University of Puerto Rico at Arecibo
Physics/Chemistry Department
Bachelor of Technology in Industrial Chemical Processes Program

STUDENT OUTCOMES ASSESSMENT PLAN AND RESULTS REPORT (Academic Years 2021-2022, 2022-2023)

I. Introduction

The student outcomes are assessed using three methods:

- Course Embedded Assessment
- Senior Exit Test
- Senior Exit Survey

After the data is collected, the faculty submits a preliminary report which includes: (1) excel data sheet, (2) level of attainment, (3) evaluation and, (4) recommendations and corrective actions. After completing the individual evaluation of each performance indicator for a given outcome, an overall attainment level is determined.

II. Course-embedded Assessment Plan and Results

OUTCOMES	Performance Indicator	Time of Data Collection	Context for Assessment	Assessment Method (Professor)	Results	Average Results
General Criteria						
1. Apply knowledge, techniques, skills and modern tools of mathematics, science, engineering, and technology to solve broadly-defined chemical engineering technology problems appropriate to the program.	a. Apply chemistry and unit operations concepts in chemical processes.	2021-2022 2022-2023	TEQU3105	Pre/Post Test V. Montalvo	2.93 2.92	**2.93**
	b. Identify, calibrate and operate chemistry laboratory instruments.	2021-2022 2022-2023	QUIM4012	R. Infante	2.86 2.52	**2.69**
	c. Identify and operate unit operations equipment.	2021-2022 2022-2023	TEQU3202/3204	Laboratory Performance Exam N. Velázquez	3.76 3.86	**3.81**

	d. Use updated handbooks and catalogs to obtain or replace components of a chemical process.	2021-2022 2022-2023	TEQU4105 TEQU4207	Performance Exam V. Montalvo	3.88 3.68	**3.78**
2. Design systems, components, or processes meeting specified needs for broadly-defined chemical engineering technology problems appropriate to the program.	a. Design a laboratory-scale chemical process and obtain a purified product.	2021-2022 2022-2023	TEQU4020 TEQU4206	Portfolio 2021-2022 G. Peña 2022-2023 M. Medina	4.00 3.10	**3.55**
	b. Design a laboratory-scale chemical process including a preliminary costs analysis.	2021-2022 2022-2023	TEQU4020 TEQU4206	Portfolio 2021-2022 G. Peña 2022-2023 M. Medina	4.00 3.10	**3.55**
3. Apply written, oral, and graphical communication in broadly-defined technical and non-technical environments and use appropriate technical literature.	a. Prepare technical reports related to laboratory experiments or tests.	2021-2022 2022-2023	QUIM4012	Laboratory Reports R. Infante	3.42 3.10	**3.26**
	b. Present oral reports using multimedia.	2021-2022 2022-2023	TEQU4020 TEQU4206	Portfolio 2021-2022 G. Peña 2022-2023 M. Medina	3.99 3.90	**3.95**
	c. Identify and use appropriate technical literature.	2021-2022 2022-2023	TEQU4037	Seminar Report V. Montalvo	4.00 3.73	**3.87**
4. Conduct standard tests, measurements, and experiments and analyze and interpret the results to improve processes.	a. Interpret and execute properly Standard Operting Procedures (SOP's).	2021-2022 2022-2023	TEQU3202/3204	Laboratory Performance Exam N. Velázquez	3.74 3.92	**3.83**
	b. Apply the scientific method in the assessment and evaluation of experimental results.	2021-2022 2022-2023	QUIM4012	Laboratory Reports R. Infante	3.19 3.01	**3.10**

	c. Formulate recommendations and suggest modifications to improve processes.	2021-2022 2022-2023	TEQU4020 TEQU4206	Portfolio 2021-2022 G. Peña 2022-2023 M. Medina	4.00 3.30	**3.65**
5. Function effectively as a member as well as a leader on technical teams.	a. Design and perform laboratory experiments in teams according to a plan.	2021-2022 2022-2023	TEQU4020 TEQU4206	Portfolio 2021-2022 G. Peña 2022-2023 M. Medina	4.00 3.80	**3.90**
	b. Comply with the ethics codes and behavior rules in the workplace.	2021-2022 2022-2023	TEQU4105 TEQU4037	Exam V. Montalvo	3.69 3.64	**3.67**
Program Criteria						
1. Apply operating principles (including testing and troubleshooting) of chemical processes and equipment in accordance with applicable safety (including process hazards), health and environmental standards.	a. Identify the state and federal regulatory agencies of the chemical processes industry.	2021-2022 2022-2023	TEQU4018	Exam R. García	3.83 4.00	**3.92**
	b. Interpret and apply the occupational and environmental health and safety regulations related to chemical processes industry.	2021-2022 2022-2023	TEQU4018	Exam R. García	4.00 4.00	**4.00**
	c. Comply with the troubleshooting/testing protocols in the workplace.	2021-2022 2022-2023	TEQU3202/3204	Laboratory Performance Exam N. Velázquez	3.87 4.00	**3.94**
	d. Use personal protective equipment.	2021-2022 2022-2023	TEQU3202/3204	Laboratory Performance Exam N. Velázquez	3.75 3.85	**3.80**

