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Adapting the Learning-Cycle to Enrich Undergraduate Neuroscience Education for All Students

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A learning-cycle approach to science instruction is not new to science educators (Karplus, 1977; Kolb, 1984; Bergquist, 1991; Zollman, 1990; Allard and Barman, 1994). Somewhat less known, however, is the usefulness of this approach for creating lab activities for a broad audience of undergraduates. The following paper presents a brief overview of a laboratory activity that can be adapted for use by instructors of introductory neuroscience courses. The three-hour activity is geared towards tapping key elements of the learning-cycle approach, with a particular emphasis on the exploration phase of the model. Students work as members of small teams to explore a contemporary issue involving memory and gain hands-on experience from the outset, to which conceptual information is then added during lecture the following week. The approach is in marked contrast to the more traditional practice in the sciences where laboratory activities generally serve to punctuate already presented lecture material.

Keywords: problem-based learning; undergraduate neuroscience education; laboratory experiences; non-science majors.

INTRODUCTION

Undergraduates seeking interdisciplinary courses in the sciences have shown strong interest in neuroscience offerings (Stricker, 2005). Consequently, neuroscience educators are likely to see more non-science students enrolling in their introductory courses in years ahead. Given their broad range of academic backgrounds and interests, these students often take only a single science course in fulfillment of an institution's general education requirements. As such, neuroscience educators stand to benefit from careful consideration of the pedagogical frameworks they rely on for designing and implementing their various lecture and laboratory activities. In this paper we describe adaptation of an established learning framework to generate low cost, high engagement solutions for improving the neuroscience classroom experience for all undergraduates.

Contemporary models of science education are as broad in scope as they are in number (Roth, 1989; Monk and Osborne, 1997; Polman, 2000). Popular byproducts of such models include guided-discovery (Mayer, 2002), problem-based learning (PBL) (Neufeld and Barrows, 1974), and student-centered investigative laboratory experiences (FitzPatrick, 2004). Although generally informative and useful, the sheer number of available choices can be overwhelming to neuroscience educators seeking practical insights on course pedagogy. What is needed is a proven yet malleable framework that allows one the flexibility to develop and implement lecture and laboratory activities that are cost-effective, impacting, and engaging.

Over twenty years ago a working model of the learning-cycle approach was proposed that has since become a popular framework among science educators (Karplus, 1977; Kolb, 1984; Zollman, 1990; Allard and Barman, 1994). As can be seen in Figure 1, this approach prioritizes immediate *engagement* with the to-be-learned material by encouraging students to solve a problem via question-and-answer; reflecting upon and *exploring* possible interpretations of ideas; *experimenting* with these notions; and then using their own words to *explain* their observations. Although originally intended for full-scale implementation of all four components, it is not uncommon for today's science educator to adapt select elements of the framework to meet course-specific needs. One such adaptation has students entering the learning-cycle at the exploration stage *prior to* engaging the problem through more focused Q&A (Bergquist, 1991). In our own course this has translated to designing laboratory activities that

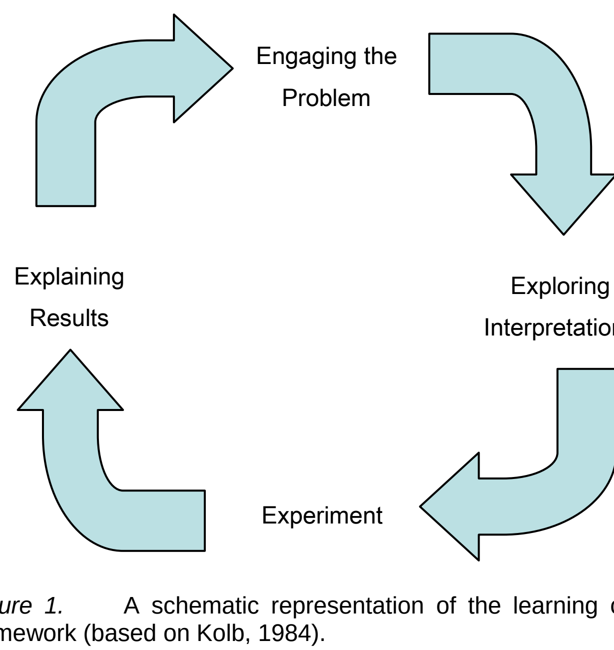

Figure 1. A schematic representation of the learning cycle framework (based on Kolb, 1984).

take place *before* introduction of the material in lecture; a strategy that is particularly well-suited for courses whose enrollments are characterized by a broad range of student ability and interests.

