Rio Salado College

Nanotechnology Program Review

Review Period: Academic Years 2017-2019

Review Conducted: AY2019-2020

Rio Salado College, part of the Maricopa County Community College District (MCCCD), began offering technician training in the field of nanotechnology in late 2016. This recently-launched program is a unique community-college offering, specifically within the MCCCD group, and it originated after Rio representatives attended a Nano workshop at Penn State University.

I. Degrees and Certificates in the Nanotechnology Program

Program Title: CCL in Nanotechnology
Major Code: 5840
Total Credits: 18

Description: The Certificate of Completion (CCL) in Nanotechnology program is designed to provide students with the general principles and foundational skills in the micro/nano-fabrication industry and related manufacturing industries. Students will become familiar with nanotechnology processes, materials, and methods for characterization and fabrication. Product stewardship, occupational safety and health procedures are emphasized throughout the program. An Associate in Applied Science (AAS) in Nanotechnology is also available.

Program Notes:
Students must earn a grade of C or better in all courses within the program.

Admission Criteria:
A high school diploma or GED equivalency is required.
Formal application and admission to the program is required.

Required Courses:		**18**
MNT201	Materials, Safety and Equipment for Nanotechnology	3
MNT210	Basic Nanotechnology Processes	3

	MNT220	Materials in Nanotechnology	3
	MNT230	Patterning for Nanotechnology	3
	MNT240	Nanotechnology Applications	3
	MNT250	Characterization of Nanotechnology Structures and Materials	3

Program Title: AAS in Nanotechnology
Major Code: 3168
Total Credits: 62

Description: The Associate in Applied Science (AAS) in Nanotechnology program is designed to provide students with the general principles and foundational skills in the nano/micro-fabrication industry and related manufacturing industries. Students will become familiar with nanotechnology processes, materials, and methods for characterization and fabrication. Product stewardship, occupational safety and health procedures are emphasized throughout the program. A Certificate of Completion (CCL) in Nanotechnology is also available

Program Notes:
Students must earn a grade of C or better for all courses required within the program.
+ indicates course has a prerequisite and/or corequisites.
++ indicates any suffixed courses.

Required Courses:			**18**
Certificate of Completion in Nanotechnology (5840)			18
Restricted Electives:			**17-22**
	BPC110	Computer Usage and Applications (3) OR	
	CIS105	Survey of Computer Information Systems (3)	3
+	ECE102	Engineering Analysis Tools and Techniques	2
+	ECE103	Engineering Problem Solving and Design	2
+	MNT110	General Principles of Nanotechnology	3
+	MNT120	Introduction to Micro Electro-Mechanical Systems	3
+	PHY111	General Physics I	4
	CIS+++	Any CIS Computer Information Systems course	1-8
	CSC+++	Any CSC Computer Science course	1-8
General Education Requirements			**22-27**

General Education Core **12-17**

First-Year Composition **6**

+	ENG101	First-Year Composition (3) OR
+	ENG107	First-Year Composition for ESL (3) AND
+	ENG102	First-Year Composition (3) OR
+	ENG108	First-Year Composition for ESL (3)

Oral Communication **3**

	COM100	Introduction to Human Communication (3)

Critical Reading **0-3**

+	CRE101	College Critical Reading and Critical Thinking (3) OR
	Equivalent as indicated by assessment	

Mathematics **3-5**

+	MAT151	College Algebra / Functions (4) OR
+	MAT182	Plane Trigonometry (3) OR
+	MAT187	Precalculus (5) OR
	Satisfactory completion of a higher level mathematics course	

General Education Distribution **10**

Humanities, Arts and Design **3**

	HIS+++	Any HIS History course in the Humanities, Arts and Design area (3) HIS102 is recommended.

Social-Behavioral Sciences **3**

	ECN212	Microeconomic Principles (3)

Natural Sciences **4**

+	CHM130	Fundamental Chemistry (3) AND
+	CHM130LL	Fundamental Chemistry Laboratory (1)

II. Program Purpose and Mission

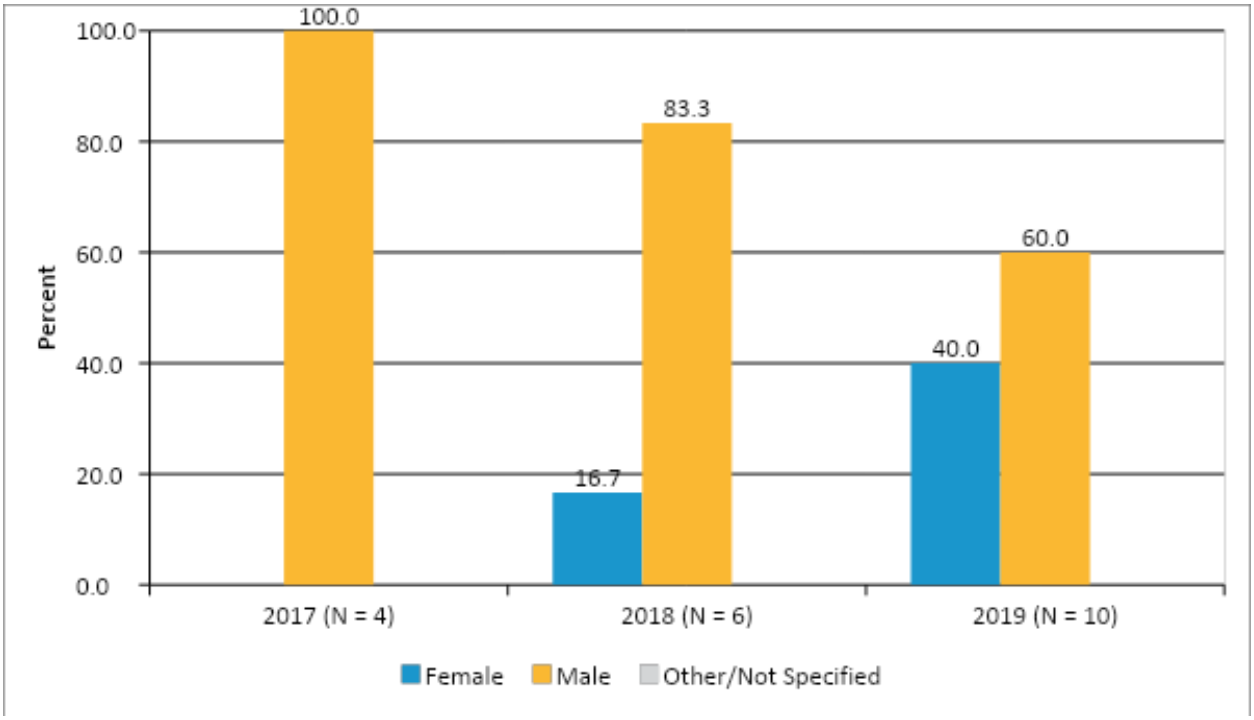
The Nanotechnology program is designed to provide students with the general principles and foundational skills in the micro/nano-fabrication industry and related manufacturing industries. Students will become familiar with nanotechnology processes, materials, and methods for characterization and fabrication. Product stewardship, occupational safety and health procedures are emphasized throughout the program.

Through flexible starts and virtual lab opportunities, the Nanotechnology Program directly supports the College's mission to "transform the learning experience through: Customized, high-quality courses and programs; and …Flexibility, affordability, and innovation."

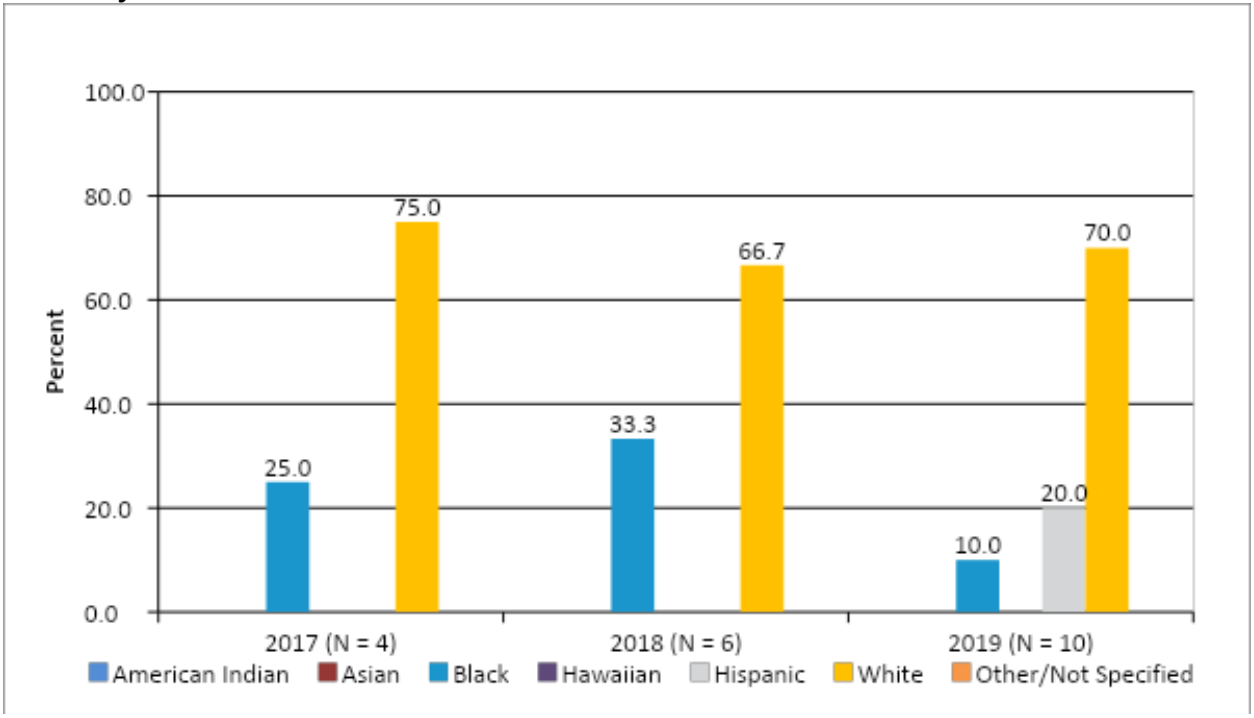
III. Student Population of the Nanotechnology Program

