Mission-driven, Manageable and Meaningful Assessment of an Undergraduate Neuroscience Program

Gary Muir, St. Olaf College
Assoc. Professor, Psychology and Neuroscience Program
Director, Center for Innovation in the Liberal Arts
Acting Director, Evaluation & Assessment
ST. OLAF COLLEGE - Neuroscience Concentration

Intended Learning Outcomes

*Students will demonstrate:*

1. knowledge of neuroscience, including:
   a. history of neuroscience;
   b. fundamental principles of cellular and neuron-endocrine systems;
   c. scientific questions addressed by neuroscientists;
   d. methodologies employed in neuroscience research;
   e. the language of neuroscience, especially pertaining to interdisciplinary dialogue.

2. awareness of the scope of neuroscience including the breadth of the field, the diversity of research questions and approaches that compose it, and the thematic principles that unify and define it.

3. awareness that the scope of neuroscience necessitates an interdisciplinary perspective; they will show competence in approaching a problem using tools, symbols and paradigms from multiple disciplines.

4. familiarity with the scientific process, including the ability to independently
   a. critique and synthesize scientific literature;
   b. develop a testable hypothesis;
   c. identify and use appropriate instrumentation;
   d. design a controlled experiment;
   e. interpret data;
   f. communicate experimental results

5. knowledge of the breadth of careers available to neuroscience students and the educational steps and other activities prerequisite to these career paths, including technical competence and the ability to identify and use appropriate professional resources.
MIDDLEBURY COLLEGE – Neuroscience Major

Neuroscience Learning Goals

1. Students should demonstrate a broad intellectual foundation in neuroscience, including molecular, cellular, cognitive, philosophical, and systems-level perspectives, and should understand how those perspectives are interrelated.

2. Students should understand the significance of the scientific method as a route to understanding, including the importance of objective observation, hypothesis development, experimental design, statistical analysis, analytical reasoning, and arriving at conclusions based upon evidence.

3. Students should learn to critically assess neuroscience literature.

4. Students should develop their written and oral communication abilities, such that they can convey the essence of neuroscience to both technical and non-technical audiences.

5. Students should become proficient with neuroscience research techniques.

6. Because it reflects the nature of neuroscientific research, students should develop both the ability to work collaboratively, as well as independently, on scholarly projects.

POMONA COLLEGE – Neuroscience Major

Students should be able to independently:

1. describe the major areas of Neuroscience and current topics within them
2. demonstrate familiarity with basic neuroanatomy and nervous system function on a molecular, cellular and systemic level
3. read papers in the primary literature and
   - recognize
     1. the research question being asked and its significance,
     2. the hypothesis being tested,
     3. the predictions being used to test the hypothesis
   - evaluate
     1. the appropriateness of the experimental design
     2. the interpretation of the results
   - identify
     1. an appropriate next step to take in this research
4. identify a topic of current interest, develop a hypothesis in this area and design a research program to test this hypothesis
5. present the results of a scientific experiment or a proposed experimental design clearly in standard scientific written and oral formats
UNIVERSITY OF ARIZONA - Neuroscience and Cognitive Science - Undergraduate Major

Expected Learning Outcomes:

Learning outcomes for students in the Neuroscience and Cognitive Science major

The student learning outcomes listed below are divided into three areas: scientific inquiry, ethics and professionalism, and NSCS content-specific knowledge.

Scientific inquiry

The design of the NSCS major with regard to scientific inquiry reflects a tiered approach. Students will develop proficiency in the following abilities in core courses and enhance their competency in elective courses.

At the end of their course of study in neuroscience and cognitive science, students will demonstrate the ability to:

A. Think critically about complex problems involving the brain and the mind.
   Students will acquire a solid foundation of content knowledge about the nervous system and cognitive processes through core courses. These courses will emphasize the distinction between popular beliefs about the brain and mind and what can be concluded on the basis of current scientific knowledge.
   Elective courses will introduce more advanced students to current research issues that will require critical analysis.

