SEEDS Student Learning Outcome(s)/Rubric

Scientific Reasoning

Students Learning Outcomes:

- ***Explain disciplinary content (key principles and ideas) pertinent to the course.***
- ***Describe and explain the social and ethical implications of the content examined in the course.***
- ***Apply scientific reasoning to the solution of problems.Interpret and manipulate different types of data across a range of assignments.***
- ***Articulate scientific information accurately and clearly in a variety of situations.***
- ***Assess the validity of scientific claims.***

Note: *Courses certified in this category should meet learning objectives 1, 2, and 3 below, as well as at least 2 of learning goals 4 through 7.* A course is typically designed around a topic or question that the instructor deems interesting, timely, or important; it has its own learning goals which are not necessarily built around the generic learning objectives below. Nonetheless, while not necessarily central to the motivation of the course, the learning objectives below should naturally be addressed in a rigorous (although perhaps not always explicit) manner as the course progresses.

Criterion	Exemplary/Excellent	Proficient/Good	Emerging Competence	Unsatisfactory/Needs Improvement
Disciplinary Content Knowledge	Demonstrates strong aptitude in the recollection, or application of the principles or ideas pertinent to the course.	Student consistently and accurately applies basic course material.	Student accurately applies concepts to some situations but makes frequent errors and omissions.	Poor performance in basic recall of key course concepts or principles.

Societal value/ethical implications.	Accurately and clearly explains (across multiple points) the relevance of the course to society or of the ethical implications of the course contents.	Describes the societal or ethical relevance of the course.	Partially explains the societal/ethical relevance of the course.	Fails to explain how the course relates to society or ethical issues.
Application of the Scientific Process	Demonstrates strong capability to solve problems via application of scientific reasoning or is readily able to identify how different aspects of scientific reasoning led to a solution or finding.	Ability to apply or identify scientific reasoning is sufficient to enable progress through the course and to appreciate course objectives.	Ability to apply/identify scientific reasoning is limited or developing.	Little to no competence at applying or identifying scientific reasoning has been demonstrated.
Data Interpretation and Manipulation.	Demonstrates facility with interpreting and/or manipulating data across multiple assignments and data types.	Data interpretation or manipulation ability is sufficient to enable understanding and appreciation of course material.	Student demonstrates some ability to interpret or manipulate data, but with frequent errors or deficiencies in understanding.	Little to no ability to interpret or manipulate scientific data is evidenced.
Science Communication	Demonstrates an ability to articulate complex scientific information in an accurate and clear manner in multiple instances.	Can communicate scientific information, but with room for improvement in clarity or accuracy.	Makes reasonable attempts at clear & accurate communication, but with significant deficiencies.	Poor, incomplete, or missing attempts in science communication assignments.
Lab Activity	Performs nearly all lab activities in a careful, complete, and thorough manner, including in written or oral reports; attains a strong personal understanding of the goals and relevance of the lab activities.	Is able to perform most lab activities (including reports) in a sufficient manner, but with minor deficits in understanding or technique.	Makes reasonable effort toward completion of several lab activities, but with several deficiencies in technique, report, understanding, or number of activities completed.	Minimal to no effort or attendance in lab activities; poor technique, report, or personal understanding of lab objectives.
Assessing Scientific Claims	Consistently identifies and explains errors, bias, approximations,	Explains and identifies some errors, such as bias, approximations,	Identifies but fails to explain some errors, such as bias, approximations,	Fails to explain and identify errors, such as bias, approximations,

	reproducibility, or other subtleties when interpreting scientific information.	reproducibility, or other subtleties when interpreting scientific information.	reproducibility, or other subtleties when interpreting scientific information.	reproducibility, or other subtleties when interpreting scientific information.

Scientific Reasoning Explained:
Science touches on a range of issues pertinent to our everyday lives. These include fundamental questions (the origin of life, the evolution of the universe, the nature of matter and forces), practical matters (personal health, the construction and functioning of everyday structures and technology), and critical societal matters (climate change, gene editing technology, energy generation/transmission, nuclear proliferation, drug and vaccine development).

Scientific Reasoning is a powerful problem-solving methodology for asking and answering questions about the natural world. It involves the collection of facts through observation and/or experimentation, followed by the application of logical reasoning to infer an (often tentative) conclusion from those facts. The process is iterative: new facts or insights may lead to new observations or experiments (or vice versa), resulting in a refinement of one's conclusions or the emergence of new questions. Other key components of scientific reasoning include openness to questioning assumptions and conclusions, independent replication of observations/experiments and their results, striving for objectivity, and minimizing bias.