a. Student Data Analysis

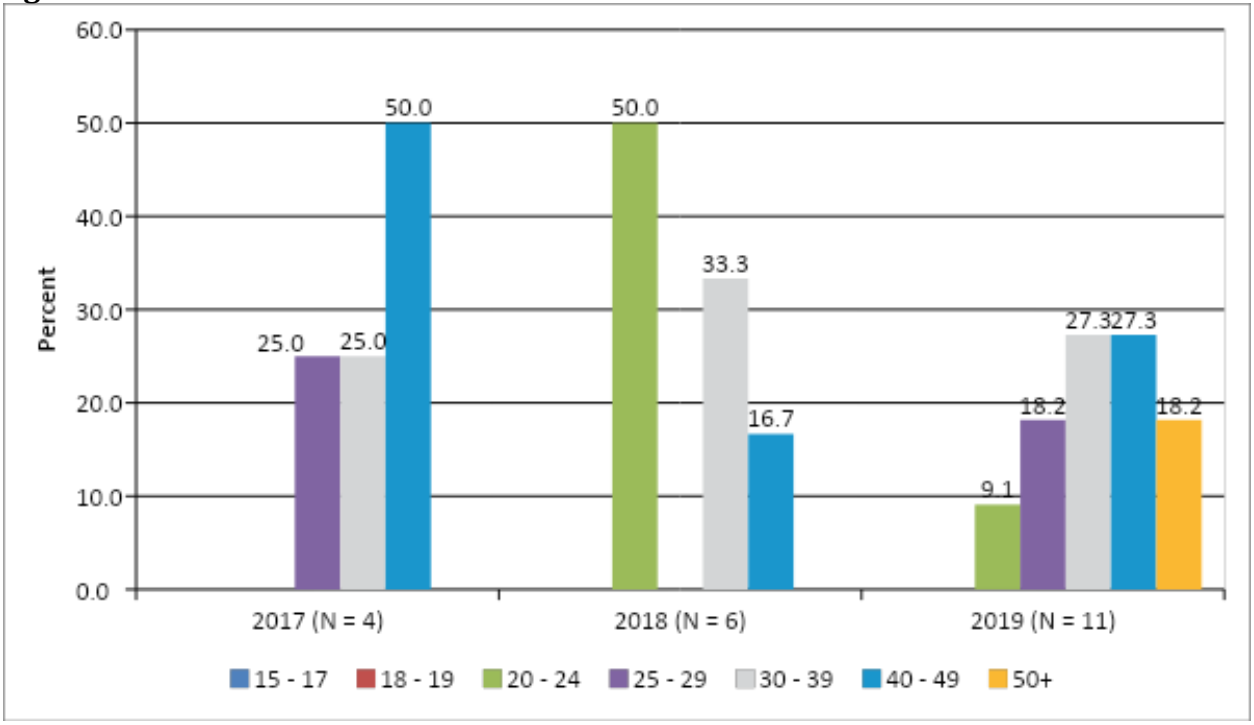
Gender Trends



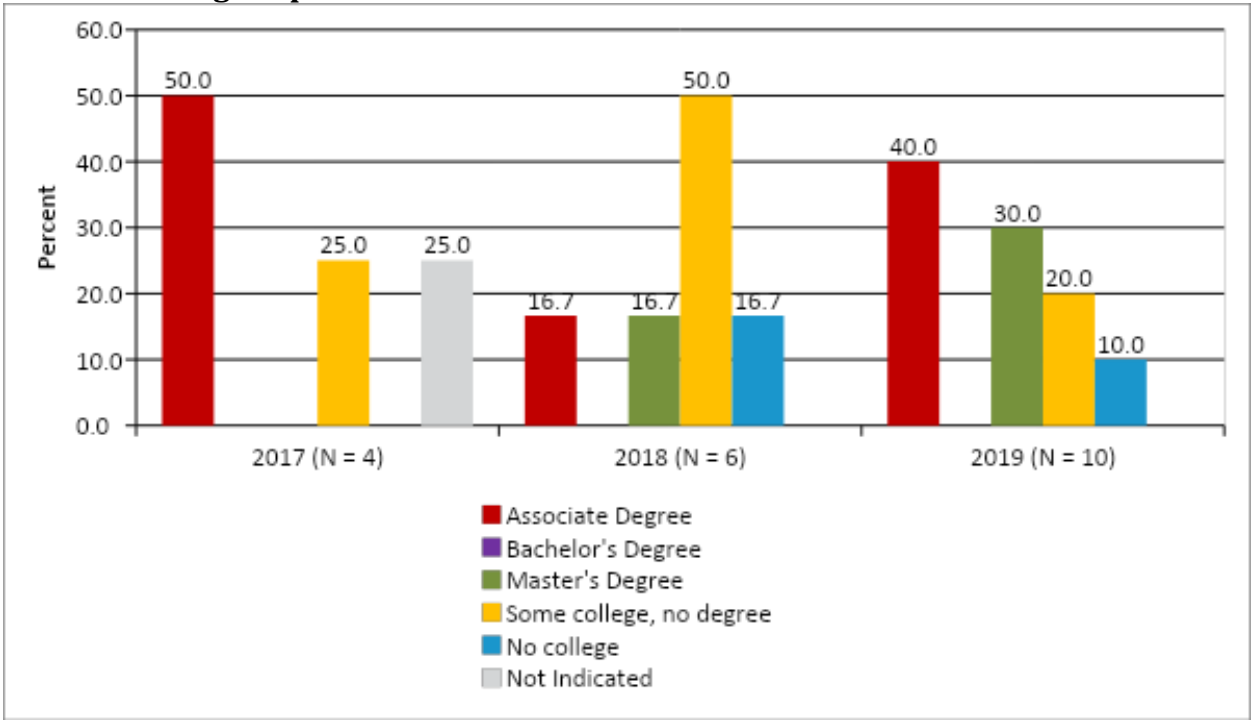
Ethnicity Trends



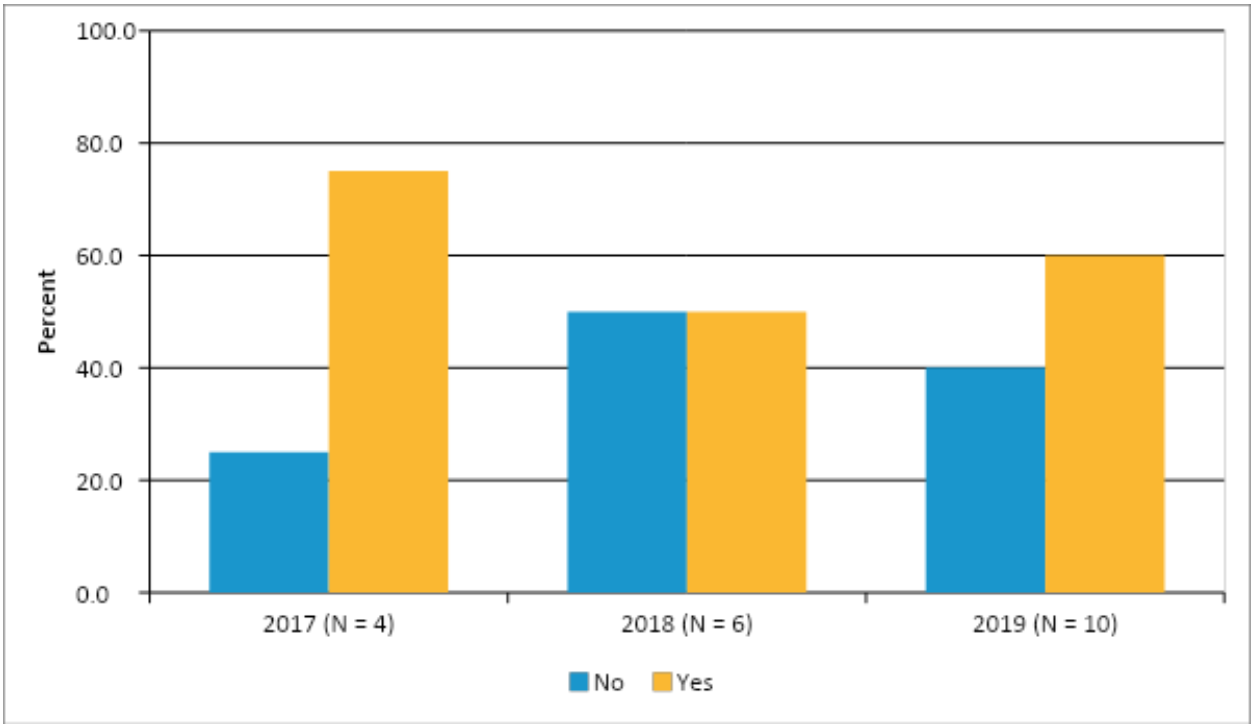
Age Trends



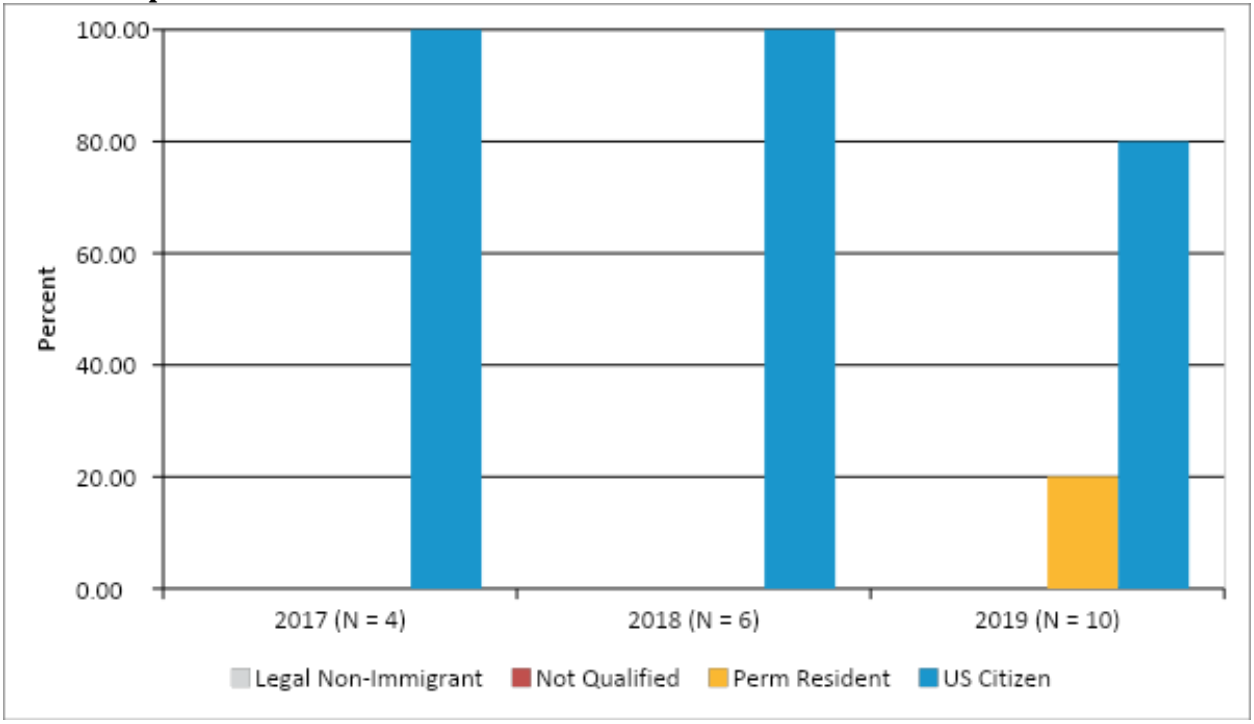
Previous College Experience Trends



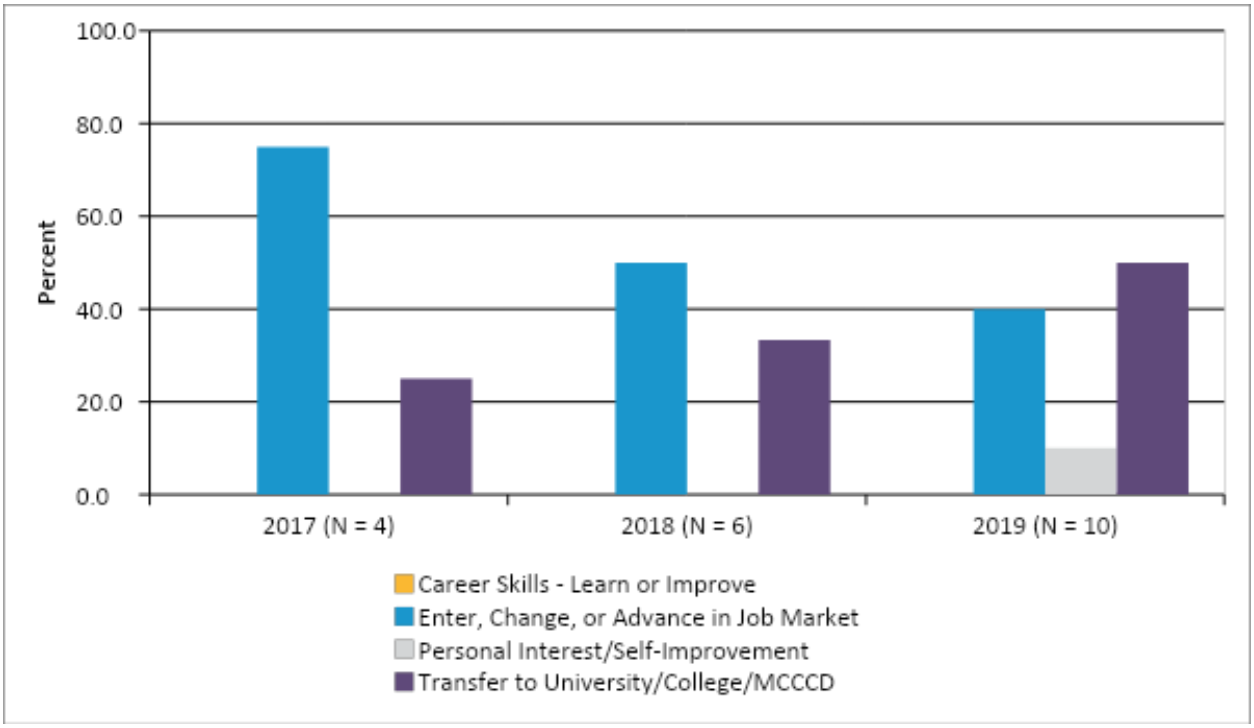
First Generation Trends



Citizenship Trends



Current Intent Trends



We currently serve a mostly white, male population seeking to enter, change, or advance in the job market. We are recruiting more underserved, racial minority, and female populations through our industry and community outreach efforts. For example, we are working on a partnership with Adult Basic Education for ABE/GED student pathways. We also have a commitment from Medtronic (see letter in Addendum section) to provide a local manager to serve on the Industry Advisory Board, to provide work-like experiences and internships, to provide access to Rio students to their labs and work spaces, to interview program graduates, and to present information at career fairs to assist with recruiting.

b. Enrollment Trends

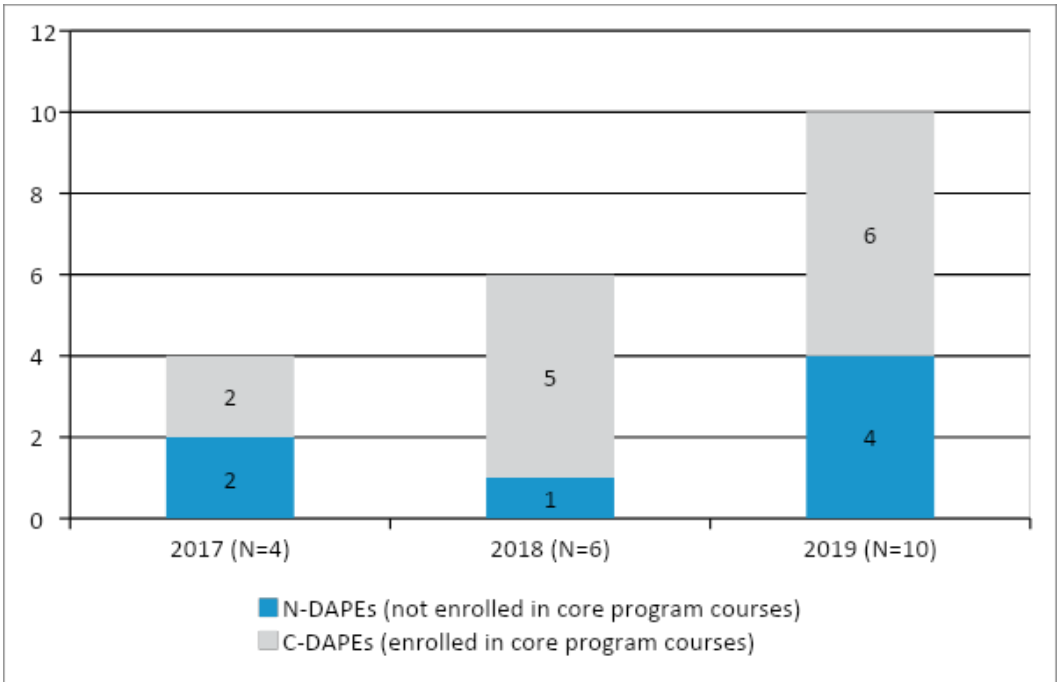
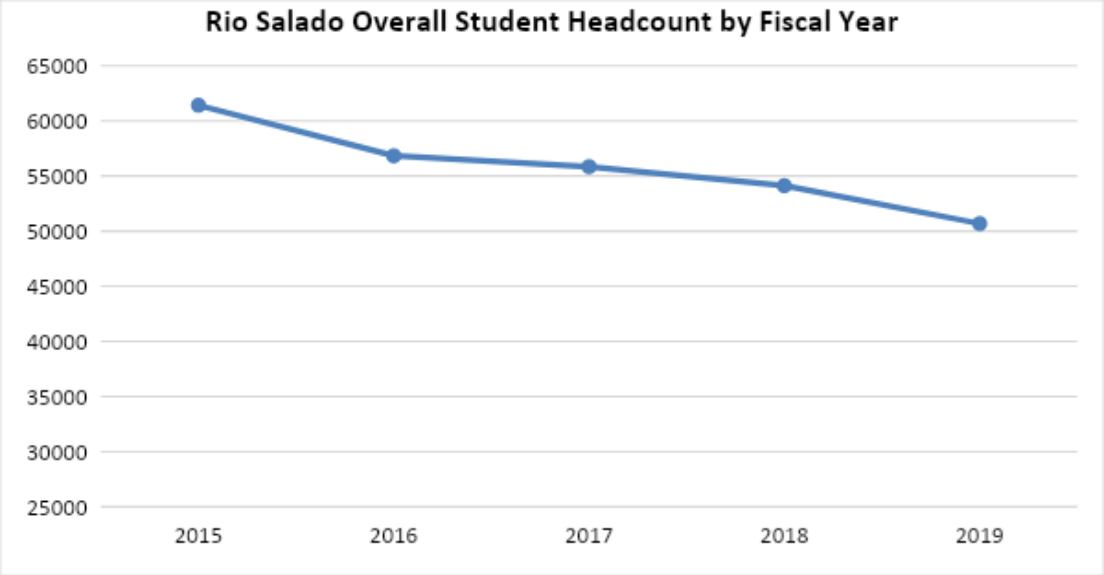


Table 1. FTSE by Year - Nanotechnology			
	2017	**2018**	**2019**
C-DAPEs (Declared Academic Plan /Enrolled in Core Program Courses)	0.50	1.00	2.40