B. Develop strategies to solve complex problems creatively and with cognitive flexibility.
   Core courses will introduce students to challenging problems involving the nervous system and the mind, and engage students in discussion and analysis of the societal implications of such problems, and how such problems might be addressed.
   Elective courses will provide students with opportunities to evaluate different approaches to problems involving the nervous system and cognitive processes.
   Independent study opportunities will allow students to initiate and investigate challenging research topics under the direction of a faculty mentor.

C. Engage in self-initiated learning and discovery.
   Upper-division course assignments will require students to identify research topics to investigate and evaluate using current scientific evidence.
   Students may choose to participate in research projects, guided by a faculty member.

D. Read and critically evaluate both formal scientific literature and scientific results disseminated through the mass media.
   Core courses will include assignments in which students must evaluate claims in mass media against what is known from the scientific literature.
   Core courses will include assignments in which students will be required to locate and review primary sources (scientific journals and papers).
   At the discretion of the instructor, students can receive partial course credit for attending colloquia and lectures by UA or visiting scientists (e.g., the College of Science NEXT lecture series, seminar series).

E. Effectively communicate (orally, written or electronic) the principles and concepts of biological and cognitive sciences to scientists, other students, and the public.
   400-level courses will include requirements for research papers and/or presentations.
F. Analyze and mine quantitative data, showing an understanding of fundamental concepts of statistics, simulations, and computational approaches to data analysis.
   Students will complete a core course in statistics and experimental design.
   Both core and elective courses will require students to analyze and interpret scientific data in course readings and assignments.

Ethics and professionalism
Students will:

A. Understand that the practice of science is governed by ethical and professional standards.
   In addition to discussion in core courses, students will be required to complete the online course in principles of scientific research with human participants and to attend an annual seminar on ethical issues/
B. Understand the complex interrelationship among science, technology, and society
C. Recognize the societal implications of developments in NSCS

NSCS Knowledge-specific outcomes
Students will:

A. Be familiar with experimental approaches and tools used in Neuroscience and Cognitive Science.
B. Have a firm understanding of core content, including:
   1. The molecular and cellular fundamentals of neural excitability and synaptic physiology.
   2. The principles of information processing in neuronal circuits and networks.
   3. The fundamental principles of sensory processing across modalities.
   4. The fundamental principles of motor system functioning.
   5. The general organization of the brain and its relation to physiological and cognitive processes.
   6. The basic principles of neural development.
   7. The range of typical and atypical cognitive processes and the pathological mechanisms underlying common diseases and disorders of the nervous system.
   8. The molecular, cellular, and cognitive bases of learning and memory.
   9. The basic principles of cognition, attention, language, emotion, and consciousness and the development of these functions.

NSCS Program outcomes
The NSCS major has been designed to accomplish 2 goals:

1. To provide a thorough education in the methods and ethics of scientific inquiry, using neuroscience and cognitive science as the disciplines for exploration. We believe that this will serve as the basis for acquiring the level of scientific literacy and the grounding in ethics needed by our citizens.

2. To provide graduates with breadth and depth of understanding about the field of neuroscience and cognitive science that will render them well qualified for admission to graduate or professional schools such as medicine, dentistry, veterinary medicine, nursing, pharmacology, psychology, and related fields. They will be competitive for positions in a variety of health-related industries, in high school and adult education, and in disciplines that increasingly require understanding of biology and biotechnology, including law, policy-making and business.
COLLEGE OF WOOSTER – Neuroscience Major

Neuroscience majors are expected to have completed a curriculum that enables them to demonstrate the following core competencies:

1. **Awareness of critical scientific principles.** Students are expected to be able to demonstrate a basic understanding of core disciplines that contribute to neuroscience, including basic principles in chemistry, mathematics, biology, and psychology.

2. **Awareness of experimental methodology, design and data analysis.** Students should be able to employ the scientific method for their own inquiry. The opportunities for developing skills in experimental design and methodology through participation in research and course-related laboratories should enable neuroscience majors to choose and perform appropriate statistical analyses for their experimental results and interpret those results.

3. **Awareness of historical trends and theoretical perspectives that inform the field.** Students should be able to demonstrate knowledge of the scientific history and the major theoretical perspectives that inform the field.