	e. Comply with the safety rules in the workplace.	2021-2022 2022-2023	TEQU3202/3204	Laboratory Performance Exam N. Velázquez	3.75 3.85	**3.80**
2. Apply chemical engineering principles (such as fluid mechanics, material and energy balances, heat transfer, reactions, thermodynamics, and separations) to the design, improvement, and operation of chemical processes and appropriate to program educational objectives.	Demonstrate knowledge of unit operations concepts applied to a chemical process in:					
	a. Fluid mechanics	2021-2022 2022-2023	TEQU3201	Exam V. Montalvo	3.52 3.48	**3.50**
	b. Material and energy balances	2021-2022 2022-2023	TEQU3107	Exam V. Montalvo	3.01 2.74	**2.88**
	c. Heat transfer	2021-2022 2022-2023	TEQU3203	Exam A. García	3.10 3.50	**3.30**
	d. Thermodynamics.	2021-2022 2022-2023	TEQU4007	Exam A. García	3.40 3.71	**3.56**
	e. Separations	2021-2022 2022-2023	TEQU4009	Exam G. Peña Pre/Post Test A.García	2.37 3.28	**2.83**
	f. Chemical reactions orders and rates.	2021-2022 2022-2023	TEQU3003	Exam A. García M. Medina	2.82 2.38	**2.60**
3. Apply instrumentation and process control, quality control, computer applications, and materials of construction to the	a. Identify the components of a control system.	2021-2022 2022-2023	TEQU4021/ TEQU 4022	Exam H.Torres	3.71 3.50	**3.61**
	b. Operate automated control systems.	2021-2022 202 2-2023	TEQU4021/ TEQU 4022	Exam H.Torres	3.34 3.00	**3.17**

design, improvement, and operation of chemical processes.						**3.86**
	c. Use computer programs and simulators in chemical processes design and operation.	2021-2022 2022-2023	TEQU3106	Portfolio G. Peña Pre/Post Test A.García	3.98 3.74	**3.47**
	d. Select suitable materials to avoid deterioration of the chemical process components.	2021-2022 2022-2023	TEQU3201	Exam V. Montalvo	3.60 3.33	
4. Apply chemistry concepts and laboratory skills in inorganic and organic chemistry.	a. Apply inorganic chemistry concepts.	2021-2022 2022-2023	TEQU3001	Pre/Post Test M. Medina	3.14 2.84	**2.99**
	b. Demonstrate laboratory skills in inorganic chemistry.	2021-2022 2022-2023	QUIM3026	Laboratory Performance Exam R. Rivera	3.67 3.11	**3.39**
	c. Demonstrate laboratory skills in organic chemistry.	2021-2022 2022-2023	QUIM3451	Pre/Post Test R. Rivera	2.71 3.00	**2.86**
5. Apply statistical process and quality control to chemical operations.	a. Demonstrate knowledge in statistical analysis calculations.	2021-2022 2022-2023	QUIM 3026 QUIM 3026	Pre/Post Test R. Rivera Pre/Post Test R. Rivera	1.75 2.35	**2.05**
	b. Apply statistical process and quality control to chemical operations.	2021-2022 2022-2023	QUIM3026 QUIM3026	SPC Module R. Infante SPC Module R. Infante	3.32 3.00	**3.16**

Results Summary Cycle 7			
General Criteria		Program Criteria	
1	3.30	1	3.89
2	3.55	2	3.11
3	3.69	3	3.53
4	3.53	4	3.08
5	3.79	5	2.61

Results Summary Cycle 6 (Previous)			
General Criteria		Program Criteria	
1	3.41	1	3.62
2	3.97	2	3.17
3	3.78	3	2.88
4	3.71	4	2.85
5	3.74	5	3.03

Evaluation:

The course embedded assessment results for cycle 6 show that all student outcomes were met at a satisfactory level. In cycle 7, most student outcomes were met at a satisfactory level and program criteria 5 was met at a developing level. In cycle 6, program criteria 4 obtained the lower score. Follow up recommendations from cycle 6 included the revision of the assessment instruments. The score of PC4 increased from 2.85 in cycle 6 to 3.08 in cycle 7. Several corrective actions were implemented in each performance indicator.

PC4.a was assessed using pre/post tests in the General Chemistry for Technology I (TEQU 3001) course during the first semester of the program. This is the first time that some students are enrolled in a Chemistry course. Most students improved their scores in the post test.

- Feedback was provided regarding lower scored test items.
- Students were encouraged to participate in institutional tutoring services.
- Quizzes were integrated during the semester to assess the concepts included in the pre/post tests.
- More examples were discussed in class to improve retention.
- Educational materials and practice problems were provided.

PC4.b was assessed in the Analytical Chemistry Laboratory (QUIM 3026) course using an individual performance exam. Most of the students demonstrated domain in the proper use of the analytical balance and preparation of solutions.
The following corrective actions were implemented:

- The performance exam was revised and the solution preparation component was included.
- Additional time was taken out to reinforce these skills. For example, after the demonstration of the technique; each student had to prepare their own solution with a unique mass and volume.