The program is slowly growing, even during these recent years of overall College decline. It is important to note that MNT250 was not developed until 2017. Although students could enroll in the program, they had to get a waiver for the class up until that time.

In Summer and Fall of 2018, Rio contracted with LaneTerralever for a marketing campaign. The company produced some high-quality assets targeting students in Maricopa County, including:

- Undeclared students (those who have not chosen a University or Major yet)
- Concurrent enrollment – students with an interest in science or technology who want to take nanotechnology courses while still in high school
- Undeclared students at Rio Salado College or at other MCCCD campuses.
- Current and former military prospects
- Displaced/Placed corporate workers – typically with some type of technician background or experience in a clean room who would like to further their careers

The assets were deployed via a brief social media campaign. Though this effort generated leads, they did not result in significant increases in enrollment. Program-specific advisors would call potential leads, but very few responded to those calls. Renewed marketing efforts are discussed in section XI.

Table 2. Top Course Enrollments Trended - Nanotechnology			
Course	**2017**	**2018**	**2019**
MNT201-HY	2	4	4
MNT210-HY	1	4	4
MNT220-HY	1	0	4
MNT230-HY	1	1	4
MNT240-HY	0	1	4
MNT250-HY	0	1	4
Total-	5	11	24
Note: Top 5 courses by highest enrollment count each year are highlighted in yellow.			