IDS-222: FUNDAMENTALS OF NEURO-SCIENCE

At Willamette University, a selective liberal arts college in the Pacific Northwest, all students must complete a minimum of one laboratory-based science course as part of their general education requirements towards graduation. The vast majority of students opt first for introductory offerings in biology, followed by chemistry, environmental and earth sciences, then physics. In addition to these more traditional offerings however, students may also choose a lab-based course in neuroscience to fulfill their sciences requirement. As is the case at other schools offering introductory courses in neuroscience, in recent years this latter option has gained in popularity among undergraduates, in particular among those students with interdisciplinary interests.

IDS-222 Fundamentals of Neuroscience is an annual offering geared towards freshmen and sophomore students whose academic backgrounds range from the humanities to the sciences. For example, a recent section included theatre, English, economics, and politics majors, in addition to psychology, exercise science and biology students. As such, one of our perennial challenges in IDS-222 continues to be delivery of hard science without making science overly hard. The course meets three times a week and includes a three-hour laboratory.

In developing our course framework we reviewed several different lecture and laboratory formats from across the country. Not surprisingly, the majority of these tended towards science education for science students. Given our need to reach beyond the typical sciences audience, we structured our course plan with non-sciences students in mind. A key feature of our approach was the decision to precede rather than follow lectures with laboratory activities. Importantly, we sought to move away from the time-honored practice of labs being used to amplify concepts introduced in lecture, and toward a model that allowed for more immediate and direct contact with lab-based content.

As a preliminary step we schedule the laboratory sections of our course later in the preceding week (e.g., Thursday), which allows us to introduce the following week's topic during lab instead of lecture. We find this affords instructors the added benefit of an intervening weekend for any last minute changes to the following week's lecture content that may have surfaced during laboratory discussion. Moreover, feedback from students indicates they are able to glean more from weekly readings if such lead-time is available prior to discussing assigned material in lecture.

The week before being introduced to the neuroscience of memory in lecture, students arrive to lab and are separated into groups and given a set of instructions for an activity on Alzheimer's Disease (for further detail, see Appendix I). Each group is assigned to one computer for access to all necessary materials and software (see Table 1 below). By design, each student must actively participate in order for the group to arrive at its explanation for an empirical question involving Alzheimer's Disease. Student engagement is monitored throughout the exercise and at the end a brief questionnaire is administered to gauge student reaction to exploring course content in a lab-led fashion.

Internet Access
Access to instructions, relevant web pages, literature review.
CogLab™
Access to experimental procedures and protocols (http://coglab.wadsworth.com/).
Microsoft Office™
Prepare memory test, presentation of findings (PowerPoint).
Record and analyze data (Excel).
Notetaking and generating laboratory report (Word).

Table 1. A list of materials and software used for the Alzheimer's laboratory activity.

Table 2 provides summary statistics for each of the eight questions from the short survey administered the week following the lab activity. Overall, student responses suggest support for introducing the topic of memory during the previous week's lab, with several providing written comments like, *"First learning about Alzheimer's in laboratory helped put my mind around the various issues and controversies much better…please have all our labs this way!"* Moreover, students perform well on a weekly, in-class quiz given before lecture-based introduction of

Item	Mean (SD)
1. Covering memory in lab before discussing it in lecture helped me track information during lecture better.	8.1 (1.3)
2. Overall, pre-exposure to different memory experiments in lab helped me digest lecture material better.	8.4 (1.1)
3. Serving as a participant in the online memory experiment increased my understanding of the material.	7.8 (1.9)
4. I prefer having topics introduced in labs, the week before they are covered in lecture.	8.1 (1.4)
5. Hands-on lab activities help give me a better understanding of material covered in the textbook.	8.4 (1.5)
6. Working as a member of a team during our memory lab was helpful to me.	7.6 (1.8)
7. I felt last week's memory lab exercise was engaging and held my attention.	8.5 (1.1)
8. Overall, introducing the topic of memory before lecture discussion of the material was helpful to me.	8.9 (1.0)

Table 2. Summary statistics from a follow-up survey on the learning activities given after the lecture component was completed. Students responses (n = 14) are on a 10-point Likert scale (1 = strongly disagree; 10 = strongly agree).

memory content, suggesting that retention of information learned during the preceding week's lab is not adversely impacted by the passage of time.