4. **Advanced awareness of a particular area of study within neuroscience.** By narrowing the focus to a particular area of the larger field of neuroscience at the advanced level, students should be able to demonstrate a mastery of the literature, laboratory methods, and their ability to perform independent research. To facilitate this goal, students should plan and complete elective coursework that leads to and supports their Independent Study project.

5. **Critical thinking and independent thought.** The development of critical thinking skills is a necessary component of any liberal arts curriculum, and neuroscience education is not unique in this respect. Neuroscience majors should be able to demonstrate critical thinking skills as a direct result of our instructional practices.

6. **Effective communication skills.** Students should be able to demonstrate the ability to communicate effectively across various formats including oral and written communication. In addition, students should be able to demonstrate technical proficiency, not only with graphical programs in order to present their ideas as figures or graphs, but also with aspects of instructional technology, such as webpage construction and presentation software.

7. **Ethics.** Students should be able to demonstrate an understanding of the ethical principles of science and be able to articulate the reasons that ethical conduct in science is important, including the concept of personal responsibility for research conduct, the treatment of human and animal subjects, and the trust that clinicians and patients must place on research findings.

**Programmatic Goals**

**Awareness of Humanities, Social Sciences and other fields.** In accord with the liberal arts tradition, neuroscience majors should have completed course work to inform their perspective in a variety of subject areas outside the natural sciences. Students should work closely with advisors to ensure appropriate breadth in their undergraduate curriculum and understand how these disciplines can inform their own.

**Career planning.** We expect that our graduates will have been afforded the opportunity in the course of their undergraduate years to be informed of the various career possibilities that exist for neuroscience graduates, and to have received advising relevant to the accomplishment of the individual student’s career goals.
# COLLEGE OF WOOSTER - Neuroscience Rubric for I.S. Assessment of Experimental Methodology, Design and Data Analysis (ILO#2)

## METHOD

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Not Addressed</th>
<th>Some Attention to Criterion</th>
<th>Moderate Level of Achievement</th>
<th>Good Level of Achievement</th>
<th>Outstanding Achievement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organization and Design</td>
<td>Contains many unnecessary descriptions of procedures.</td>
<td>Contains a number of unnecessary and disruptive descriptions of procedures.</td>
<td>Contains some unnecessary descriptions of procedures.</td>
<td>Good level of detail, but contains minor unnecessary descriptions of procedures.</td>
<td>Does not contain unnecessary descriptions of procedures and does outline relevant procedures with appropriate detail. Pattern of organization makes it easy to follow. Presents sequential information in appropriate chronology.</td>
</tr>
<tr>
<td>Pattern of organization is difficult to follow.</td>
<td>Pattern of organization is generally easy to follow. Presents some sequential information in a disorganized, difficult pattern.</td>
<td>Design is good in purpose and audience. Bias and confounds are well minimized. Appropriate sample size used. Data are suitable for appropriate statistical analyses.</td>
<td>Design is good in purpose and audience. Bias and confounds are well minimized. Appropriate sample size used. Data are suitable for appropriate statistical analyses.</td>
<td>Student selects variables that are appropriate for research purpose and audience. Research is designed to allow appropriate statistical analysis, but research is weakened by bias, confounds, or small sample size.</td>
<td></td>
</tr>
<tr>
<td>Student designs a poor research project with inappropriate variables or inability to evaluate data set.</td>
<td>Student shows multiple problems with research purpose and audience. Major weaknesses in ability to evaluate data statistically. Bias, confounds, OR inappropriately small sample sizes, OR inappropriate variables selected.</td>
<td>Student selects variables that are appropriate for the research purpose and audience. Research is designed to allow appropriate statistical analysis, but research is weakened by bias, confounds, or small sample size.</td>
<td>Student selects variables that are appropriate for research purpose and audience. Research is designed to allow appropriate statistical analysis, but research is weakened by bias, confounds, or small sample size.</td>
<td>Student selects variables that are appropriate for research purpose and audience. Research is designed to allow appropriate statistical analysis, but research is weakened by bias, confounds, or small sample size.</td>
<td></td>
</tr>
</tbody>
</table>

