used in high technology industry (semiconductors, magnetic media, biomedical devices, etc). Explain why specific tools and processes are used. **Notes:** data collected in ETUDES	**Year This Assessment Occurred:** 2015-2016 **Result:** Target Not Met Students described the use of various sputtering and process tools, but many found their description difficult because of the lack of familiarity with the vocabulary, and or needing hands-on experience. This was even more difficult in winter 2016 (04/01/2016) **Resource Request:** N/A (other than internships) **GE/IL-SLO Reflection:** N/A (other than internships)	
		Year This Assessment Occurred: 2015-2016 **Result:** Target Not Met Students have challenges with this SLO, and most likely because we don't have a hands-on component where they can see the process equipment. Students who participated in internships, and/or have work experience using these tools. are able to identify two-three tools fairly well (04/01/2016) **Resource Request:** We need to fund internships at NASA-ASL (this is still a need for NANO) **Resource Request:** We need to fund (more) internships at NASA-ASL (this is still a need for NANO) **GE/IL-SLO Reflection:** N/A **GE/IL-SLO Reflection:** N/A	
		Year This Assessment Occurred: 2015-2016 **Result:** Target Met All of the students were able to identify one or more process tools associated with each type of material/structure. Interestingly students who were strong in one area, e.g. semiconductors, were not weaker in a new area, e.g. nanocarbon, ceramics, or metals and alloys. Students with a four-year degree (all of this smaller class) had a slight advantage in learning techniques, but not significantly. (04/01/2016) **Resource Request:** N/A **GE/IL-SLO Reflection:** N/A	**Action Plan:** Develop more tours of local industry that show students fabrication tools and process, including thin film and nanocarbon deposition, and ideally finished products, such as solar PV films, nanocarbon materials, and semiconductor (MEMS). (12/16/2012)
		Year This Assessment Occurred: 2015-2016 **Result:** Target Met Students were able to match process tools and techniques	

Course-Level SLOs	Assessment Methods	Assessment Findings/Reflections	Action Plans
		for nanostructures for general categories of materials, but not so much for specific nanomaterials. This was a particularly small class, very experienced in narrow domains, but not the larger subject area. (04/01/2016) **Resource Request:** None **GE/IL-SLO Reflection:** Not applicable	
Process Optimization - What are the key methods and approaches to process optimization, including optimizing process => structure => properties **Course-Level SLO Status:** Active **Start Date:** 01/01/2012 **End Date:** 01/01/2013	**Exam - Course Test/Quiz -** weekly writing assignments and midterm/final writing assignment or project **Target for Success:** Describe approaches for process optimization, including diagraming process intervention points, characterization tools, and tying structure => property relationships to to process => structure relationships, and demonstrating the turnkey / interlocked relationships in the PNPA rubric. **Notes:** data collected in ETUDES	**Year This Assessment Occurred:** 2014-2015 **Result:** Target Not Met Process optimization is also challenging, as we need extended time on this topic. For students with hands-on activities, this is straightforward but requires critical thinking, and some experience with both processing equipment and characterization tools. (03/30/2015) **Resource Request:** Need hands-on experience with process tools	
		Year This Assessment Occurred: 2013-2014 **Result:** Target Not Met This has been a difficult task for students who do not have process development tools to work on, however the student interns at NASA-ASL have been able to do this. NANO62 may help in this effort, as it has a more active laboratory activity. (04/01/2014) **Resource Request:** N/A **GE/IL-SLO Reflection:** N/A	
		Year This Assessment Occurred: 2012-2013 **Result:** Target Not Met Process optimization was simply too difficult for this group, that didn't have sufficient skills entering the class to understand engineering parameter space. (05/01/2013) **Resource Request:** None **GE/IL-SLO Reflection:** Not applicable	
		Year This Assessment Occurred: 2011-2012 **Result:** Target Met Over half of students exhibited a strong understanding of using characterization tools to optimize process, and especially the link between process => structure => proeprties, a key PLO. This turned out to be a difficult curriculum effort, and one that is requiring continual efforts in development. In order for scenario based curriculum to be effective, the instructor must both have a firm	**Action Plan:** Discuss the two experiments developed in 2012: carbon nanosphere chains (CTIC) and CSiN thin films (Samco) as process development efforts, and using the PNPA-2 rubric for integrating process => structure => (multitechnique) characterization. (12/16/2012)

