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ARTICLE

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

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Academia has recently been under mounting pressure to increase accountability and intentionality in instruction through development of student "intended learning outcomes" (ILOs) developed at multiple levels (e.g., course, program, major, and even institution). Once these learning goals have been determined, then classroom instruction can be purposefully designed to map onto those intended outcomes in a "backward design" process (Wiggins and McTighe, 2005). The ongoing challenge with any such process, however, is in determining one's effectiveness in achieving these intended learning goals, so it is critical that efficient tools can be developed that enable these goals to be assessed. In addition, an important requirement of any ILOs is that they are mission-driven, meaningful and parsed in such a way that they can be used to obtain evidence in a manageable way. So how can we effectively assess these outcomes in our students? This paper describes key factors to consider in the planning and implementation of assessment for an undergraduate neuroscience program.

Key words: neuroscience program, neuroscience curriculum, assessment, evaluation, Intended Learning Outcomes (ILOs), curriculum mapping, backward design

Assessment. For many faculty, this single word evokes a negative response…and often a strong one. But while the exact reason faculty may have this reaction varies, what all faculty have in common is that they are expected to conduct more assessment now than ever before, and this is only likely to increase in the foreseeable future. This increased emphasis on assessment comes about in part as a result of increasing external pressures from accreditation bodies, but also from recognition that there is real value to assessment that is done well for students, faculty, programs, and institutions.

For some, the problem with assessment lies in it being seen as "just one more thing to do," but in the case of most faculty it is not something more for them to do because they are, in fact, already doing it. Walvoord (2004) points out that if you have ever said…"Hmmm, they did better on X this semester but Y is still a problem. I wonder if they could learn it better if I…."…then you have already been engaged in "stealth" assessment! Defined in this way, most faculty at some time or another have been doing assessment, and many may be constantly engaged in assessment without actually thinking of it in those terms.

Faculty feelings around assessment can also be the result of frustration about the process. Faculty may see assessment as a time-consuming and meaningless endeavor, and, regrettably, sometimes those perceptions are accurate. To achieve effective assessment and avoid this problem, it is critical that assessment be:

- **Mission-Driven**: How does your assessment connect to the mission and goals of your program, department, and/or institution?
- **Meaningful** (utilization-focused): Who will use the evidence that is gathered, and for what purpose?
- **Manageable**: How will this actually get done given the resources you have available?

(Walczak et al., 2009)

These three points provide a useful framework for basing decisions on when planning any effective and successful assessment exercise. The remainder of this article will provide an overview of planning assessment based on this framework, particularly at the program-level.

Defining assessment

The purpose of assessment is to provide systematic, summarized information about the extent to which a group of students has realized one or more Intended Learning Outcomes (ILOs). In this way, assessment is the systematic collection and analysis of information to improve student learning. Importantly, assessment is not about getting it perfect, instead, it is all about improving student outcomes. Assessment, therefore, can provide tools for monitoring student learning (*formative assessment*) and evaluating student learning (*summative assessment*). Finally, assessment is not a one-time event, but a dynamic, on-going process.

Assessment can occur at multiple levels (or units of analysis):

1. **Classroom assessment**: assessment of individual students at the course level, typically by the class instructor
2. **Course assessment**: Assessment of a specific course
3. **Program assessment**: Assessment of academic and support programs
4. **Institutional assessment**: Assessment of campus-wide characteristics and issues.

(Palomba and Banta, 1999)

Assessment at each of these levels will demonstrate different aspects of student learning, and a robust assessment program will be one that not only conducts assessment at all of these levels, but also connects them to each other in **meaningful** ways. For example, the connection must be clearly made that students successfully achieving their learning outcomes in individual *courses* is what ultimately leads to students successfully achieving many of the intended learning outcomes of a *program*.

Program-level Assessment

Program-level assessment involves the systematic and ongoing method of gathering, analyzing and using information from various sources about a program and measuring program outcomes in order to improve student learning (Figure 1). In this way we can assess student learning and experience to determine whether students have acquired the skills, knowledge, and competencies associated with their program of study. Further, we can obtain an understanding of what the program's graduates know, what they can do, and what they value because of this knowledge.