## Appropriate Level of Detail for Replication

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Not Addressed</th>
<th>Some Attention to Criterion</th>
<th>Moderate Level of Achievement</th>
<th>Good Level of Achievement</th>
<th>Outstanding Achievement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Describes the experiment so poorly or in such a nonspecific way that it cannot be replicated and lacks replication of operational definitions.</td>
<td>Presents an experiment that is marginally replicable, where parts of the basic design must be inferred, and fails to construct a comprehensive operational definition.</td>
<td>Lacks some major methodological information OR presents only an implied comprehensive operational definition and some specific operational definitions.</td>
<td>Good overall level of detail, but does not present enough detail in secondary or minor methodologies for complete replication.</td>
<td>Contains effective, quantifiable, concisely organized information that allows the experiment to be replicated. Student constructs stated comprehensive operational definitions and well-developed specific operational definitions.</td>
<td></td>
</tr>
</tbody>
</table>

## RESULTS

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Not Addressed</th>
<th>Some Attention to Criterion</th>
<th>Moderate Level of Achievement</th>
<th>Good Level of Achievement</th>
<th>Outstanding Achievement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Analysis</td>
<td>There is no attempt to summarize or evaluate the data and only raw data are reported.</td>
<td>Data are not analyzed beyond the descriptive level; inferential statistics are not performed or are performed incorrectly.</td>
<td>Some analyses may not be appropriate for the research question or analyses may not have been properly performed; descriptive statistics may be adequate, but inferential statistics are inadequate.</td>
<td>Choice of methods of summarizing and analyzing data are appropriate for the data, and for answering the fundamental research question; statistical analyses are performed properly; data analysis may be incomplete; basic analyses are done, but some important follow-up or post hoc analyses are not performed; analyses, though correct, are lacking in thoroughness.</td>
<td>A clear description of the data and statistical methods employed is provided. Methods of summarizing and analyzing the data are ideal for the hypotheses of the I.S. and the data collected. Data analysis is complete and thorough. Analyses are performed and reported properly.</td>
</tr>
<tr>
<td>Graphs/tables are missing or wholly inadequate for purposes of presenting the findings of the study; if present, graphs/tables have been prepared or drawn incompletely or carelessly.</td>
<td>Graphs/tables do not clearly or effectively present the results; captions, labels or legends are missing or inappropriate; too much or too little information is presented in the graphs/tables; graphs/tables are sloppy and appear to have been prepared in a haphazard manner.</td>
<td>Captions, labels or legends may be partly inadequate or missing; an inappropriate type of graph may be used for the specific type of variable used; graphs may be too &quot;busy,&quot; or have too much wasted space; size of graph as prepared is inappropriate (too small or too large) for the circumstances; graphs/tables are inadequate but could have clearer visual appeal.</td>
<td>Figures and tables are appropriate, but do not present the results in a completely clear way; captions, labels, or legends are not completely descriptive of what is displayed on the graph/table; graph/table may be difficult to interpret; graphs may be lacking in visual appeal.</td>
<td>Figures and tables are clear and effectively represent the findings of the study; the graphs/tables are effectively captioned and labeled and have descriptive legends; graphs/tables are visually appealing and readily understood.</td>
<td></td>
</tr>
</tbody>
</table>
**Student Learning Outcomes**

1. Students will be able to articulate the concepts and methodologies of the interdisciplinary field of Neuroscience and Behavioral Biology, including evolution and animal behavior, molecular, cellular, and developmental biology, and systems, social, cognitive, and behavioral neuroscience.
2. Students will be able to evaluate scientific literature critically and to formulate hypotheses and design scientific experiments.
3. Students will be able to engage in the research process through undergraduate honors research, independent research projects and coursework.
4. Students will be able to communicate scientific information in a clear, reasoned and stylistically appropriate manner both verbally and in writing.
5. Students will be able to evaluate the ethical dimensions and societal implications of research in Neuroscience and Behavioral Biology.
6. Students will have the foundation to pursue successfully a post baccalaureate education and/or professional career.

