GELO Assessment

The American Association for Higher Education and Accreditation (AAHEA) describes assessment as an ongoing process aimed at understanding and improving student learning. The principal goal of this assessment process is to provide faculty with data that can be used to guide planning and implementation of appropriate curricular and instructional changes to support and improve student learning (AAHEA, 2013).

Scientific Reasoning may be divided into reductionist science approaches and integrative science approaches or systems thinking. Reductionist science aims to create study and control groups that are as similar as possible except for the factor under investigation. Reductionist sciences begin with hypothesis generation which may result from inductive or deductive logic. Reductionist sciences aim at explanation or establishing the existence of cause and effect relationships including the efficacy of an intervention. Integrative sciences often build upon reductionist sciences. They draw from multiple disciplines incorporating multiple influences or determinants of outcomes; look for interactions between factors; and use evidence-based approaches to understand and propose strategies for addressing complex problems. (A A C & U STIRS project https://aacu.org/stirs/framework#one)

SFC GELO Scientific Reasoning: Understand scientific 1) concepts and 2) reasoning and 3) analyze and 4) interpret various types of data.

The extent to which students engage in Scientific Reasoning can be assessed using the criteria in the following rubric modeled after that reported by Puncochar and Klett (2013). Construction of their rubric followed assessment methods and practices recommended by Sundre et al. (2009) in a NSF funded project (DUE 0618599) to further the development of collegiate scientific and quantitative reasoning assessment tools and procedures**.** The rubric, devised by a team of professors, incorporates competency guidelines from the American Association for the Advancement of Science (AAAS), the National Research Council (NRC), and the National Science Teachers Association (NSTA). The four learning outcome criteria in the paragraphs below mirror the college's bulletin description of the core competencies expected of students associated with the SR GELO.

The following table lists the four learning outcomes that students should demonstrate proficiency in, with the level of proficiency commensurate with the level of the course. Also included are suggestions that instructors may wish to consider using to evaluate student proficiency in those areas. It is important to note that not all of the suggestions need be implemented for a successful evaluation, and this list of suggestions is not exhaustive; the instructor may find other ways to complete the evaluation.

Student learning outcome:	Assessment suggestions:
1. Demonstrate an understanding of key science concepts associated with the course	a. Vocabulary definitions b. Identification and Classification (use of a key or scheme of analysis, etc.) c. Understanding of discipline related fundamental theories d. Application of a model to new situations e. Interpretations based on fundamental theories
2. The ability to engage in a scientific reasoning process (steps of the scientific method, induction, deduction, hypothesis testing, etc.)	a. Distinguish between inductive and deductive inferences b. Recognize and develop testable (falsifiable) hypotheses c. Use of a hypothesis to develop testable predictions d. Demonstrate an understanding of fact vs. theory e. Demonstrate an understanding cause/effect vs. correlation f. Understanding of randomization and study vs. controlled groups g. Distinguish between experimental vs. observation study designs
3. The proper use of the scientific method (data analysis / mathematical tools)	a. Understanding of qualitative vs. quantitative data b. Able to distinguish dependent, independent, and controlled variables c. Appropriately records data d. Able to recognize relationships between variables e. Interpretation of data in both tabular and graphical forms f. Manipulation of relationships to solve problems (calculus, algebra, statistical or proportional arguments) g. Able to perform error analysis and order-of-magnitude estimates
4. The ability to interpret results and communicate their knowledge in both oral and written form appropriate to the discipline	a. Presentation of data in both tabular and graphical form b. Proper use of scientific terminology and language c. Proper technical writing format d. Clear presentation of evidence to support conclusions e. Class discussion assignments f. Projects (papers and/or presentations) g. Scientific posters h. Lab reports (individual reports, lab notebooks)

Puncochar and Klett (2013) report that laboratory reports, term papers, essays, and short answer problem-based items proved to be excellent articles for assessing science understanding and the use of scientific concepts, recognition and use of scientific reasoning methods, understanding general scientific principles, and the use of mathematics in scientific reasoning and / or problem solving.

The following rubric lists how to gauge students' mastery of the four aforementioned learning outcomes:

Assessment Rubric for Scientific Reasoning

Definition: Understand scientific concepts and reasoning and analyze and interpret various types of data

Learning Outcome	Level 4	Level 3	Level 2	Level 1 (novice)
1. Understanding of Key Science Concepts	Correctly uses science concepts to explain a variety of phenomena	Correctly uses some science concepts to explain phenomena	Provides proper descriptions or definitions of the concepts	Recognizes the concepts in descriptions or definitions
2. Engages in Scientific Reasoning Process	Correctly identifies all of the steps in the process and performs all of them correctly	Recognizes all of the steps in the process and performs some of them correctly	Recognizes most of the steps in the process and performs them with guidance	Can state some of the steps in the process but does not always define them correctly or recognize them in use
3. Use of Scientific Method	Collects, graphs, and/or interprets data appropriately and performs calculations of his/her own design	Collects, graphs, and/or interprets data appropriately and correctly performs calculations provided	Collects, graphs, and / or interprets data with guidance. Performs calculations provided with guidance.	Struggles to collect, graph, and/or interpret data. Struggles to perform calculations provided.
4. Communicate knowledge	Writes and speaks with clarity, communicates understanding, writes papers, essays, reports or maintains a lab notebook in proper format	Communicates a general understanding, writes papers, essays, reports with minimal errors or maintains a lab notebook in proper format with minimal errors	Communicates a general understanding, but does not always write papers, essays, reports with minimal errors or maintain a lab notebook in proper format	Uses some key words or phrases but does not communicate a general understanding. Writes papers, essays, reports with many errors. Unable to maintain a lab notebook in proper format

Notes for the GELO committee that evaluates the artifacts:

The committee members who evaluate the artifacts should check whether the artifact is capable of assessing each of the four student learning outcomes. This does *not* mean that the artifact must implement all of the assessment suggestions.

Secondly, the committee members may assess how finely the artifact can distinguish between different student mastery levels within each learning outcome, as per the mastery definitions within the Assessment Rubric.

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