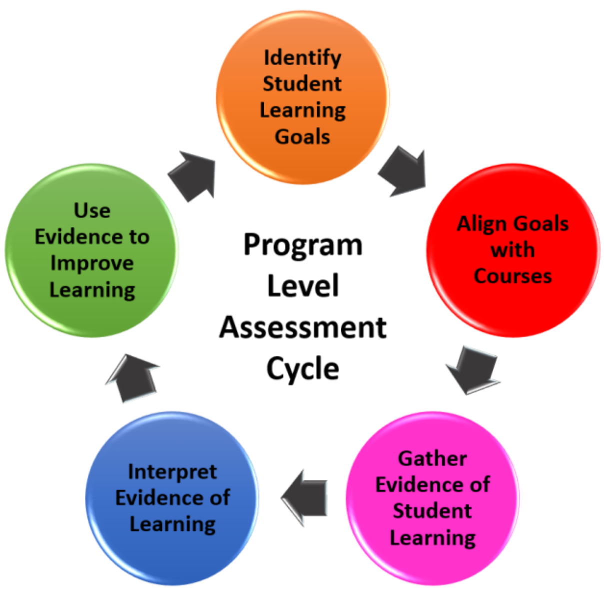

Figure 1. The Program-level Assessment Cycle (modified from Maki, 2002, 2004).

In contrast, it is important to identify what program-level assessment should NOT be:

- An evaluation of individual students
- A tool for faculty evaluation
- Strategic planning
- Optional
- The job of one faculty member
- Done by the Administration
- A meaningless bureaucratic exercise
- A waste of time, time consuming and complex
- The same plan used every year
- Mere compliance with external demands

Not surprisingly, the negative associations faculty have with assessment is often because their previous experience with assessment has violated one or more of these assessment "don'ts." Importantly, it should be noted that many items on this list in some way violate the requirement that assessment be **mission-driven**, **meaningful** and **manageable**.

Getting started with assessment

There are three steps to assessment (Walvoord, 2004):

1. Articulate your Goals
2. Gather Evidence
3. Use Information for Improvement

1) Articulate your goals

Developing an Assessment Plan

An assessment plan specifies a well-defined systematic approach to conduct outcomes assessment in the context of the college's mission. The Plan guides the assessment efforts and should specify:

- ***Content***, assessments taking place based on the program's needs, including Intended earning Outcomes (ILOs).
- ***Focus***, an informal document to be internally distributed or formal for an external audience.
- ***When*** assessments will take place, timeline or schedule for implementation and continuance.
- ***Who*** will be involved in the various steps of the evaluation process, distinct division of labor, evidence of faculty and student involvement.
- The anticipated ***Consequences*** of that process.

Developing Intended Learning Outcomes (ILOs) for a Neuroscience Program

Part of a Neuroscience program-level assessment plan should include the development of Intended Learning Outcomes (ILOs) for the program. **Backward design principles** (Wiggins and McTighe, 2005) provide a very effective approach to structuring programs with "good design – of curriculum, assessment, and instruction – focused on developing and deepening understanding of important ideas" (p.3). The critical component of backward design is that we *begin* our design process by asking what it is we want our students to have learned by *the end* of the program. Once we have identified those goals and the explicit intentions guiding our program, we can then determine what acceptable evidence for having met those goals might look like. Once we have designed specific ways to assess whether we have been effective at achieving our desired goals, can we then construct a plan of learning experiences and instruction to guide student learning toward those goals. These backward design principles force us to critically reflect on what the learning benefit is to the student in these situations and how such an approach affects our students' ability to achieve the set intended goals.

Several very useful guidelines exist for structuring the undergraduate neuroscience curriculum (Ramirez, 1997; Wiertelak, 2003; Wiertelak and Ramirez, 2008) and these can be used in helping identify ILOs we want for students coming out of a neuroscience program. Note also that while these guidelines are very consistent in some areas – for example, all incorporate some level of increased knowledge of experimental methodology in their goals – they remain flexible enough to be relevant to the wide variety of program types that exist in neuroscience (Wiertelak and Ramirez, 2008).

Kerchner, Hardwick, and Thornton (2012) surveyed faculty on what they considered to be 'Core Competencies' in an undergraduate neuroscience program and the use of those core competencies for assessment purposes. Faculty identified the top five core competencies as being (in rank order from highest rated): critical/integrative thinking; basic neuroscience knowledge; scientific inquiry/research skills; independent thinkers/self-motivated learners; communication skills; and quantitative skills.

Consistent with these guidelines and core competencies, a review of a small sample of Neuroscience program-level ILOs posted on program websites from Pomona College, Middlebury College, University of Arizona, College of Wooster, and St. Olaf College shows that all have a similar ILO around students demonstrating an "Awareness of experimental methodology, design and data analysis."