Course-Level SLOs	Assessment Methods	Assessment Findings/Reflections	Action Plans
		understanding, and a recent experience actually doing this work. (04/01/2012) **Resource Request:** none	
Process Reproducibility - What are the key methods and approaches to achieving process reproducibility, and what QA/QC methods are also employed in that process? **Course-Level SLO Status:** Active **Start Date:** 01/01/2012 **End Date:** 01/01/2013	**Exam - Course Test/Quiz -** weekly writing assignments and midterm/final writing assignment or project **Target for Success:** Describe methods and approaches to achieving process reproducibility, including flow charts, process diagrams, and points of intervention, for nanofabrication and processing (manufacturing) in high-tech related industries (semiconductors, thin films, magnetic media, and biomedical devices). **Notes:** data stored in ETUDES	**Year This Assessment Occurred:** 2014-2015 **Result:** Target Not Met This SLO will require reworking the curriculum, adding a section on process reproducibility, etc. We'll probably rewrite SLOs and incorporate this into a larger SLO. (03/30/2015) **Resource Request:** N/A	
		Year This Assessment Occurred: 2013-2014 **Result:** Target Not Met As with the previous reflection, this activity is difficult for students who do not have access to process tools, and active laboratory, and real-world materials. For this reason a more hands-on environment for teaching these methods should be considered. (04/01/2014) **Resource Request:** N/A **GE/IL-SLO Reflection:** N/A	
		Year This Assessment Occurred: 2012-2013 **Result:** Target Not Met About half of the class was able to describe technologies to address uniformity measurements, i.e., QA/QC, but their lack of experience with technical tools made this difficult (05/01/2013) **Resource Request:** None **GE/IL-SLO Reflection:** Not applicable	
		Year This Assessment Occurred: 2011-2012 **Result:** Target Not Met We did not spend significant time one this topic, other than descriptions of process optimization and being able to reproduce a particular data point in a process matrix. This area needs further development in the course, and reflects the 'newness' of NANO54. (04/01/2012) **Resource Request:** none **GE/IL-SLO Reflection:** research and analysis	**Action Plan:** Use guest lecturers (and/or student presentations) to discuss how QA-QC is used in an industry to ensure process uniformity and/or continuous process improvement. (12/16/2012)

NANO 62:NANOMATERIALS ENGINEERING - STRUCTURES, PROCESSING & CHARACTERIZATION

Course-Level SLOs	*Assessment Methods*	*Assessment Findings/Reflections*	*Action Plans*
Nanostructures - Identify a dozen nanostructures, their key properties (structure-property relationships), and why they are important in advanced materials engineering. **Course-Level SLO Status:** Inactive	**Case Study/Analysis -** Case studies were given in class for analysis of high performance materials, desired properties, and methods of fabrication and characterization **Target for Success:** 75% or more of students having a thoughtful analysis of a case study **Notes:** This project was hard for students without industry experience	**Year This Assessment Occurred:** 2016-2017 **Result:** Target Not Met Students developed a case study for structures, as a milestone for their final project, but only 50% were able to do an adequate job of describing the key structure property relationship for a nanomaterial (11/14/2017) **Resource Request:** N/A	**Action Plan:** Add more in class activity time to work on the case study (06/30/2017)
	Discussion/Participation - Weekly questions are assigned to determine if students are following the material **Target for Success:** 75% of students should be able to name 10 or more nanostructures, what they are (composition, chemical bonding, structure, etc.) and basic physical properties of each structure **Notes:** This is a fairly basic SLO, students should be able to master this by the end of the quarter (ten key nanostructures)	**Year This Assessment Occurred:** 2016-2017 **Result:** Target Met Students did a good job with class discussion and activities around nanostructures, as well as weekly assignments (11/14/2017) **Resource Request:** N/A	**Action Plan:** Continue developing in-class activities (11/14/2017)
Nanofabrication - For each of the dozen nanostructures, identify a fabrication technique, including equipment, process materials, and process steps **Course-Level SLO Status:** Active **Assessment Cycles:** End of Quarter **Start Date:** 04/01/2017 **End Date:** 06/30/2017	**Case Study/Analysis -** A case study was used to assess the degree of knowledge of integrated design, engineering, fabrication and characterization of a dozen nanostructures **Target for Success:** 75% of students should be able to name 6 or more key nanostructures **Notes:** This is a fairly basic SLO in the class	**Year This Assessment Occurred:** 2016-2017 **Result:** Target Not Met Nanofabrication remains a challenging topic in nanomaterials, partly because it requires more engineering practice. (11/14/2017) **Resource Request:** N/A	**Action Plan:** Find videos that can be shown in class which illustrate how various fabrication tools are deployed in nanomaterials engineering (06/30/2017)
	Discussion/Participation - Weekly	**Year This Assessment Occurred:** 2016-2017	**Action Plan:** As noted previously, find