Scope and Application of this rubric:
This rubric provides guidelines for: (a) assessing if courses at Montclair State University satisfy the SEEDS Exploration learning outcomes for Scientific Reasoning; and (b) assessing if student learning outcomes are met by a course already certified under the Scientific Reasoning category. The learning objectives below provide guidance on these two points.

Learning objectives and criteria for certification as a SEEDS course:
For these purposes, a scientific reasoning course applies the methodologies and content knowledge of the natural sciences (Astronomy, Biology, Chemistry, Earth Science, and Physics). While a scientific reasoning course need not originate in departments corresponding to those disciplines, the course should make significant use of the content knowledge and methods of the natural sciences.

Disciplinary content knowledge:

- The proposed course largely (>60%) centers on content knowledge, methodologies, or applications directly connected to one or more of the natural science fields listed above.

- Students should achieve minimal proficiency in disciplinary content knowledge. i.e., students should be able to recollect, interpret, and understand the majority of the basic scientific facts, terms, principles, and concepts presented in the course, as evidenced by performance on exams, homework, or other assignments.

Societal value or ethical implications:

- The proposed course will emphasize the importance, relevance, or application of its scientific content in terms readily understood by the non-scientist. This may include the application of scientific knowledge or inquiry to relevant problems/issues in society, politics, public health, or international affairs; to problems/issues of immediate practical interest or technological relevance; or to problems/issues of fundamental, philosophical, or aesthetic interest. The course will illustrate why science is relevant to students' lives. The course may also discuss ethical issues in science. This may include ethical issues in the application of scientific knowledge (Should we mandate vaccines, perform geoengineering, develop new nuclear weapons?), or ethical issues that arise in the accumulation of scientific knowledge or the process of scientific inquiry (How can studies be carried out in an unbiased way? How should research dishonesty be addressed/prevented? Why are some groups underrepresented in particular fields of science?).
- Students will be able to articulate or otherwise recognize the importance, relevance, or application of the course contents to societal or ethical issues as discussed above.

Application of the scientific process:

- The proposed course emphasizes understanding of the scientific process as practiced in the natural sciences. Students learn how key findings emerge via the application of scientific reasoning. They are able to apply scientific reasoning to infer the outcome of a process, make a prediction, or solve a problem.
- Students are able to apply scientific reasoning as just described on assignments, exams, or in laboratory or research work. They are able to solve problems or reach conclusions through sound application of logical reasoning and scientific/mathematical principles or ideas. They are able to identify how steps or components of the scientific process led to important results, findings, or conclusions in the discipline.

Working with and interpreting data:

- The proposed course provides opportunities for students to read and interpret scientific data and information in multiple forms, including plots/charts/graphs, tables, symbols/equations/mathematics, or verbal and written descriptions of scientific information. Students also learn to produce or manipulate data of a scientific nature to arrive at conclusions or answers to scientific problems.

- Student assignments provide sufficient opportunities to assess their ability to both read/interpret and produce/manipulate scientific data or information.

Communicating science:

- The proposed course provides opportunities for students to explain scientific concepts via written, oral, or artistic means. This might include providing a written summary of the content of a scientific article, discovery, or topic; giving a presentation on research or a course project; explaining the results of a lab or field experiment via their lab notebook or presentation; generating an artistic rendering, display, or performance relevant to a scientific topic.
- One or more student assignments will allow assessment of a scientific communication activity as described above.

Laboratory activity:

- The proposed course provides opportunities for students to carry out experiments, demonstrations, laboratory investigations, computer modeling, field observations, or research analyses as appropriate to the course discipline. Hands-on or project-based learning activities enhance understanding and are strongly suggested components of scientific reasoning courses.
- Student assignments or activities are able to assess student competence in one or more of the activities listed above.

Assessing scientific claims:

- The practice of science and the interpretation of scientific results is rarely definitive and is often plagued by ambiguities. Students may encounter this when dealing with the assumptions of a study or problem, estimating or understanding possible sources of error or bias (including human sources of bias), assessing results for their reproducibility, and generally evaluating scientific claims for their reasonableness and faithfulness to the scientific process. Students may encounter and reckon with these issues throughout the proposed course.
- Selected activities or assignments will allow an evaluation of students' capacity to assess the validity of scientific claims or test their ability to estimate errors, identify sources of bias, or characterize the reproducibility of results.