It is notable, however, that only between 20-40% of respondents in Kercher et al. (2012) reported that assessment of these top five core competencies was used in program-level assessment. In contrast, 50-70% of respondents reported that assessment of these same core competencies was used in individual student-level assessment, and this suggests that there is a common disconnect between how goals for students and for programs are assessed when they should be intentionally and explicitly connected.

Finally, consider involving students in the process of course/curriculum design (Cook-Sather et al., 2014) and developing program ILOs.

Writing measurable ILOs

Having well-defined and measurable ILOs clarifies expectations of students; what you expect them to be able to do, and what they can expect to learn in your course. Further, clear ILOs give the instructor a set of reference points against which student performance can be measured. This helps the instructor step outside the content of their course and think about it in a larger context, and makes it easier to create tests and assignments to evaluate student performance. Ideally these ILOs will have clear and measurable outcomes that: have a clear *purpose;* use *action words* (for example, see McBeath [1992] for action verbs that correspond with each level of Bloom's Taxonomy*);* describe *meaningful* learning; result in *observable* behaviors/products; represent *high level* learning; and are easily *understandable*. While it can take faculty involved in a program some time to design and craft ILOs that meet these objectives, investing the initial time to do these well will greatly help in effectively gathering the desired information about student learning and avoiding later problems with the assessment process.

2) Gather Evidence

Assessing Program-level ILOs

Once program-level ILOs have been written, it is important to 1) construct a Curriculum Map to identify where students are gaining experiences that will help them reach those program ILOs, and 2) conduct a Program Assessment Audit to identify what assessment is already occurring in the program that could be used in assessing ILOs, and where it is occurring in the program curriculum (Table 1).

Intended Learning Outcomes	**Neuro 101 (100-level Course)**	**Neuro 201 (200-level Course)**	**Neuro 301 (300-level Course)**	**Capstone Course**	**Outside Class**
Apply specific theory	Pretest (D)	Embedded Questions (D)	Independent Project (D)	Posttest (D)	
Acquire necessary skills and knowledge	Knowledge Pretest (D)	Skills Pretest (D)	Practical Assessment (D)	Team Project (D)	Senior Survey (I)
Proficiency in written communication skills	Paper (D)			Comprehensive Paper (D)	
Prepare for post-graduate opportunities					Senior Survey (I) Placement Data (I)

Table 1. A curricular map and assessment audit from a fictional neuroscience program. D = Direct assessment; I = Indirect Assessment

Direct and Indirect Assessment

There are two main types of assessment evidence that can be collected from students:

1. ***Direct assessment*** is evidence of *what* students actually know, can do, or care about by directly assessing their work. Some common **direct** assessment "artifacts" are:
   - Theses, papers, essays, abstracts – individually or in a portfolio
   - Presentations and posters
   - Oral or written examination items
   - Responses to survey or interview questions that ask for examples of knowledge, practice, or value
   - Some Classroom Assessment Techniques (CATs) (Angelo and Cross, 1993). Some advantages of CATs are that they are *authentic* (students are already being assessed as part of the course), *flexible* (many different types of assessment can be used), and *transparent* (criteria for success clear to both students, faculty, and outside constituencies).

2. ***Indirect assessment*** is evidence of learning-related experiences or perceptions, *how* or *why* they learned (or didn't) and affective aspects of learning. Some common **indirect** assessment "artifacts" are:
   - Course mapping, course-taking patterns or transcript analysis
   - Responses to survey or interview questions about experiences, perceptions, self-reported progress, or impact of program experiences
     e.g., "When taking into consideration all of your Neuroscience courses and your [research] project, to what extent did the Neuroscience major enhance your ability to design a strong experiment? Indicate any particular courses that you believed developed this skill and how they helped."
   - Reflective journals

It is often very useful to pair indirect observations of processes and perceptions with direct observations of outcomes since they provide evidence of different aspects of student learning. Further, it is usually beneficial to assess a specific ILO using multiple, complementary methods.

Rubrics can be an effective tool for measuring learning using direct assessment artefacts, in part, because they can increase the reliability of the results. For example, AAC&U VALUE rubrics can be used for assessing learning across 16 areas, including critical thinking, problem solving, and quantitative literacy. Alternatively, rubrics can be designed locally to assess specific aspects of a neuroscience program, such as the rubric created to assess the *Experimental Methodology, Design and Data Analysis* ILO in the College of Wooster Neuroscience Program (Table 2).