Course-Level SLOs	Assessment Methods	Assessment Findings/Reflections	Action Plans
	questions are given to determine if students are following the material. Nanofabrication is built into each week's topic (nanostructure) **Target for Success:** 75% of students should be able to list two or more fabrication techniques for each nanostructure **Notes:** This is a difficult topic, as fabrication requires some degree of knowledge in engineering	**Result:** Target Not Met Students didn't do appreciably better in describing fabrication tools in their weekly assignments (11/14/2017) **Resource Request:** N/A	videos to show in class that illustrate how fabrication tools are used in nanomaterials engineering (11/14/2017)
Nanocharacterization - For each nanostructure, identify a characterization tool and a procedure for determining structure, composition, chemical bonding, and support for process development. **Course-Level SLO Status:** Inactive	**Case Study/Analysis -** Students will develop a case study around the characterization of a key nanostructure, and as much as possible, identifying two or more tools and methods for characterization **Target for Success:** 90% of students should be able to describe at least one method of analysis of nanostructures, and 75% should be able to describe two methods of analysis **Notes:** This is a fairly straightforward SLO, but it takes time for students to become familiar with characterization tools.	**Year This Assessment Occurred:** 2016-2017 **Result:** Target Not Met Case studies of characterization tools were somewhat more successful than fabrication, but only half of students could align characterization tools with nanostructures (11/14/2017) **Resource Request:** N/A	**Action Plan:** Do more in class activities versus case studies, which are more complicated for students (06/30/2017)
	Discussion/Participation - Weekly questions are assigned to assess if students are tying the fabrication and characterization with design and engineering of nanostructures **Target for Success:** 75% of students should be able to assign two or more characterization tools for each nanostructure. **Notes:** It takes time to learn the characterization tools, and tying them into the integrated engineering	**Year This Assessment Occurred:** 2016-2017 **Result:** Target Met Students did somewhat better in weekly discussions of characterization tools used in nanomaterials engineering (06/30/2017) **Resource Request:** N/A	**Action Plan:** Do more in class activities and exercise (applied to NANO53 this fall) (06/30/2017)

method is difficult.

Course-Level SLOs	Assessment Methods	Assessment Findings/Reflections	Action Plans
PNPA/PNPC integrated engineering method - This is an overarching SLO, very similar to the PLO (Program Learning Outcome) for the NANO program. The integration of nanomaterial design and engineering of specific physical properties, with fabrication and characterization methodology, provides a holistic design/engineering of nanomaterials. **Course-Level SLO Status:** Active **Assessment Cycles:** End of Quarter **Start Date:** 04/01/2017 **End Date:** 06/30/2017	**SLO Assessment Results**	**Year This Assessment Occurred:** 2016-2017 **Result:** Target Met Students did a VERY good job in their final class presentations, and showed that they could combine structure => properties relationships with and integrated approach to nanomaterials engineering (characterization and fabrication) (06/30/2017) **Resource Request:** N/A	**Action Plan:** Increase the number of in-class activities, and have a midterm case study project as a milestone. (06/30/2017)
	Class/Lab Project - This activity is a final project for students, where they present a nanostructure, desired (key) properties, why this material is important, and methods of fabrication and characterization. **Target for Success:** 90% of students should be able to do a good job describing why a material is important, the key structure property relationships, and how to fabricate and characterize it. **Notes:** This is an integrative assessment method which will show if the design of the course was effective, i.e. the integrative materials engineering method.		