- Demonstrative videos of mass measurement and pH measurement were prepared for the students.

The performance exam will be implemented since the first general chemistry laboratory.

PC4.c was assessed in the Organic Chemistry Fundamentals Laboratory (QUIM 3451) course using pre/post test. The test theoretically assesses basic separation and purification skills used in organic chemistry. This performance indicator was met at a developing level. Most students improved their scores in the post test.

The following corrective actions were implemented:

- Emphasis on the discussion of the techniques to be developed.
- Individualized monitoring during the execution of the technique.
- Collaborative work during the execution and after the data collection.
- Workshops were offered during the summer to reinforce laboratory skills of those students affected by the pandemic.

In cycle 7, the lower score was obtained for program criteria 5 - performance indicator a. Several corrective actions were taken to strengthen statistics concepts.

PC5.a was assessed in the Analytical Chemistry Laboratory (QUIM 3026) course using a pre/post test. During the first two periods of the laboratory, intensive workshops of statics concepts and excel applications are presented to the students. This performance indicator is addressed through all the semester and the program. The students are evaluated for the use of statistical tools in their technical reports. Continuous feedback is provided until they manage the statistical concepts because they are required in all the laboratory courses of the program. This performance indicator was met at a developing level. Most students improved their scores in the post test.

The following corrective actions were implemented:

- Six modules of the statistical component were offered.
- The Microsoft Excel program was used instead of the calculator for the statistical analysis.
- Individualized follow-up was offered during each Excel workshop.
- Peer collaborative work was assigned during and after each workshop.

The program criteria 5 - performance indicator b was met at a satisfactory level. It was assessed in the Analytical Chemistry Laboratory (QUIM 3026) course using a project. To assess this performance indicator an SPC Educational Module was designed including a project that must be completed by the students. The project requires the creation and evaluation of control charts and quality processes diagrams.

The program criteria 1 obtained the highest score, which is the result of emphasizing the importance of federal and local regulations through the curriculum.

In conclusion, the overall compliance with the student outcomes is satisfactory in the courses' assessment.

III. Senior Exit Test Results

Outcome	Results SET 2022
Criterion 3	
GC1	2.89
GC2	3.14
GC3	3.21
GC4	3.05
GC5	3.39
GC6	3.58
GC7	3.06
GC8	3.36
GC9	3.41
GC10	3.94
GC11	1.96
Program Criteria	
PC1	2.76
PC2	2.83
PC3	2.28
PC4	3.15

Outcome	Results SET 2023
General Criteria	
GC1	3.04
GC2	3.13
GC3	3.53
GC4	3.18
GC5	3.38
Program Criteria	
PC1	3.05
PC2	2.23
PC3	2.44

PC4	2.88
PC5	2.69

The scores for the SET 2023 were lower than the ones for the SET 2022. The senior exit test was revised as result of the revision of the student outcomes and the assessment plan. All items were revised and new items were included for the following revised outcomes GC2.b, GC3.b, GC5.a, PC2.c, PC2.f, PC3.d, PC4.a, PC4.c, PC5.a, PC5.b. The total of items was reduced from 124 to 100. The revised test was offered for the first time in 2023. In general, students' performance in courses is above the level of performance in the senior exit test. Although the senior exit test is a cumulative evaluation, a stable trend in performance from observed. The average score varies from 76% in 2022 to 73% in 2023. As a corrective action, review sessions for the test were implemented.

IV. Senior Exit Survey Results

Outcome	**Results SET 2022**
General Criteria	
1	3.65
2	3.52
3	3.74
4	3.58
5	3.77
6	3.55
7	3.75
8	3.67
9	3.58
10	3.83
11	3.86
Program Criteria	
1	3.73
2	3.55
3	3.52
4	3.91

Outcome	Results SET 2023
General Criteria	
1	3.52
2	3.68
3	3.62
4	3.63
5	3.75
Program Criteria	
1	3.85
2	3.47
3	3.47
4	3.20
5	3.39

The senior exit survey was also revised as the result of the student outcomes revision. Questions were evaluated and the space for students' recommendations remained as part of the survey. Students are encouraged to complete this part. The results obtained from the senior exit survey reveal that students are confident about their academic training. All outcomes were met at a satisfactory level. Recommendations from the students were discussed and evaluated in PACAC meetings.

V. Continuous Improvement of the Program

The results of the course embedded assessment, the SET and the SES were used as fundamental information for the program's continuous improvement actions. Most scores improved when the assessment instrument was changed from a pre/post tests in the courses to performance exams in the laboratories. After evaluation of the first year (2021-2022) of Cycle 7 results, the faculty decided that an upgrade of the laboratory equipment was required. The upgrade of the equipment was divided in two phases, unit operations equipment and chemical analysis instruments. In 2023, the upgrade was completed and in place to support the compliance with the student outcomes.