Though each course is trending in the right direction, it is difficult to identify trends since this is a new program with a small dataset.

c. Student Graduation Data

Table 3. Cohort Graduation Rates - Nanotechnology CCL						
				FY Award Conferred		
				2017	2018	2019
Total Graduates[1]				0	2	4
FY Cohorts[2]	Cohort (N)	Conferred Award(N)	% Conferred Award			
2017	3	1	33.3%	1	0	0
2018	3	0	0.0%	0	0	0
2019	2	2	100.0%	0	2	0

[1]Reports the total number of graduates without cohort classification constraints. [2]Cohort created based on first FY that student declared the academic plan. Cohort created to compute approximate graduation rates; however, for programs with small numbers (Cohort <50), rates are subject to high degrees of variability and should not be used for making inferences. Cohorts will not be identical in size to those created for persistence, which is based on term with summer terms modified.

Table 4. Cohort Graduation Rates - Nanotechnology AAS

				FY Award Conferred		
				2017	2018	2019
Total Graduates[1]				0	1	1
FY Cohorts	Cohort(N)	Conferred Award(N)	% Conferred Award			
2017	0	0	NA	0	0	0
2018	1	1	100.0%	0	0	1
2019	3	2	66.7%	0	0	2

[1]Reports the total number of graduates without cohort classification constraints. [2]Cohort created based on first FY that student declared the academic plan. Cohort created to compute approximate graduation rates; however, for programs with small numbers (Cohort <50), rates are subject to high degrees of variability and should not be used for making inferences. Cohorts will not be identical in size to those created for persistence, which is based on term with summer terms modified.

IV. Student Goals

As seen in the Current Intent Trends chart on page 10, most students have a goal of career advancement. As a workforce program the declared intent is to produce technicians for the Nanotechnology and related industries. The graduates we have been able to track are working in related jobs (and/or follow-up schooling), including:

- Production Technician at Cantel Medical
- Grad school at Johns Hopkins
- Arizona State University - Chemical Engineering BS
- Learning Designer Associate at Arizona State University (turned down an offer from Intel for Manufacturing Tech)
- Pursuing on line BS Eng Applied Electronics at NMSU
- Intel Manufacturing Tech

- Serial Entrepreneur bringing a Nano product to market (2 weeks from Program Completion)
- Process Tech likely to be promoted to Process Eng Tech at end of program (2 weeks from completion)

Are students in your program satisfied with the program? How is student satisfaction assessed?

Students are sent the following questions at the end of the course to evaluate their instructor:

1. My instructor communicated the course policies and procedures.
2. My instructor communicated his/her expected response time for messages and grading assignments.
3. My instructor responded to messages within the stated time frame.
4. My instructor graded assignments within the stated timeframe.
5. My assignment feedback explained why I earned or lost points.
6. My instructor's feedback on assignments helped to increase my understanding of the course content.
7. My instructor provided complete responses to my question

Table 5. Distance End-of-Course Evaluation Data

						Number of Surveys	34
Course	Q1	Q2	Q3	Q4	Q5	Q6	Q7
MNT201	4.88	4.88	5.00	5.00	4.88	4.88	5.00
MNT210	4.88	4.88	4.88	4.88	4.88	4.75	4.88
MNT220	4.88	4.88	5.00	4.88	4.88	4.88	4.88
MNT230	4.33	3.67	4.33	4.33	4.00	3.67	4.00
MNT240	4.50	4.50	4.50	4.50	4.50	4.50	4.50
MNT250	4.50	4.75	4.75	4.50	4.75	4.75	4.75
Total	4.76	4.73	4.85	4.79	4.76	4.70	4.79

Scale information: 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree

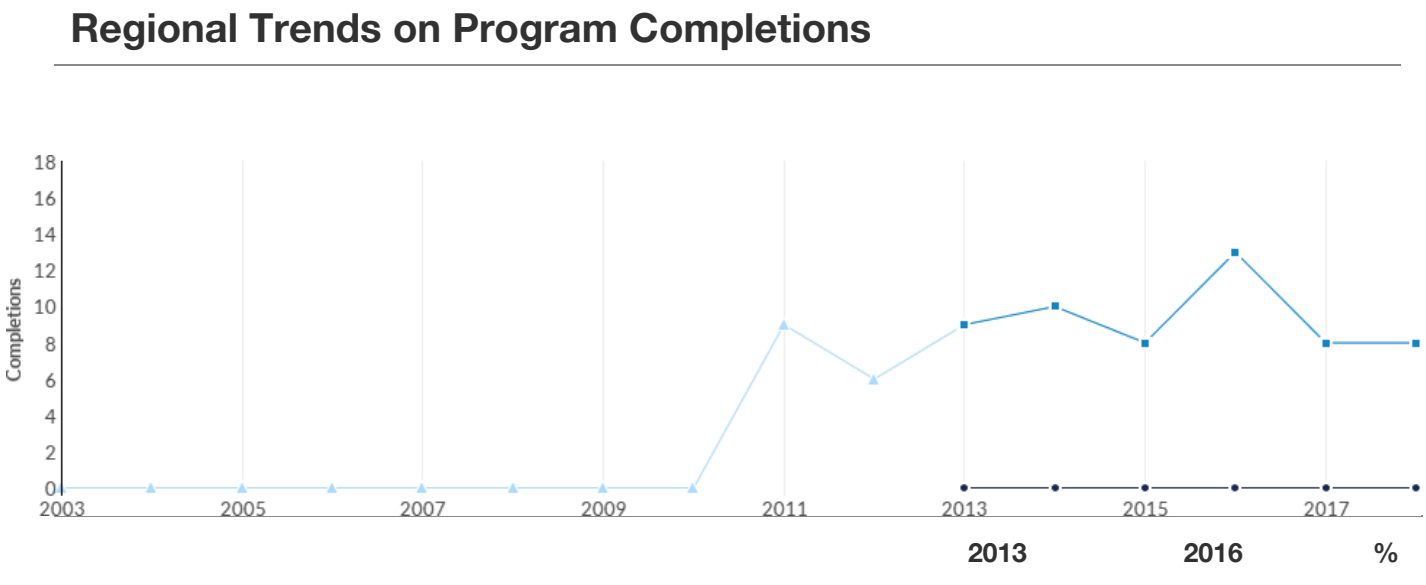
Overall, student feedback is quite positive. The two areas with room for improvement are communication of expectations and quality of feedback in MNT230. Adjuncts have received specific training to address these issues.

V. Evaluation of Curriculum

As noted in the introduction, the program originated after a workshop at Penn State University. A feasibility study was conducted and an industry advisory board (IAB) created. At the first IAB meeting, the curriculum was affirmed as relevant and timely.

The composition of the original IAB was educator-heavy and industry-light. During the first three years, we have slowly migrated to include more industry representatives. Based on industry recommendations, we have applied for a grant to align the curriculum with four new industry workforce certificates from the American Society of Testing and Materials (ASTM). This consolidation will provide a new focus in the areas of optics and photonics, two areas of interest for our partner, Medtronic.

Program improvements have been extensive. Rio Salado's Nanotechnology Program in general, and their labs specifically, benefited from the *Research Experience for Teachers* program and Prop 301 funding in AY18-19. Since industry feedback indicated that the labs needed to reflect work that students (potential employees) could perform, the courses were updated to ensure the students learned skills that could be communicated to industry during their interviews. Additionally, the online labs were updated with numerous changes during this time. Each lab includes a statement that the student can use to explain how their training translates to relevant job skills, such as fabrication and characterization tools and processes.



		Completions	Completions	Change
●	Distance Offered Programs	0	0	0.0%
●	Non-Distance Offered Programs	9	8	-11.1%
●	All Programs	9	8	-11.1%

(Data from Rio Salado College and Arizona State University)

VI. Student Learning Outcomes

CCL in Nanotechnology Competencies:

1. Examine safety procedures and equipment used in the nanotechnology industry. (MNT201)
2. Compare and contrast classification procedures for materials in the nanotechnology industry. (MNT201, MNT220)
3. Describe manufacturing concerns in the nanotechnology industry. (MNT210, MNT220)
4. Compare and contrast nanotechnology manufacturing processes. (MNT210, MNT220, MNT230, MNT240)
5. Compare and contrast various types of patterning processes. (MNT210, MNT230)
6. Explain properties of colloids and self-assembly materials. (MNT220)
7. Describe photolithography techniques, technology and tools. (MNT230)
8. Explain photoresist applications. (MNT230)
9. Compare and contrast product and research trends in nanoscience and nanotechnology. (MNT240)
10. Examine applications for nanotechnology in the health science, energy, manufacturing, electronics, food, and environmental industries. (MNT240)
11. Review characterization tools and techniques for nanotechnology structure and materials. (MNT250)
12. Compare and contrast types of electron beam characterization tools and procedures. (MNT250)
13. Examine tools and processes for advanced Scanning Probe Microscopy (SPM). (MNT250)

AAS in Nanotechnology Competencies:

1. Examine safety procedures and equipment used in the nanotechnology industry. (MNT201)

2. Compare and contrast classification procedures for materials in the nanotechnology industry. (MNT201, MNT220)
3. Describe manufacturing concerns in the nanotechnology industry. (MNT210, MNT220)
4. Compare and contrast nanotechnology manufacturing processes. (MNT210, MNT220, MNT230, MNT240)
5. Compare and contrast various types of patterning processes. (MNT210, MNT230)
6. Explain properties of colloids and self-assembly materials. (MNT220)
7. Describe photolithography techniques, technology and tools. (MNT230)
8. Explain photoresist applications. (MNT230)
9. Compare and contrast product and research trends in nanoscience and nanotechnology. (MNT240)
10. Examine applications for nanotechnology in the health science, energy, manufacturing, electronics, food, and environmental industries. (MNT240)
11. Review characterization tools and techniques for nanotechnology structure and materials. (MNT250)
12. Compare and contrast types of electron beam characterization tools and procedures. (MNT250)
13. Examine tools and processes for advanced Scanning Probe Microscopy (SPM). (MNT250)

Many of these outcomes have been translated into the résumé bullets below that students can use upon the completion of the labs:

- "I am familiar with the safety equipment and protocol in the Fabrication cleanroom".
- "I have a beginner's understanding of vacuum systems and have tracked gauges (to understand how vacuum is created), I have performed leak checks, and manipulated system pressure with a mass flow controller."
- “I have used a profilometer and ZeMaps software to capture images of multiple rough oxide samples to determine 5x+ and 5x-, Sa, and Sq for every sample, and created a lab report that expressed each for four samples. Additionally, I have used an ellipsometer to measure data; build a Cauchy model; fit the data; and analyze the data of multiple/varying oxide thicknesses.”
- “I have set up a sample to be sputtered, achieved a vacuum, struck a plasma, sputtered a sample, and brought the tool back to the atmospheric pressure."
- “Given various forms of wafer etching characteristics of multiple materials, I have analyzed etching data and calculated dry etch rates.”
- “Given data obtained during the characterization steps throughout the lift-off process, I can describe the lift-off process, and determine the influence of a lift-off photoresist on feature quality by analyzing the data.”
- “I can explain the procedures necessary to perform contact lithography; and describe the advantages and disadvantages of Contact Printing; Proximity Printing; and Projection Printing.”