Assessing an ILO in an Undergraduate Neuroscience Program: An Example

Crisp and Muir (2012) describe an attempt to empirically assess the following ILO for the Neuroscience Concentration (similar to an interdisciplinary minor) at St. Olaf College:

> "Students will demonstrate 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."

In that article we assessed the development of an interdisciplinary perspective in undergraduate students taking a core neuroscience course (Neuro234) using two simple assessment instruments, but I will only mention one here. Students (n=25) wrote in class for 10 minutes in response to the open-ended question *"What is neuroscience?"* at the beginning (Week 1) and then again at the end of the semester (Week 15). These hand-written responses were transcribed and analyzed for changes in use of disciplinary and interdisciplinary concepts and terminology from PRE- to POST-test in individual students. In summary, results showed that from PRE to POST, 1) students wrote longer answers to the prompt, 2) used significantly more integrative terms in their responses, and 3) referenced more disciplines significantly more often.

As a part of the 2014 FUN Summer Workshop session on which this article is based, faculty workshop participants (n=50) were also asked to write a response to the prompt *"What is neuroscience?"* to demonstrate how this assessment could be used. In contrast to asking for hand-written responses, however, responses were collected via participants' own devices using the free PollEverywhere polling software (www.polleverywhere.com). A word cloud of faculty responses could then be immediately shown to the participants where the relative frequently of the terms were represented in the font sizes (where more frequent terms had larger font sizes). These word clouds can provide a useful first pass of such qualitative data because major differences between the frequencies of terms used across these three groups may be visible at a glance. For example, it is obvious from the word clouds (generated using the free tool at www.Wordle.net) that the term "interdisciplinary" occurs significantly more frequently in the faculty responses (Figure 4) than in both PRE (Figure 2) and POST (Figure 3) student responses. Similarly, it is clear that the term "neuroscience" appears significantly more frequently for PRE and POST students than for faculty. It should be noted, however, that this could well be a result of students being more likely than faculty to begin their answer to the question "What is Neuroscience?" with "Neuroscience is…" In addition, responses were stored on the PollEverywhere site, and this allowed for further analysis of the complete responses at a later date.

Quantitative analysis of the relative frequency of selected terms across groups confirmed the initial impression conveyed by the word clouds (Figure 5).

METHOD

Criterion	1 Not Addressed	2 Some Attention to Criterion	3 Moderate Level of Achievement	4 Good Level of Achievement	5 Outstanding Achievement
Organization and Design	Contains many unnecessary descriptions of procedures.	Contains a number of unnecessary and disruptive descriptions of procedures.	Contains some unnecessary descriptions of procedures.	Good level of detail, but contains minor unnecessary descriptions of procedures.	Does not contain unnecessary descriptions of procedures and does outline relevant procedures with appropriate detail.
	Pattern of organization is difficult to follow.	Pattern of organization is difficult to follow at times.	Pattern of organization is generally easy to follow. Presents some sequential information in a disorganized, difficult pattern.	Very good organization is the general pattern.	Pattern of organization makes it easy to follow. Presents sequential information in appropriate chronology.
	Student designs a poor research project with inappropriate variables or inability to evaluate data set.	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.	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.	Design is good in purpose and audience. Bias and confounds are well minimized. Appropriate sample size used. Data are suitable for appropriate statistical analyses.	Student selects variables that are appropriate for research purpose and audience. Demonstrates ability to eliminate bias and minimize potential confounds. Appropriate sample size. Good design for statistical analyses. Superior research project.

Table 2. A portion of the rubric for assessment of the *Experimental Methodology, Design and Data Analysis* ILO in the College of Wooster Neuroscience Program.

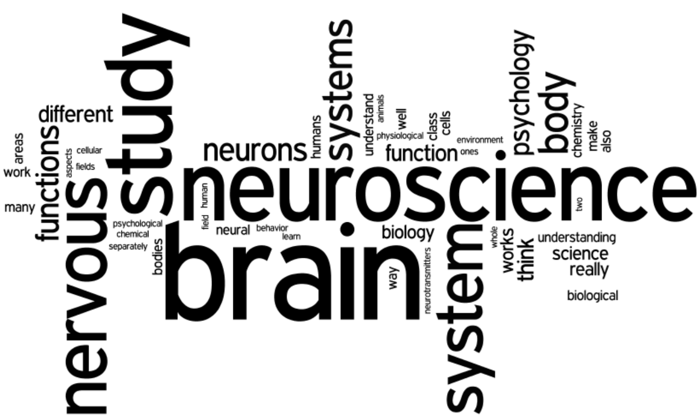

Figure 2. Word Cloud of top 50 words in student (n=25) PRE responses. Larger terms are those more frequently occurring in responses.