SUMMARY

Our adaptation of a learning-cycle framework yields a lab-led approach for introducing students – in particular non-sciences students – to neuroscience course content in a low-cost and effective way. The memory activity itself is designed to place students in a situation where they must first explore a problem by working both individually and collectively towards its solution. The strength of the activity is its ability to immerse a diverse group of students in a problem-based, investigative learning situation before they encounter the content in lecture or their textbook. Although more formal measures of enhanced learning using this approach have yet to be conducted, our experience is that students welcome the opportunity to learn more about a topic of interest to them, especially if first allowed hands-on access to it before it is introduced in lecture.

One aspect of the lab-led approach we have found critical for success is that of timing. In most undergraduate neuroscience courses, coverage of memory processes generally takes place during the final third of the semester. This means that students are familiar with general lab protocol, have grown more comfortable working in groups, and have had experience using the web for completing assignments. Though certainly adaptable for use at an earlier point during the term, we find that non-sciences students in particular work best when confidence among group members is relatively high. For this reason, instructors planning to adopt this activity would do well to gauge their particular students' abilities as early as possible in the semester and, if need be, adjusting the lab schedule accordingly.

An obvious constraint for any laboratory-based activity concerns the amount of space and number of resources one has at their disposal. For example, in our case only eight desktop computers are available and with a potential for as many as twenty students in any given semester, this means group members must share computers. For most of our lab exercises this is generally not a problem, but in this particular activity we find students benefit from more of a "divide and conquer" approach (at least at the outset of the exercise), such that a computer for each student is considered ideal. Given the ubiquity of laptop computers among college students these days, we now make a habit of asking those students who own one to please bring it along with them to lab, thus allowing for more efficient use of our limited number of desktop machines.

Without question, non-sciences students present a different challenge to those of us accustomed to teaching science content courses to science-minded students. For this reason we as neuroscience educators need to prioritize development of laboratory exercises that are not only rigorous and informative, but also exploratory, engaging, and fun. Our learning-cycle, lab-led approach to introducing non-sciences students to various topics in neuroscience incorporates key elements from the science education literature. Chief among these is the idea that student learning is improved in those situations where instructors take care to develop balanced and thoughtful investigative experiences for all, particularly those for whom a course in the sciences and its accompanying laboratory are considered novel experiences.

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APPENDIX I

Instructions for "Diagnosis: Alzheimer's" Activity

"Our in-depth discussion of the topic of memory won't begin until next week in lecture. The purpose of today's lab activity is to get you started thinking about the various controversies and issues faced by researchers interested in the neuroscience of memory. To facilitate this, you will work in groups of four to solve a problem having to do with memory impairment. This will take you the entire three-hour period so be sure to work efficiently in order to finish on time.

You and your lab partners are to imagine you've just been made aware by your mother that your elderly grandmother has been diagnosed with Alzheimer's Disease (AD). Your task is to work-up a profile for your mother that highlights the chief symptoms of the disease; at least three of the various ways the disease has been/is being explored by researchers and their accompanying findings/conclusions; and what sorts of behaviors your mother can expect as the disease takes hold. To do this effectively, you will need to budget your time carefully, dividing chores amongst group members in such a way as to maximize efficiency at all stages of the activity.

Roughly the first 45 minutes should be spent perusing the web, identifying diagnostic criteria by visiting as many websites as possible (e.g., WebMD, Johns Hopkins, Oregon Health Sciences University, etc.) to generate a profile of leading symptoms and their impact. Whenever possible, be sure to take note of what sorts of "behavioral microscopes" these researchers are using to test their hypotheses. This will be helpful to you come time to choose your own experimental task below. As always, be sure to keep track of URLs as you proceed. These will be used as part of your presentation to the larger group.

The next approximately 45-60 minutes should be spent at the CogLab website engaged in active experimentation. Note that you will find at least four sections containing memory experiments. As a group you are to choose one paradigm that you think best reflects the kinds of behavioral tests used by Alzheimer's researchers to diagnose symptoms in people like your grandmother. For example, you might feel the Deese-Roediger-McDermott (DRM) paradigm is particularly well-suited for this situation. Regardless of which one you settle on, take careful notes throughout and be prepared to justify your decision and why you believed it most appropriate given the diagnosis of AD. Once you have chosen your task, each group member is to serve as a participant in the design and their data collected and collated with other group members for subsequent presentation. The balance of lab time (~1.25 hrs.) will be devoted to each group crafting a *brief* Powerpoint presentation of their findings (no more than four slides), including a bulleted summary of their web search for diagnostic criteria, past and present research endeavors by AD investigators, etc., as well as the CogLab-generated graph of group data and any concluding remarks. Each of the three groups will be allowed 10 minutes during the final 30 minutes of lab to present their findings and will be expected to explain the rationale behind their choice of CogLab paradigm."

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