- "I had the opportunity to research the three main types of PVD, and can describe each and can describe which thin film characterization techniques can be used to measure the physical properties of PVD coatings."
- "Based on the data obtained in a virtual lab, I was able to analyze and determine which ligands formed the most successful Self Assembling Molecules on aluminum and gold surfaces."
- “I have investigated surface mobility properties and analyzed surface nucleation as a result of heat treatment.”
- “I have simulated operating the Lindberg tube furnace to analyze data from an oxide color chart, the Fick’s law chart, and an oxidation process chart.”
- “I have operated a Reactive Ion Etcher to process and characterize a wafer to obtain etch data and calculate etch rates.”
- “I can explain the procedures necessary to perform contact lithography; and describe the advantages and disadvantages of Contact Printing; Proximity Printing; and Projection Printing.”
- “I have used an online lab to simulate an exercise that uses photolithography to create a master mold.”
- “I have used an online lab to simulate using a PDMS stamp to print a thiol-based self-assembled monolayer onto selected areas of a gold film”
- “I can describe the fabrication issues involved with microfluidic devices, the fabrication process of PMDS microfluidic devices, and identify the applications of hydrostatic transport of a liquid media.”
- “Because of my participation in a virtual lab, I can demonstrate the procedures necessary to fabricate a photochemical cell, and explain how to characterize the photochemical cell using current and voltage measurements.”
- “I have created silver nano wires and can explain how to choose the tools utilized to characterize nano wires.”
- “I have created conductive silver nanogrids on glass and can explain how to choose the tools utilized to characterize silver nanogrids on glass.”
- “I have utilized an optical profilometer to create trace color 2D and 3D images and reported step height measurements.”
- “I have prepared TEM samples, understand how to set up a TEM, and have taken pictures of both dark and light field operations.”
- “I have mounted samples, optically imaged them, and manually operated a SEM to perform magnification, focus, brightness and contrast functions. I have measured and captured images of features on a sample.”
- “I can describe the fundamentals of noncontact and intermittent-contact Atomic Force Microscopy.”
- “I am familiar with the Veeco SPMLab image analysis/processing software.”
- “I am familiar with magnetic force (MFM) and scanning tunneling microscopy (STM).”

In addition to these skills, graduates are prepared to pass certification from ASTM in Safety and Characterization methods. Certifications in Fabrication and Material Properties are forthcoming.

Program-level learning outcomes

The final exams in each course are comprehensive and aligned with the program outcomes as detailed above. The department uses final exam results to measure program outcomes.

Class	Program Outcomes	Final Exam Average
MNT201	1, 2	94.4
MNT210	3, 4, 5	93.4
MNT220	2, 3, 4, 6	91
MNT230	4, 5, 7, 8	98
MNT240	4, 9, 10	72
MNT250	11, 12, 13	88

After conducting item analysis, questions missed by more than 50% of students are reviewed for accuracy and possible updates. In the case that a question is valid, but still missed more than 50% of the time, the lead faculty meets with the Chair to discuss teaching and additional resources to help the students be more prepared. During the latest review, several questions were selected for analysis:

Course	Number of Questions for Analysis
MNT201	6
MNT210	5
MNT220	4
MNT230	1
MNT240	14
MNT250	5

The analysis revealed that improvements need to be made in the students' ability to:

- Compare and contrast (advanced) nanotechnology manufacturing processes;
- Compare and contrast product and research trends in nanoscience and nanotechnology; and
- Examine applications for nanotechnology in the health science, energy, manufacturing, electronics, food, and environmental industries.

These issues will be addressed in the curricular revisions detailed in the Recommendations section.

College-Wide Student Learning Outcomes

In addition to the program-level outcomes addressed above, Rio Salado College places a high priority on developing core competence in the following areas:

1. **Critical Thinking:** The student will demonstrate the ability to analyze information, evaluate material, use inference to draw conclusions, and use deductive reasoning and inductive reasoning at a college level
2. **Information Literacy:** The student will demonstrate the ability to determine an information need, access successfully and evaluate critically the needed information, and organize and apply the information appropriately to accomplish a given research task.
3. **Oral Communication:** The student will demonstrate the ability to prepare and present oral communication in a variety of contexts as a college-level speaker.
4. **Reading:** The student will demonstrate the ability to comprehend a variety of materials by determining the central idea and providing textual evidence, drawing inferences or valid conclusions, analyzing the author's purpose and bias, and applying the text to a given task or course content.
5. **Writing:** On a written assignment, the student will demonstrate the ability to generate relevant and sufficient content; organize his or her thoughts coherently; adhere to the conventions of correct mechanics and sentence structure; and use correct terminology and rich vocabulary in the fulfillment, at the college level, of his or her writing assignments.

For more information: http://www.riosalado.edu/about/teaching-learning/assessment/Pages/SLO.aspx

Oral assignments were recently incorporated into all six of the 200-level MNT courses including MNT201, MNT210, MNT220, MNT230, MNT240, and MNT250. Students must deliver an oral report summarizing their learning and specifically what they can apply in the workforce. Previously, the grading rubric did not have the appropriate naming conventions to facilitate data collection. As of Fall 2020, the rubric is being revised so that data collection can begin in Spring 2021.

New weekly writing prompts ask the students to compare and contrast what they learned with research about key words from the lesson. These new assignments will be added to the classes

in Spring 2021 and Rio Learning Outcome Grant (RioLOG) funding is currently being used to pay the lead adjunct faculty member to create custom rubrics aligned with the written communication and critical thinking learning outcomes. This work will be completed in Spring 2021 with data collection targeted for Summer 2021.

College-Wide Student Learning Outcomes are discussed in the STEM department meetings twice a year. Beginning Spring 2021, we will be able to add data from the MNT courses to inform these conversations.

In preparation for the Fall 2021 STEM department meeting, baseline data will be pulled, areas for improvement identified, and RioLOG funding offered to subject matter experts to initiate PDCA cycles as necessary.

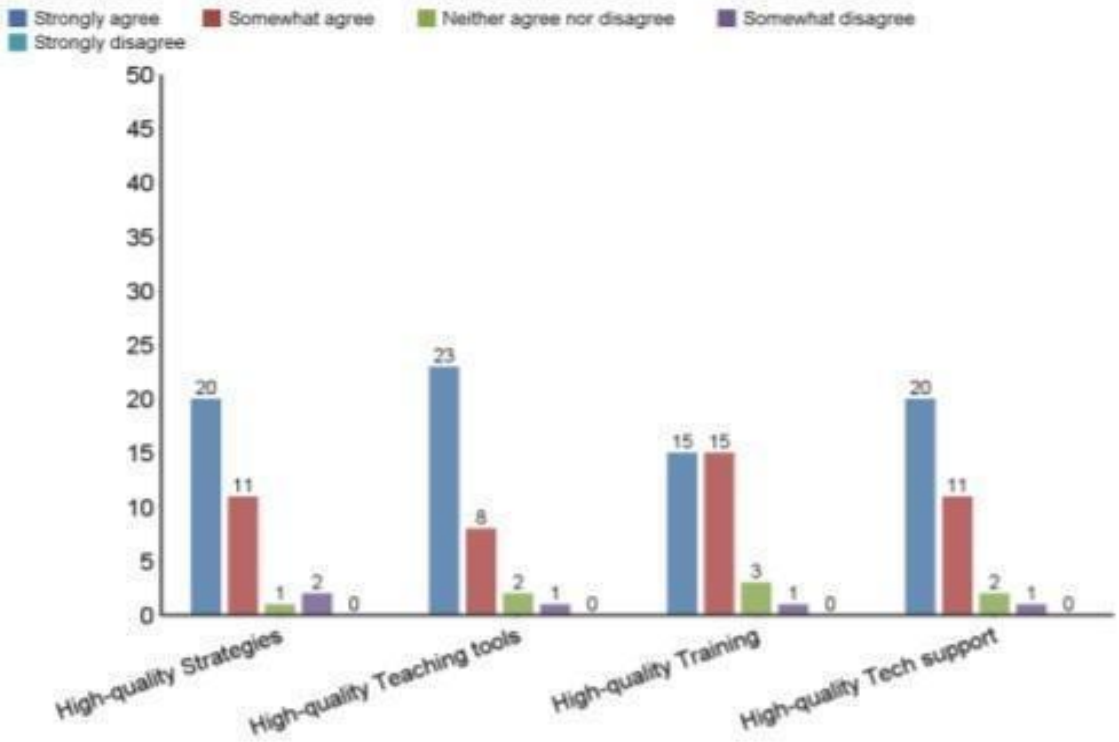
VII. Effective Teaching

The key pieces of evidence of effective teaching are the outstanding teacher evaluations detailed earlier and low turnover rate of adjunct in Nanotechnology. In all the years of the program, we have not lost a single faculty member by choice or for poor performance. We are bringing one new adjunct on board in 2020 to diversify the cohort of instructors.

The STEM faculty meet twice a year during the All-Faculty meetings for training on effective teaching strategies. All new faculty are required to complete AFD101 and are strongly encouraged to complete additional AFD courses. Faculty are invited to professional conferences, mostly regionally, but occasionally on the national level. For example, two of our adjuncts participated in Nanotechnology training at Penn State and again at ASU and the Southwest Center for Microsystems Education (SCME) in Albuquerque.