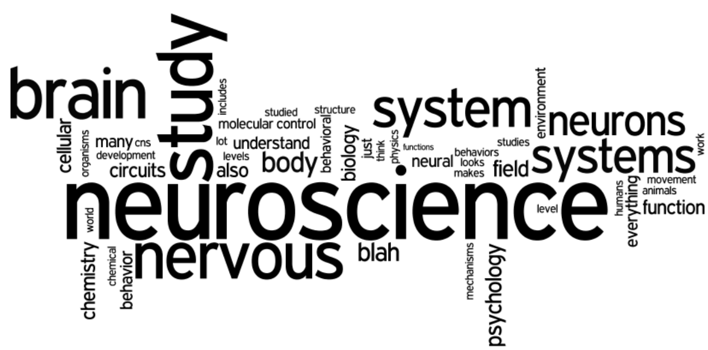

Figure 3. Word Cloud of top 50 words in student (n=25) POST responses. Larger terms are those more frequently occurring in responses.

Interestingly, this analysis shows that the terms “multidisciplinary” and “interdisciplinary” are seen almost exclusively in faculty responses (e.g., “interdisciplinary” faculty=16/50 responses; PRE = 0/25 responses; POST = 2/25 responses). In contrast, specific disciplines or disciplinary terms, such as chemistry, biology and psychology, appear much more frequently in student responses (especially in the POST group) than in faculty responses (e.g., “psychology*” faculty=3/50 responses; PRE = 8/25 responses; POST = 9/25 responses). Because faculty workshop participants were not given exactly the same time as students to respond to the prompt, and the method of collection was different (handwritten vs. via a device), the number of words in responses could not be compared.

While these results should be considered preliminary at best, it is interesting to speculate whether these differences might reflect differences in novice and expert (Bransford et al., 2000) definitions of the “interdisciplinary” nature of neuroscience, with experts seeing “interdisciplinary” as an integration of disciplines, and novices seeing “inter-disciplinary” more as a collection of separate disciplines. Similarly, decreasing references to “brain” from PRE to POST to faculty might also reflect a movement in thinking from novice to expert as students move away from the notion that, as one PRE response stated, “neuroscience is the study of the brain.” In summary, it is worth noting that using a simple assessment tools such as the one I describe here, can provide us with useful quantitative and qualitative results about what our students are learning and how their thinking is changing as a result.

How will you measure success?

This can be a difficult question for programs to answer, but as with most other aspects of assessment, the clearer we can be about our goals, the more effective and useful to us our assessment endeavor will ultimately be. Criteria are most often stated in terms of percentages, percentiles, averages, or other quantitative measures. For example, the Neuroscience and Behavioral Biology at Emory University states a goal of having 80% of graduating seniors achieve a score of very good or excellent on their Neuroscience Concepts Inventory. For each learning outcome, it is useful to describe where you would like to be within a specified time period (e.g., a 10% improvement in student performance within two years). Note that maintenance of your existing successes is also acceptable as a measure of success. In addition, qualitative measures of success may also be developed, if desired.

Keep it Manageable!

As mentioned earlier, it is fundamental to keep whatever assessment you are doing **manageable**. When assessment becomes unimaginable, it is not done effectively and it is also less likely to be **meaningful** as a result. One very helpful way to keep assessment manageable is to use course-embedded assessment, whenever possible. Embedded assessment utilizes artefacts generated by students as part of their existing coursework instead of requiring additional assessment artefacts generated by students solely for program-level assessment. Similarly, while faculty may be assessing student work against a different (but necessarily related) set of program-level ILOs than the course-level ILOs, faculty will be assessing students on assignments they would already be assessing as a part of the course so embedded assessment also minimizes the amount of extra work for faculty. Another way to keep it manageable is to only assess a subset of a limited number of outcomes. For example, a program may choose to assess only one program-level ILO per year. Finally, it is important to build in time for reflection in the assessment cycle so that assessment data are not being collected without the opportunity to deeply consider the results and their implications for the program.