**Assessment Summary**

<table>
<thead>
<tr>
<th>What outcomes from the above list did you assess this year?</th>
<th>What methods did you use to gauge student achievement of these outcomes?</th>
<th>Findings: What did you learn from your assessments?</th>
<th>Action Plans: How will you use your findings to strengthen student learning in the future? Where possible, specify 1) target date for implementation; 2) who will oversee the action; and 3) resources needed.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Students will be able to articulate the concepts and methodologies of the interdisciplinary field of Neuroscience and Behavioral Biology, including evolution and animal behavior, molecular, cellular, and developmental biology, and systems, social, cognitive, and behavioral neuroscience.</td>
<td>1. We obtained written feedback from the instructors of the core course sequence (NBB 201, 301 and 302). 2. We examined student performance on scientific critiques written for our required senior capstone seminar course (NBB 401) and are in the process of developing a grading rubric for those critiques. 3. Graduating seniors completed a survey.</td>
<td>1. The consensus was that the first three core courses do a very good job of covering most of the key areas of NBB listed in goal #1 except perhaps for cognitive neuroscience. Approximately 80% of students reach a level of very good to excellent performance on this goal. 2. Students are required to write scientific critiques covering a broad range of topics in NBB. Most students do a very good job of meeting this goal, demonstrating a solid grasp of the key concepts and methodologies from a broad range of topics. 3. Most students felt that they learned a lot from their introductory courses and that these courses should be required.</td>
<td>Due to the fact that the program is currently doing a good job of meeting this goal, major changes are not envisioned. The curriculum committee meets regularly and one of its primary functions is to make adjustments to the courses so that we do a good job of addressing this goal. The faculty recently decided that we would develop a Neuroscience Concepts Inventory and use it as the primary means of assessing performance on this goal. This will provide more detailed and specific information about how well our students are achieving this goal. The target date is Winter break.</td>
</tr>
</tbody>
</table>

**Assessment Plan**

<table>
<thead>
<tr>
<th>What outcomes will you assess in 2011-2012?</th>
<th>What methods will you use?</th>
<th>Achievement Targets: What is the overall level for satisfactory performance as determined by your departmental/program faculty?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Students will be able to articulate the concepts and methodologies of the interdisciplinary field of Neuroscience and Behavioral Biology, including evolution and animal behavior, molecular, cellular, and developmental biology, and systems, social, cognitive, and behavioral neuroscience.</td>
<td>1. Development and administration of a Neuroscience Concepts Inventory. 2. Assessment of student performance on scientific critiques written for our senior capstone seminar course using a grading rubric. 3. Senior survey.</td>
<td>1. The faculty recently that we would develop a Neuroscience Concepts Inventory and use it as the primary means of assessing performance on this goal. We would like 80% of our graduating seniors to achieve a score of very good or excellent on this inventory. 2. We will continue to develop the grading rubric for scientific critiques written for NBB 401. We would like 90% of our students to demonstrate at least good performance and for 75% to achieve very good to excellent performance in meeting this goal. 3. We intend to revise our senior survey to improve its value as an assessment tool. We would like at least 85% of seniors to feel confident or very confident that they can meet this goal.</td>
</tr>
</tbody>
</table>
Critical Thinking: A Valuable Rubric

For more information, please contact us:

Critical Thinking: A Valuable Rubric

1. Analyze: Information that is intended to be interpreted in a non-linear way for context. The way “we think with data” is intended to convey an outcome of analysis, not a linear tale.
2. Consider: The historical context of political, cultural, or environmental shifts or conditions that influence and complicate the consideration of many ideas, agendas, and viewpoints. Information that may be interpreted in many different ways.

The definition that follows were developed by John Hume and adapted in the context of

For more information, please contact us:

Critical Thinking: A Valuable Rubric

1. Analyze: Information that is intended to be interpreted in a non-linear way for context. The way “we think with data” is intended to convey an outcome of analysis, not a linear tale.
2. Consider: The historical context of political, cultural, or environmental shifts or conditions that influence and complicate the consideration of many ideas, agendas, and viewpoints. Information that may be interpreted in many different ways.

The definition that follows were developed by John Hume and adapted in the context of
Critical Thinking Value Rubric