Additional data from the 2018-19 annual adjunct faculty survey highlight the effectiveness of the teaching environment:

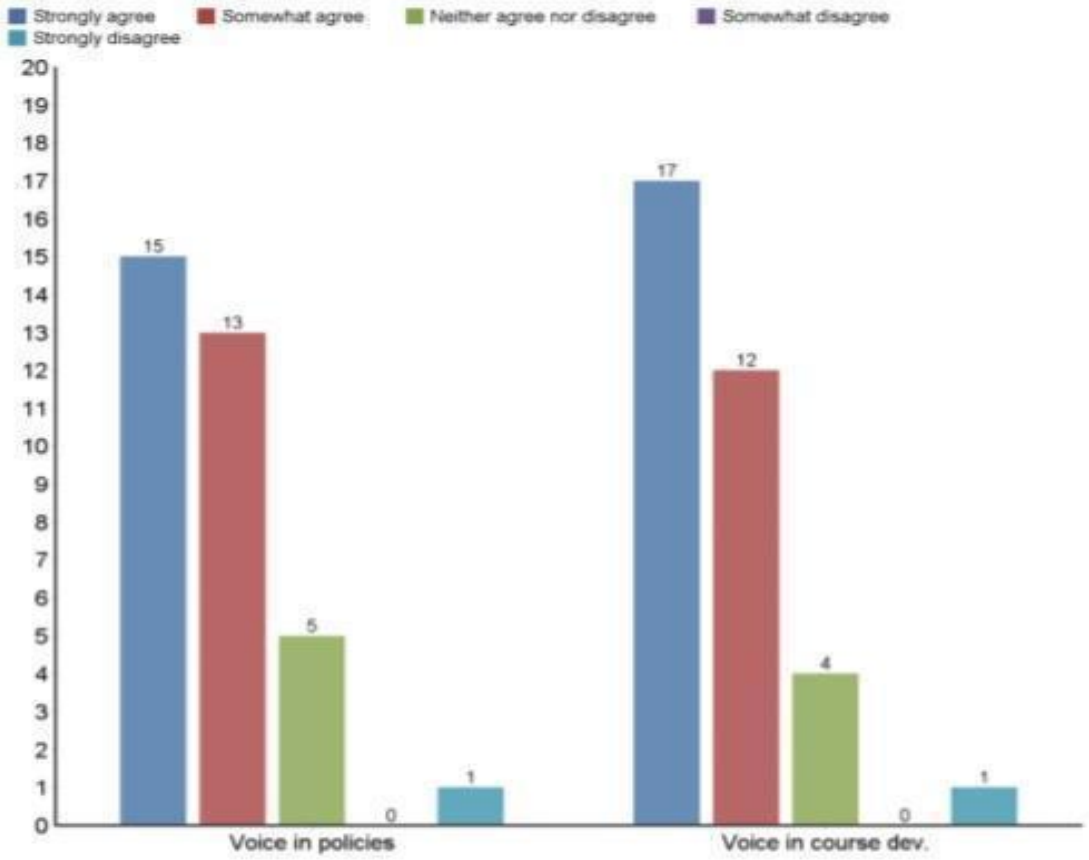
Faculty Teaching Support



#	Question	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
1	Rio Salado provides me with high quality Teaching strategies	58.82%	32.35%	2.94%	5.88%	0.00%
2	Rio Salado provides me with high quality Teaching tools.	67.65%	23.53%	5.88%	2.94%	0.00%
3	Rio Salado provides me with high quality Training.	44.12%	44.12%	8.82%	2.94%	0.00%
4	Rio Salado provides me with high quality Technical support.	58.82%	32.35%	5.88%	2.94%	0.00%

Statistic	Mean	Standard Deviation	n
Rio Salado provides me with high quality Teaching strategies	4.44	0.82	34
Rio Salado provides me with high quality Teaching tools.	4.56	0.75	34
Rio Salado provides me with high quality Training.	4.29	0.76	34
Rio Salado provides me with high quality Technical support.	4.47	0.75	34

Faculty Development



#	Question	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
1	I have a voice in the development of policies and procedures within my department.	44.12%	38.24%	14.71%	0.00%	2.94%
2	I have a voice in course development within my department.	50.00%	35.29%	11.76%	0.00%	2.94%

Statistic	Mean	Standard Deviation	n
I have a voice in the development of policies and procedures within my department.	4.21	0.91	34
I have a voice in course development within my department.	4.29	0.91	34

VIII. Retention and Persistence

Table 6. Aggregate Course Success and Retention Rates Nanotechnology					
2017		2018		2019	
Course Retention	Course Success	Course Retention	Course Success	Course Retention	Course Success
*	*	81.8%	81.8%	100.0%	84.6%

Note: Course Success = Grade A,B,C,P. Course Retention = Grade A,B,C,D,F,P.

Data show a high level of retention. Much of this can be attributed to the personal hands-on coaching of the faculty in the program, who not only support students, but encourage them to enroll in subsequent courses. Student Notes are used in RioLearn to communicate with students who are falling behind, performing poorly, or failing to log-in on a regular basis. Common announcements inform students about the next courses in the sequence and encourage retention. Additionally, students are contacted directly by the lead faculty for job opportunities, workshops (e.g. Pressure Sensor Workshop in Albuquerque), and other relevant, but ad hoc announcements. These personal touches help us retain our students at such a high rate.

Table 7. (C-DAPES) Persistence for Following Term and Following Year - Nanotechnology CCL			
Cohort Term Start	Cohort (N)	% Persist to Following Term	% Persist to Following Year
4186	3	100.0%	0.0%
4196	1		
Total	4	100.0%	0.0%

Notes. Cohort determined as first term that a student declared the academic plan and took core course during review period. Course taking activities in summer term are rolled up into the next Fall term. Persistence to next term is Fall to Spring or Spring to Fall. Persistence to next year is Fall to Fall or Spring to Spring. % Persistence excludes graduates (Term Enrollees/(Initial Cohort - Grads to date).

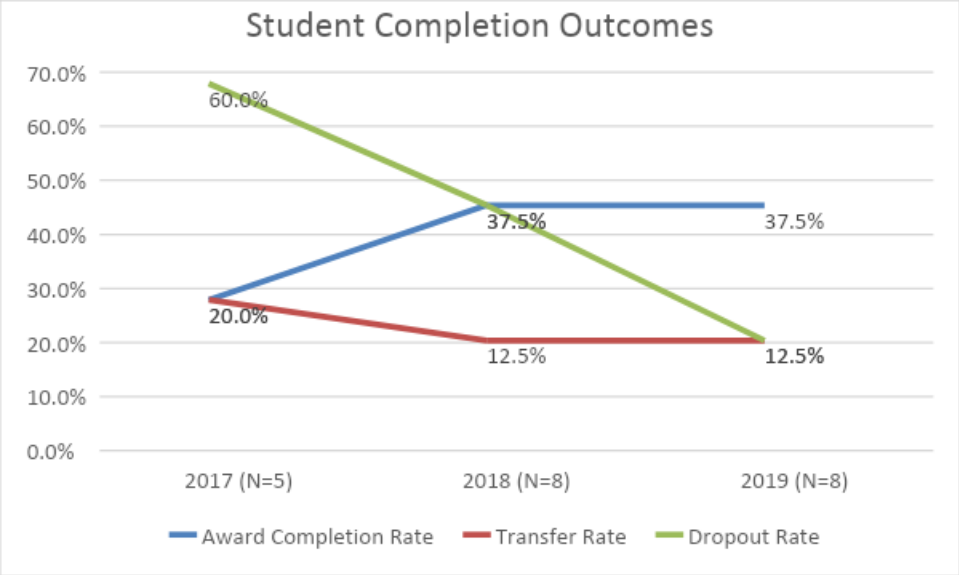
Table 8. (DAPES) Persistence for Following Term and Following Year - Nanotechnology Associate			
Cohort Term Start	**Cohort (N)**	**% Persist to Following Term**	**% Persist to Following Year**
4166	1	0.0%	0.0%
4172	2	100.0%	50.0%
4182	3	0.0%	0.0%
4186	4	50.0%	25.0%
Total	10	50.0%	20.0%

Notes. Cohort determined as first Fall or Spring term that a student declared the academic plan based on this review period. Course taking activities in summer term are rolled up into the next Fall term. Persistence to next term is Fall to Spring or Spring to Fall. Persistence to next year is Fall to Fall or Spring to Spring. % Persistence excludes graduates (Term Enrollees/(Initial Cohort - Grads to date).

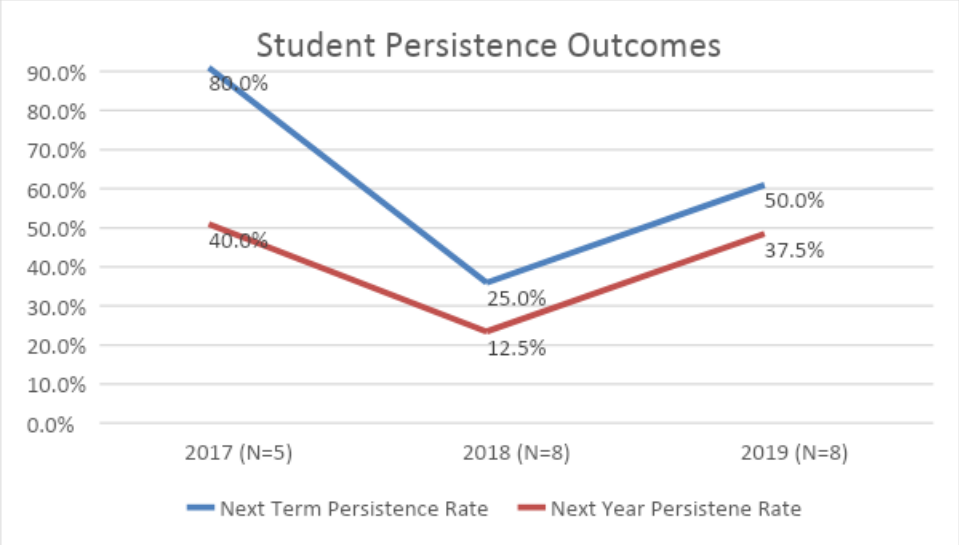
The N's here are really too small to make high quality decisions about persistence trends. There does not seem to be a pattern emerging from these historical data. In addition, almost all of the students to date have opted to complete the CCL rather than the AAS pathway. Most can complete the certificate in a year, so we would not expect a high year-to-year persistence rate for this population.