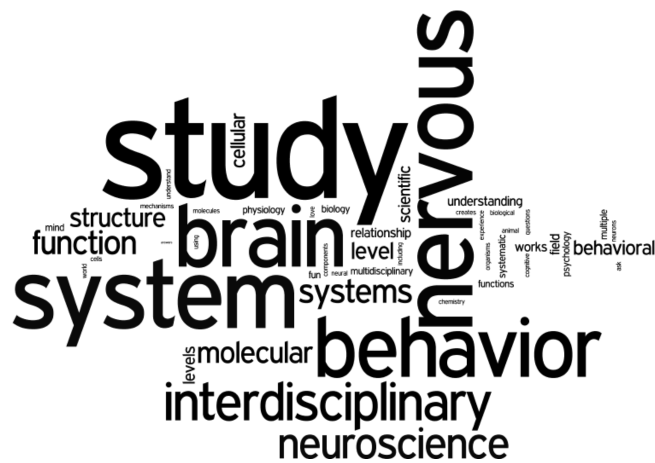

Figure 4. Word Cloud of top 50 words in faculty workshop participant (n=50) responses. Larger terms are those more frequently occurring in responses.

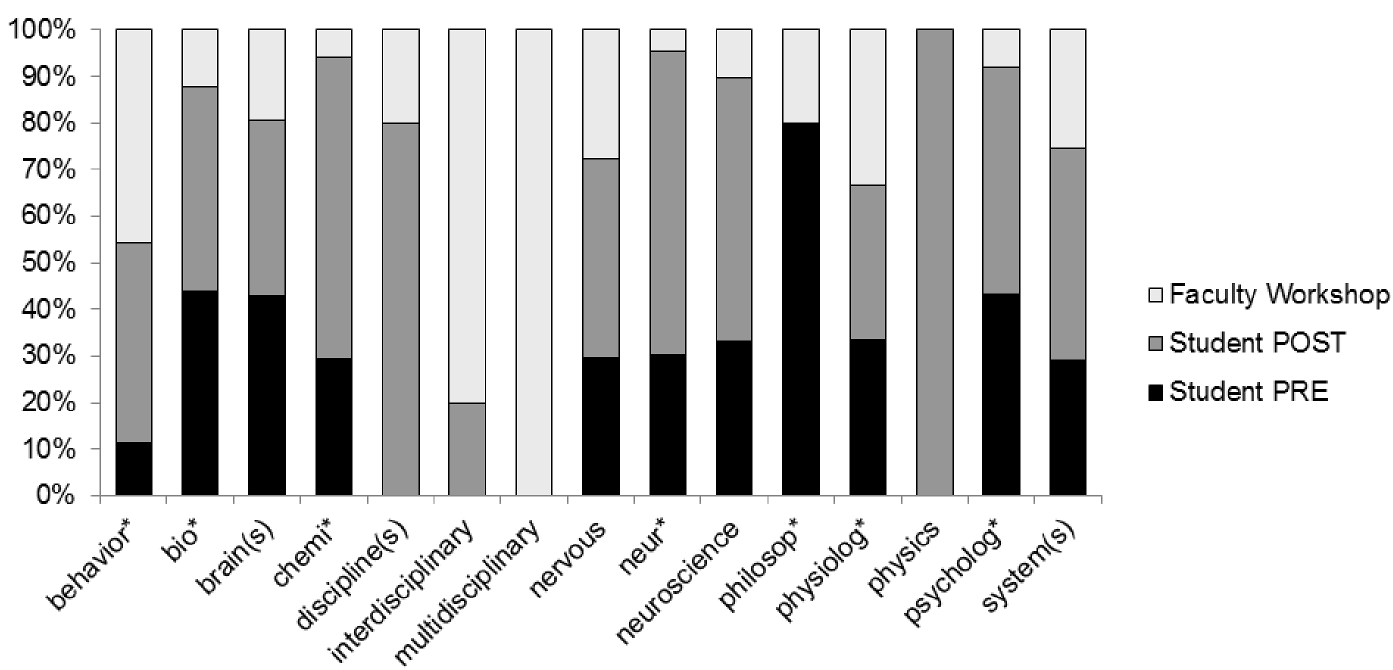

Figure 5. Relative differences in the frequency of terms used by groups in response to the prompt “What is Neuroscience?” The terms “multidisciplinary” and “interdisciplinary” are seen almost exclusively in faculty responses. In contrast, specific disciplines or disciplinary terms, such as chemistry, biology and psychology, appear much more frequently in student responses (especially in the POST group) than in faculty responses. * denotes word stems with wildcard characters were included. Note that the term “neuroscience” was analyzed separately from the word stem/wildcard term “neuro*”.

