**Outcome 5.** Graduates will be able to design effective laboratory experiments, to perform laboratory experiments, to gather data, to analyze data, and to test theories.

This outcome maps to ABET Criterion 3 b

| Course | Performance indicators |
|---|---|
| ChE 450, 451 | Graduates will be able to design and perform safe experiments using modern technology appropriate for a given problem. |
| | Graduates will be proficient in data analysis and be able to recognize error sources in experiments. |

| | |
|---|---|
| Tools used: | Laboratory Rubric |
| Data Collection: | The data are collected every semester based on the course offerings. |
| Frequency of data collection: | The data are collected every time courses are taught. |
| Data Analysis: | The data obtained are analyzed every year. |
| Closing the loop: | This outcome is subject to review every year based on performance criteria and metrics and specific action items are developed, if necessary, to revise the content of the courses. The analyzed data are presented separately to the following groups in meetings.<br>a) Faculty<br>b) Advisory Board |

*Performance criteria and metrics*:

a) Students should reach a level of proficiency defined as a goal metric value of 3.0 based on the Laboratory Rubric scale of 1-4.

# Assessment Tool:

# Laboratory Rubric

## Laboratory Rubric

| Attribute | 1-Not proficient | 2-Progressing to proficiency | 3-Proficient | 4-Superior proficiency | Score |
|---|---|---|---|---|---|
| **Design, perform safe experiments** | | | | | |
| Design of safe, effective laboratory experiment | unsafe, ineffective design | some safety problems and/or effectiveness errors | safe and effective | safer and/or more effective than expected | |
| Laboratory execution according to safe, approved experimental plan | unsafe practices, do not follow approved plan | some safety problems and/or inappropriate deviations from approved plan | safe and approved plan executed | execution or safety improved from original design | |
| Understanding of how equipment works, equipment limitations, safe operation | no understanding of how equipment works or safe operations | errors in understanding of equipment operation or safe operation | clear understanding of equipment operation and safe practices | superior understanding of equipment operation and safe practices | |
| Understanding of how equipment can be used to solve stated problem | no understanding | minimum understanding | clear understanding | exploitation of equipment functions to enhance result | |
| Understanding of key variables/parameters, appropriate ranges | no understanding | minimum understanding | clear understanding | exploitation of variables/parameters to enhance result | |
| Sufficient detail provided to demonstrate ability to solve stated problem | not provided | missing aspects | clearly provided | superior presentation | |
| **Data analysis** | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Data collected demonstrates understanding of relationship between equipment and theory | not demonstrated | demonstrated with errors | clearly demonstrated | superior demonstration | |
| Correct data/statistical analysis, correct number of significant figures | incorrect analysis, incorrect number of significant figures | errors in analysis, incorrect number of significant figures | correct analysis and number of significant figures | superior analysis and correct number of significant figures | |
| Understand important sources of error and how to deal with them | not understood | minimum understanding | clear understanding | superior understanding with in-depth explanations | |
| Ability to draw conclusions from data | not demonstrated | some of the important conclusions missing | all the important conclusions covered | all the important conclusions covered systematically | |
| **Computer usage** | | | | | |
| Appropriate use to analyze data | computer not used or used incorrectly | uses computer, but contains errors | use of computer to obtain correct/valid results | superior use of computer to obtain unique solution | |
| Appropriate use to present data | computer not used or used incorrectly | uses computer, but with errors | uses computer correctly | superior use of computer to present data systematically | |
| Effective use of information systems to obtain data/parameter values | not done | some important features of the system not used | all important features of the system used | all important features of the system used systematically | |