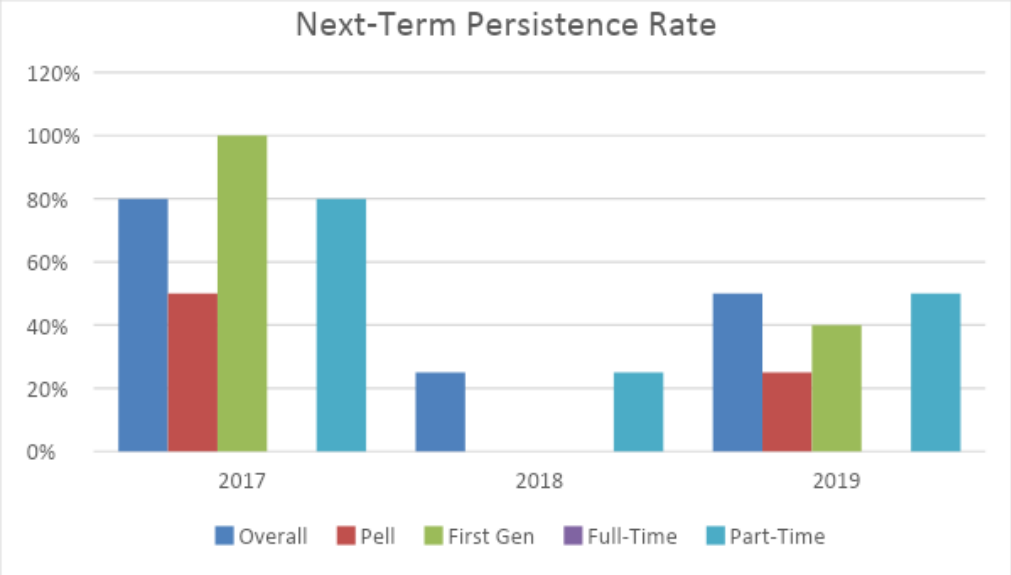
Additional Student Outcomes Analysis

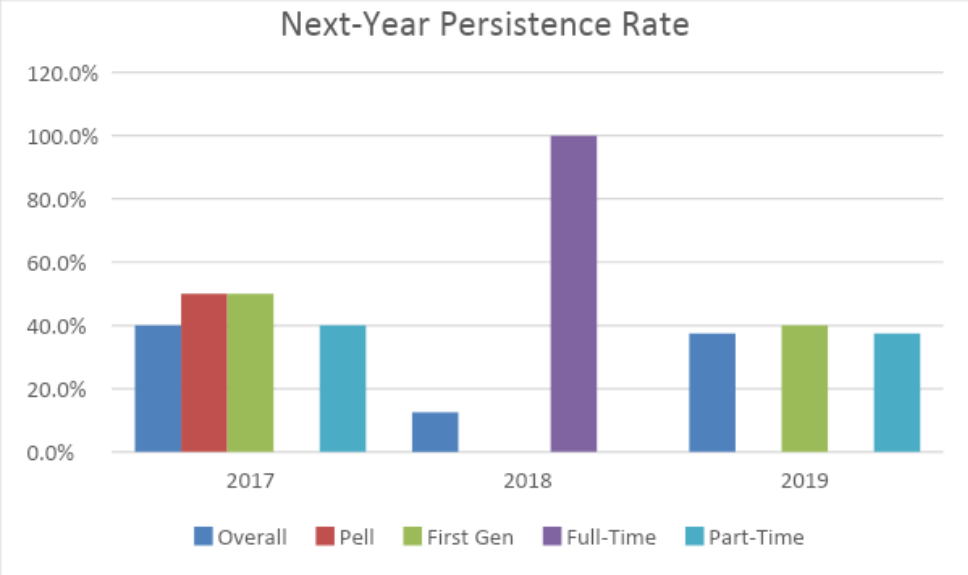
The charts below provide analysis of student early momentum and outcomes in their program(s). Cohorts were created based on first FY that student declared the academic plan and will not be identical in size to those used to track DAPES, which are based on total student enrollment in a given year. Award Completion Rate is total number of students completing the declared award out of the full cohort. Transfer Rate is total number of students enrolled in another institution of higher education after declaring the program in review at RSC. Dropout Rate is total number students who did not complete the program, did not transfer to another institution, and are no longer enrolled at RSC. Next Term Persistence Rate is total number of students enrolled in the term following their initial term in the program (i.e. Fall to Spring, Spring to Fall). Next Year Persistence Rate is the total number of students enrolled in the year following their initial year in the program (i.e. Fall to Fall, Spring to Spring). Credit Success Rate is the total number of credits earned by students of the total number of credits attempted.

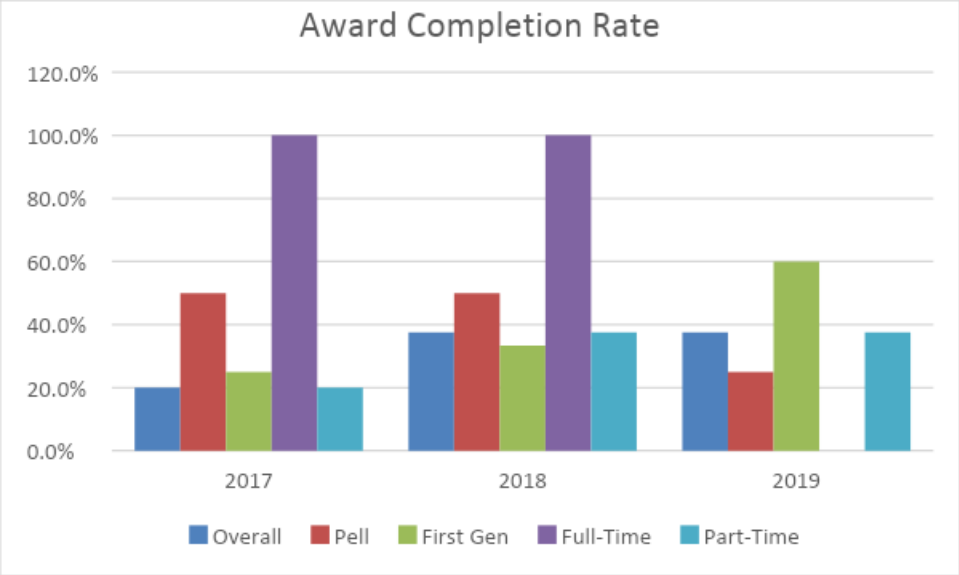


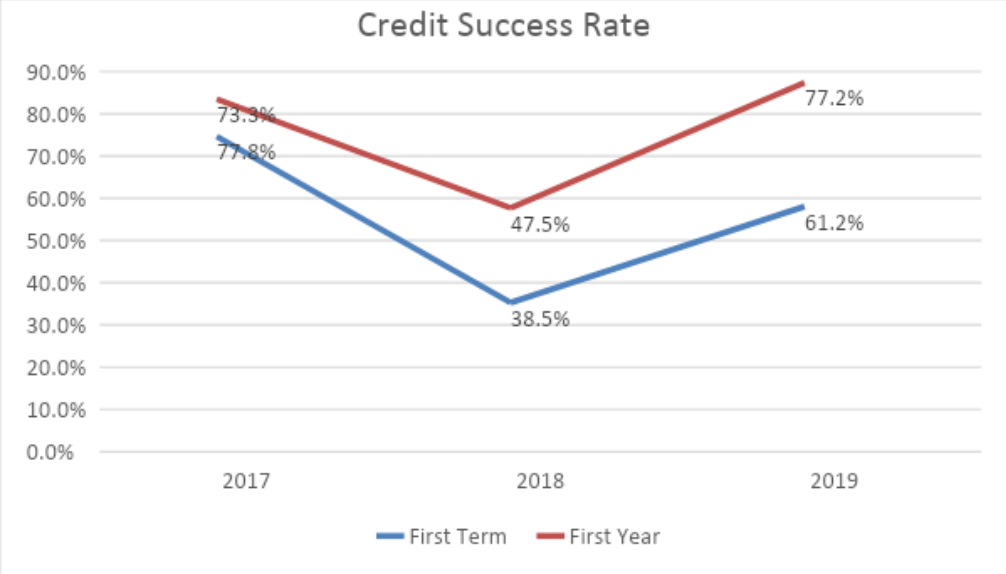
The dropout rate is very low, which directly correlates with our high retention and persistence rate. As noted above, the attention of the faculty interacting with students leads to our high rate of student success.

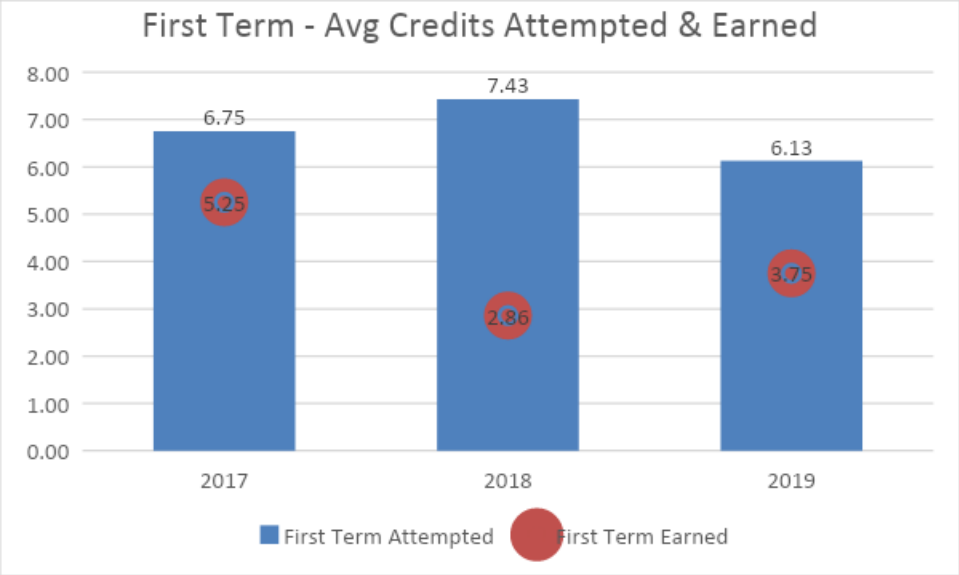



Next-Term Persistence Rate
120%
100%
80%
60%
40%
20%
0%
2017
2018
2019
Overall
Pell
First Gen
Full-Time
Part-Time


Next-Year Persistence Rate
120.0%
100.0%
80.0%
60.0%
40.0%
20.0%
0.0%
2017
2018
2019
Overall
Pell
First Gen
Full-Time
Part-Time


Award Completion Rate
120.0%
100.0%
80.0%
60.0%
40.0%
20.0%
0.0%
2017
2018
2019
Overall
Pell
First Gen
Full-Time
Part-Time


Credit Success Rate
90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
73.3%
77.8%
47.5%
77.2%
38.5%
61.2%
2017
2018
2019
First Term
First Year



Not only does the program retain its students, those who do retain have a relatively high level of success in each course and complete their certifications.

IX. Impact of Co-curricular Programs

Table 9. Nanotechnology College-Wide Learning Outcomes for All DAPEs and Co-Curricular DAPEs

Learning Outcome	All Student Activities	Activities at College Level	Percent of Activities at College Level	Co-Curricular Activities	CC Activities at College Level	Percent of CC Activities at College Level
Critical Thinking	0	0	0.0%	0	0	0.0%
Information Literacy	0	0	0.0%	0	0	0.0%
Oral Communication	2	1	50.0%	0	0	0.0%
Reading	0	0	0.0%	0	0	0.0%
Writing	0	0	0.0%	0	0	0.0%

A small proportion of students are in the Co-Curricular cohort. With the exception of Oral Communication (with a very small N), there is not a significant difference in performance at the College Level between all students and those in the Co-Curricular cohort.