What courses, programs, services, activities, and other learning experiences does St. Olaf provide to help students achieve each of the goals?

Learning Goal	General Education	Major/Concentration	Academic Services and Support	Experiential Learning Student Employment	Student Life and Co-Curricular Activities
Intentional and holistic self-development					
Broad knowledge of human cultures and the natural world					
Specialized knowledge of a particular field or topic		Neuro234			
Critical thinking and inquiry		Neuro234			
Effective communication and collaboration					
Insightful integration and application of learning		Neuro234			
Responsible interpersonal, civic, and global engagement					
Informed vocational discernment and resourceful planning		Neuro Conc.			

Table 3. St. Olaf College's institutional-level intended learning outcomes (STOGoals) and areas where students have learning experiences that advance them toward achieving those outcomes. Places in majors and concentrations (e.g., individual courses, as shown for Neuro234) where students are moved toward achieving these outcomes can then be mapped onto these institutional-level goals. In the example reported in Crisp and Muir, 2012, assessing the development of an interdisciplinary perspective in Neuro234 aligns with the institutional-level goal of integrated learning (red box).

Mission-driven and Institutional-Level ILOs

In 2013, the St. Olaf faculty approved a college-wide statement of Institutional-level intended learning outcomes (colloquially known as STOGoals; Table 3). Having these goals identified allows mapping of Course- and Program-level ILOs onto Institutional-level ILOs, in the same way as Course-level ILOs should map onto Program-level ILOs. This process of connecting outcomes to the institutional level helps to ensure that *all* levels of assessment are **mission-driven**.

3) Use Information for Improvement

Uses of Assessment

Just as important as planning and implementing your assessment, if not more so, is how you use the findings. These uses will, of course, differ greatly depending on the original goals of your assessment and where you might use the results to implement changes as a result. How the assessment was originally intended to be used is also tied to how **meaningful** it will be for its intended audience. In order to encourage programs conducting assessment to make it as **meaningful** to them as possible, we have found it useful to frame program-level assessment as "inquiry in support of learning" and to ask programs to consider "What issue, concern, or project within your program could serve as a focus for gathering evidence of student learning?" A similar question prompts programs to consider "What specific use of assessment in your program could make assessment more **meaningful** for your colleagues?"

Some examples of uses for assessment in *individual courses* are: Setting priorities for content/instruction; revising/expanding assignments; clarifying expectations for students by making your goals explicit to them; enhancing "scaffolding"; piloting or testing innovations/changes; and, finally, yet also importantly, affirming current practices. Uses of assessment for a *program*, could include: Strengthening program coherence; building and sustaining program excellence over time; sending consistent messages to students; revising program requirements; extending productive pedagogies; telling the program's story to graduate schools and employers; enhancing visibility to disciplinary and interdisciplinary associations; supporting grant applications; meeting requirements for specialized accreditation; and, importantly again, affirming current practices.

How might your Program change as a result of assessment?

Assessment Plan

- revision of intended learning outcome statement(s)
- revision of measurement approaches
- collection of and analysis of additional data and information
- changes of data collection methods

Curriculum

- changes in pedagogical practices
- revision or enforcement of prerequisites
- revision of course sequence
- revision of course content
- addition/deletion of course(s)

Academic Processes

- modification of frequency or schedule of course offerings
- improvements of technology
- changes in personnel
- implement additional training
- other implemented or planned change
- revision of advising standards or processes
- revision of admission criteria

(*Adapted from University of Central Florida Assessment Handbook, 2008*)

While the potential impact of assessment on a program is clear, it is important to also consider the impact taking an active role in assessment may have for an individual faculty member. Engaging in this process of inquiry in support of student learning may help you develop a deeper understanding of what (and how) your students learn, help you make more informed decisions about your courses, and help you contribute to more meaningful discussions about the curriculum at the course, program and institutional level.

One final note about the use of assessment. It is critical to remember that effective assessment is not a single event, but a continuous cycle of planning and identifying teaching goals, collecting and sharing evidence, evaluating evidence, and implementing changes to planning based on that evidence (Miller, 2007; Maki, 2002, 2004).

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