



Basic Proficiencies in Scientific Reasoning

AS REVISED December, 2005

As approved by Faculty Senate February 1, 2006

This recommendation is submitted in response to the guidelines of the Undergraduate Education Initiative, a campus-wide review of FSU's undergraduate curriculum, as approved by the Faculty Senate in February, 2005.

Membership

The following FSU faculty members served on the planning group for the establishment of criteria for basic proficiencies in scientific reasoning:

Dr. Frank Ammer, Biology;

Ms. Tracy Edwards, Geography;

Dr. Scott Fritz, Biology;

Dr. Robert Larivee, Chemistry;

Dr. Oguz Soysal, Physics/Engineering.

Dr. Jim Limbaugh, Assistant to the Provost, served as convener and facilitator.

The Case for Scientific Reasoning

Our General Education Goals specifically cite a focus on students' attainment of core skills in scientific reasoning—to “demonstrate foundational abilities to apply different methods of inquiry from various perspectives and disciplines to gather information.” The establishment of this goal responds to our interpretation of what type of education our students will need in our rapidly-changing world.

The explosion of technology and its pervasive impact on virtually every segment of society requires that non-scientists have a basic understanding of science—not “a matter of fact accumulation [but] a keen appreciation of the places where science and technology articulate smoothly with one's experience of life” (Flower, 2000, p. 37). Hazen and Trifel (1991) articulate this same concern:

Most societal issues concerning science and technology require a broad range of knowledge. To understand debate over disposal of nuclear waste, for example, requires knowledge of how nuclei decay to produce radiation (physics), how radioactive atoms interact with their environment (chemistry), how radioactivity can enter the biosphere

(earth science), and how it will affect living things (biology.) Other issues, such as global warming, space research, and alternative energy sources likewise depend on a spectrum of scientific concepts, although clearly more than science is involved. (p. 64)

In many respects, a science-literate individual “needs to understand a little bit of several disciplines” (Hazen and Trifel, 1991, p. 64), a premise supported by Flower (2000):

A science-literate individual possesses a basic vocabulary of scientific concepts and terms, knowledge of the processes of science utilized to test our models for making sense of the world, and an appreciation of the effect of science and technology on society, to a degree sufficient to participate in dealing with the increasingly large number of science- and technology-laden public policy questions we face. (p. 38).

Hobson (2000) offers a view that, while almost alarmist in nature, still underscores the importance of scientific literacy: “Industrial society cannot survive unless citizens are literate about science-related societal issues” (p. 240). Even the American Association for the Advancement of Science issues a similar warning, expressing its view that in the 21st century a basic understanding of scientific principles should be considered as important as a liberal arts education (Wallace, 2000) and expressing the concern that our national lack of knowledge about the sciences “may also be hazardous to our national security” because of the possibility for error in making science-related policy decisions.

Because we have a responsibility as an institution of higher learning to develop science-literate individuals, the University will use the definition of scientific reasoning, as outlined in a following section, to help students develop skills in scientific reasoning and to guide assessments of student learning outcomes.

External Mandates

The development and assessment of core skills in general education also responds to the requirements of two external entities: The Maryland Higher Education Commission and the Middle States Association of Higher Education.

The Maryland Higher Education Commission has mandated that all Maryland institutions of higher education establish specific definitions and benchmarks regarding college-level skills in seven basic skills. In addition to scientific reasoning, these skills include written communication, critical thinking, quantitative reasoning, oral communication, technological literacy, and information literacy. Said benchmarks are to be assessed on a regular basis and reported to MHEC every three years, beginning in 2007.

The University’s accrediting agency, the Middle States Association of Higher Education, in its revised standards, also specifically mentions the need to assess students’ skills in scientific

reasoning. The accreditation standards of the Middle States Commission on Higher Education state that an institution's program of general education must be designed "so that students acquire and demonstrate college-level proficiency in general education and essential skills" including those cited above (*Characteristics of Excellence*, 2002, -p. 37).

Definition

Scientific reasoning is the ability to logically solve problems through the application of the scientific method which includes: Problem identification/observation; inductive and deductive reasoning; hypothesis generation; experimentation; interpretation of results; making logical conclusions and critical evaluations.

To be considered proficient in basic skills of scientific reasoning, a student at Frostburg State University will be able to

- Make observations and identify a problem,
- Classify and interpret data,
- Develop a hypothesis,
- Design experiments/collect data,
- Critically evaluate experimental outcomes.

Please note that this definition is subject to continual review and refinement as assessment results are analyzed in light of institutional learning goals.

Connection to Undergraduate Institutional Learning Goals

Frostburg State University's definition of quantitative reasoning supports the following Undergraduate Institutional Learning Goals:

- Liberal Knowledge and Skills of Inquiry, Critical Thinking, and Synthesis...specifically, "apply different methods of inquiry from various perspectives and disciplines to gather information" and "analyze complex issues and construct logical conclusions."

Assessment Strategies

To assess students' demonstration of scientific literacy as defined at Frostburg State University, the site for initial assessments will be the "Science, Technology, and Society" course (IDIS 160) developed as a result of the approval of the recommendations of the Undergraduate Education Initiative. These courses, due to their interdisciplinary nature, serve as an appropriate locus for assessment, since they are designed specifically to build in non-science majors an appreciation for basic concepts of science and its contribution to society. Ultimately, as the assessment rubric is refined and the definition is reviewed, the assessment sites will include other first-year courses in all branches of the natural sciences as offered by the University.

A grading rubric (see Attachment A) will be used by all instructors of IDIS 160 and, ultimately, of selected first-year natural science courses in the evaluation of an assignment presented for students' completion no earlier than the tenth week of the semester (for IDIS 160, this goal can be attained through the common syllabus developed to guide the thematic development of each section).

The assessment process will be ongoing, with results from each assessment becoming part of the discussion of continued improvement of student learning. Changes will be made as necessary in response to the results of assessment. Reports on student performance in the aggregate (not by individual class) will be shared with appropriate University constituencies.

Internal Benchmarks

Frostburg State University will report that its students are demonstrating basic skills in scientific reasoning if 70% or more of the students enrolled in IDIS 160 or any other first-year natural science course participating as an assessment site have attained a “meets standards” in ALL five portions of the grading rubric.

Timeline for Implementation

1. February 2006: Faculty Senate reviews criteria for scientific reasoning.
2. Spring 2006: Initial assessments are administered in IDIS 160 courses. Initial pilot course assessments are reviewed for sufficiency.
3. Fall 2006 and beyond: Additional courses are identified for assessment. Courses offered and assessed on an ongoing basis.

*Submitted by Jim Limbaugh, Assistant to the Provost
on behalf of the Faculty Planning Group for Scientific Reasoning
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References

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- Hazen, R., J. Trefil (1991). General science in college: The key to scientific literacy. *Education Digest* 57(4), pp. 64-67.
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- Wallace, E. (2000). Scientific literacy and national security: What's the connection? *Issue Brief*, October 27, 2000, retrieved November 7, 2005, from the American Association for the Advancement of Science: <http://www.aaas.org/spp/scifree/articles/102700.shtml>.