MNT210 is offered as Honors-eligible, but we have not yet had any enrollment. The instructor has an Atomic Force Microscope project ready to assign for the first batch of honors students.

X. Program Resources

The STEM Department Adjunct Faculty Lead works 8 hours per week. We rely upon limited lab equipment (approximately $120,000 worth currently at Northern) and partnerships with industry and grant support from ASU to deliver in-person and virtual lab components. Increasing our newly-allocated lab space would provide significant experiences for students. Hosting events that bring in potential industry partners to this lab may also build our advisory board, allow us to be a training resource for industry, and/or increase enrollments.

We have the need to update, maintain, and disseminate our existing marketing assets, which include flyers, videos, pop-up banners, and a dedicated webpage.

As part of an alternative online lab, we would like to add library-designed academic support modules to courses within the Nano program that have a research component. Students would benefit by direct access to relevant sources for their research. Additional information is provided in the Recommendations section.

XI. Program Recommendations, Decisions, and Action Plans

a. Program Best Practices

Rio Salado College's Nanotechnology program, although still maturing, is a beacon of innovation and creative thinking. It is the first in the country to provide authentic hands-on relevant workforce training for technicians in an alternative format. We have received national recognition for this approach, including a position within the NSF funded Micro Nano Technology – Education Center (MNT-EC) supporting distance education practices. This type of authentic training is a blue ocean of opportunity consistent with College planning processes and goals.

b. Program Viability

The need for a technician training program such as this is exemplified by the job data below.

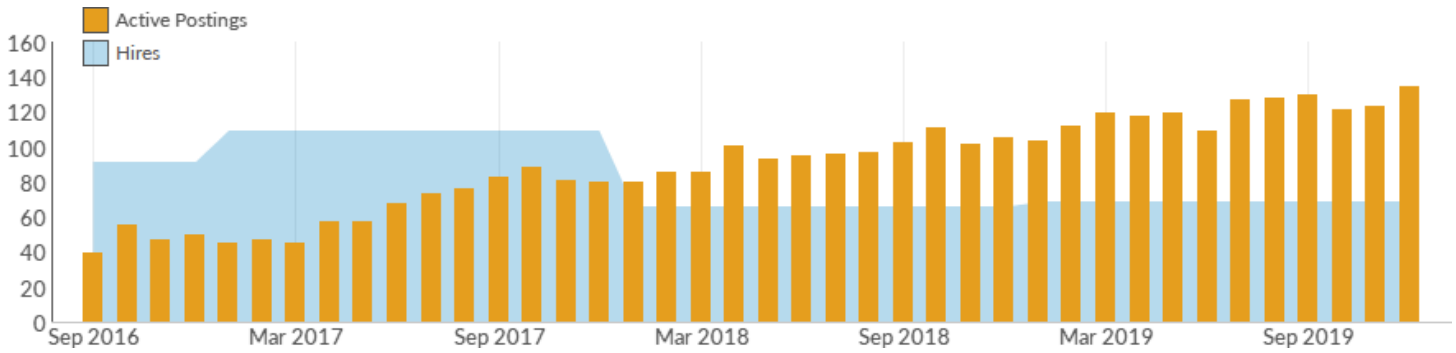
Job Postings Summary

1,219	5 : 1	34 days
Unique Postings	**Posting Intensity**	**Median Posting Duration**
5,931 Total Postings	Regional Average: 4 : 1	Regional Average: 31 days

There were **5,931** total job postings for engineers from September 2016 to December 2019, of which **1,219** were unique. These numbers give us a Posting Intensity of **5-to-1**, meaning that for every 5 postings there is 1 unique job posting. This is close to the Posting Intensity for all other occupations and companies in the region (4-to-1), indicating that they are putting average effort toward hiring for this position.

Job Postings vs. Hires

90	82
Avg. Monthly Postings (Sep 2016 - Dec 2019)	**Avg. Monthly Hires (Sep 2016 - Dec 2019)**



Occupation	Avg Monthly Postings (Sep 2017 - Dec 2019)	Avg Monthly Hires (Sep 2016 - Dec 2019)
Engineers, All Other	90	82

Target Occupations

2,589	+0.9%	$44.54/hr	193
Jobs (2018) 19% below National average	**% Change (2018-2019)** Nation: +0.7%	**Median Hourly Earnings** Nation: $46.89/hr	**Annual Openings**

Occupation	2018 Jobs	Annual Openings	Median Hourly Earnings	Growth (2018 - 2019)	Location Quotient (2018)
Engineers, All Other	2,589	193	$44.54	0.93%	0.81

Graduates are prepared for a wide range of job titles in multiple classifications and descriptions, not all of which are represented in this data.

The following are job market data from related areas:

Nanotechnology Engineering Technicians

Operate commercial-scale production equipment to produce, test, or modify materials, devices, or systems of molecular or macromolecular composition. Work under the supervision of engineering staff.

Median wages (2019)	$30.28 hourly, $62,990 annual

Manufacturing Production Technicians

Set up, test, and adjust manufacturing machinery or equipment, using any combination of electrical, electronic, mechanical, hydraulic, pneumatic, or computer technologies.

Median wages (2019)	$30.28 hourly, $62,990 annual

Inspectors, Testers, Sorters, Samplers, and Weighers

Inspect, test, sort, sample, or weigh nonagricultural raw materials or processed,

machined, fabricated, or assembled parts or products for defects, wear, and deviations from specifications. May use precision measuring instruments and complex test equipment.

Median wages (2019)	$18.82 hourly, $39,140 annual

Though the need is there, the program has not yet met enrollment expectations. For this reason, the program is currently undergoing re-evaluation. First, the chair met with the College President and Vice President of Academic Affairs. Even though some tough choices were made (Prop 301 money was reallocated, development of the site at Southern was delayed even though an architectural plan was completed), the Executive Team reaffirmed their support for the viability of the program in Fall 2019. We are working to increase the viability through five specific areas:

1. The program was accepted to the Mentor-Connect program to be mentored on a First-Time-To-ATE grant proposal. A $300,000 grant proposal was submitted to NSF in October 2020.
2. We have support from a new Senior Instructional Service Specialist to coordinate and consolidate industry and workforce connections and data. She has done a tremendous job and we have had multiple meetings with industry partners reaffirming their need for employees in these areas.
3. President Smith connected us with her former colleague Dr. Alexis Vogt who has built a related technician training program at Monroe Community College in optics. After discussion with Dr. Vogt, we are adding some optics training options to meet the local demand and assisting her with hybridization of her curriculum.
4. Rewriting curriculum to directly align with new industry standards and certification options.
5. Recruiting from a broader base of students, including traditionally underserved populations. Specifically, we are designing pathways into Nano careers for our adult learners coming from ABE/GED populations.

c. Action Research Questions

- How can we market and recruit more underserved, racial minority, and female populations in Nanotechnology?
- How can we expand access nationally to technician careers in Micro and Nano- related industries using Rio's unique online and asynchronous model? How can we modify existing labs to be fully available at a distance?
- How can we co-enroll students that are not currently served in Nano programs at other colleges?
- How can we most efficiently and equitably develop and deploy marketing and enrollment efforts to reach potential students?
- What impact does the addition of optics and photonics-related curriculum have on student enrollment, success metrics and, ultimately, job placement for graduates?

d. Recommendations

- Pathway mapping with industry representatives in Spring 2021 will consider:
    - Renaming the program to something that speaks better to the general population.
    - A three-phase curriculum revision:
        1. Consolidate the six capstone courses into four that are directly aligned with ASTM standards and replace the other two courses with new ones in optics and photonics.
        2. Create a two-tiered stackable CCL pathway with basic-level courses and more advanced courses.
        3. Reconsider restricted electives and gen ed courses in the AAS pathway to develop and streamline entries for students with limited science backgrounds.
    - Align courses and assignments in the MNT prefix with gen ed SLOs and plan more direct program-level assessment in addition to final exam item analysis.

- Following pathway mapping, work with the Library co-chairs to develop library modules with Nanotechnology research links and career options.

- Enhance the current Facebook/social media presence to include a weekly post about job opportunities in the field. Coordinate these efforts with College marketing and public relations.
- Focus on targeted recruitment opportunities rather than general interest community fairs.
- Finalize and submit the New-To-ATE grant proposal in Fall 2020. Begin work and planning in 2023 for the next step in ATE grant funding.
- Revamp marketing materials.
- Expand services at Northern as alternatives to the grant-funded and expensive ASU options. Also create online authentic versions of these labs for geographically diverse students.
- Pilot a co-enrollment model for Nano programs at other colleges that have to turn students away because they can't staff a class with limited enrollment.
- Complete a subsequent spotlight review in 2023 to gather baseline data after pathway mapping and contribute updated gen ed SLO analysis.

Addendum

September 9, 2020

Dr. V. Celeste Carter
Advanced Technology Education
National Science Foundation
2415 Eisenhower Avenue
Alexandria, VA 22314

Dear Dr. Carter:

Medtronic is supportive of the Rio Salado College (RSC) proposal entitled: *Nano Knows No Limits* within the National Science Foundation's Advanced Technical Education Program. Our Tempe office is immediately adjacent to the College and we are excited to consider their well-trained graduates for our unmet technician workforce needs.

Medtronic is a large international company with a mission to contribute to human welfare by application of biomedical engineering in the research, design, manufacture, and sale of instruments or appliances that alleviate pain, restore health, and extend life. We rely upon technicians to maintain our manufacturing of existing products and support research and development for future products.

We are challenged in finding qualified and trained technicians that understand safety and security protocols for clean room operations, basic electronics, optical features, and fabrication/characterization tools and processes. We have a strong desire to partner with Rio to grow a pipeline of talent for our current and future workforce.

In particular, Medtronic will support Rio and the *Nano Has No Limits* project in a variety of ways, such as but not limited to the following examples:

1. Providing a local manager to serve on the industry advisory board 2. Providing work-like experiences including but not limited to tours, labs, and mini internships
3. Interviewing qualified graduates from RSC for hiring consideration 4. Presenting information about career opportunities across the country for nanotechnology students in the classroom, at career fairs, and at recruitment events.

We are excited about the opportunities for the *Nano Has No Limits* project to increase access to non-traditional and diverse students to improve the quantity and diversity of technicians prepared to work for Medtronic.

Sincerely,

Ron Wilson, VP & Site Leader, Medtronic Tempe