
Calibrated Peer Review™: A Writing and Critical-Thinking Instructional Tool

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Since its 1985 beginning, the Writing-Across-the-Curriculum movement has been broadly advocated by institutions in higher education (1). Yet despite faculty knowledge and appreciation of "the power of writing as a means of engaging students and developing their thinking skills..., [the movement] has not significantly altered what goes on in classrooms" (2). Despite the best of intentions, faculty involved in these programs have soon become overwhelmed by the additional grading workload when class sizes rise (3). Consequently, in many institutions, writing requirements are relegated to small upper-division courses. Calibrated Peer Review™ (CPR) (<http://cpr.molsci.ucla.edu>) removes this barrier to writing in large classes and does more (4).

CPR was developed on a research-based model. What do scientists and engineers do? Research begins with proposals. Scientists and engineers write research proposals and review peer proposals. Scientists and engineers do research and write and peer-review research manuscripts. Peer review plays a prominent role in the progress of science. Writing with anonymous peer review is thus the model for CPR. CPR is a comprehensive, web-delivered instructional tool, which not only promotes student understanding through writing but also develops student critical-thinking skills through the process of evaluation and reviewing. Because the program is web-delivered, computer-managed, and uses peer review, instructors can use the CPR program with any class size; students can do their assignments wherever they have web access; and administrators do not need to provide additional teaching resources for grading.

How CPR Works

CPR comprises an integrated set of network tools that manage the submission and evaluation of written student work. As in traditional classes, in classes using CPR, students begin an assignment by composing a document based on an instructor's guidelines. Rather than turning in a printed paper, however, the written work is submitted electronically. After the students submit their work, the CPR program guides them through a tutorial on peer review of that particular assignment. Students then receive detailed feedback on their evaluation skills. Only when students become competent reviewers by passing the calibration exercises in the tutorial, do they evaluate their peers' work in a double-blind anonymous process to ensure privacy (5). None of the work, however, is anonymous to the instructor. Throughout an assignment, the instructor has access to all student work and can monitor and assess class and individual student progress. In the final step in a CPR assignment, students return to their own essays and, using the same criteria they have used for their peers, evaluate their own work. After the end of an assignment, CPR prepares and presents the student with an individual report, which shows all of his or her reviewers' assessments and comments. In the background, CPR prepares an instructor's report, which yields detailed information about class and individual performance. The instructor can view any document and any review; he or she can reevaluate any student's work.

CPR provides two other key features: an assignment authoring tool and an assignment library. The authoring tool enables the instructor to create the components of the

writing and reviewing activity that form the assignment. The assignment library, created and published on the website by other faculty in the discipline, lets an instructor bypass the hours of development time it takes to craft a well-written assignment and select a relevant topic for his or her class.

The instructor has two choices in using CPR: he or she can author new assignments or use existing library assignments. Only imagination limits the CPR assignments that faculty create. Any topics instructors want their students to delve into deeply can be developed into an effective assignment. The CPR Assignment Authoring Tool facilitates the task and ensures that all the components of a complete assignment occur. Rather than prepare their own assignments, instructors can opt to use one in the CPR library. They simply select the assignment, set the class parameters for timing and grading the assignment, and inform the students. The next step is to examine the student performance and results.

What CPR Enables

Three tenets of Writing-Across-the-Curriculum programs and intensive writing courses undergird the pedagogy of CPR: *Expository writing promotes understanding, clear writing demonstrates clear thinking, and evaluation requires higher-order, critical-thinking skills* (6,7). Not only do students understand more deeply when they *write* about what they are learning, the peer-review evaluation process requires that they develop higher-order, critical-thinking skills. Learning to write and writing to learn are not equivalent. English composition courses alone can lead to well-crafted prose without a deep understanding of complex ideas and arguments in other disciplines. CPR instruction focuses student learning on thinking about important concepts and content in specific disciplines.

Frequent, well-crafted assignments, where students write and receive feedback, teach students to write well. In addition, the use of guided peer review promotes a classroom environment where students 1) have their own authorities for their learning and must make decisions; 2) give sound advice to their peers, even on matters with which they are having difficulty; 3) profit from reading text from other students; and 4) work out their own understandings of methodologies and ways to interpret information (8).

CPR Impact on Student Learning

Studies at three different universities in chemistry, biology, and economics independently document that students taught using CPR assignments perform ~10% better on traditional course exams than students taught through traditional lecture and textbook methods. This finding holds whether the exams are essay based (Table 1), problem based (Table 2), or multiple choice (9).

Table 1. Average Grades on Phase-Diagram Questions on Midterm, Chemistry 20L, UCLA

Quarter	Phase-diagram CPR	Actual grade	Percent
Winter 1998	Not used	6.2/10	62%
Winter 2000	Not used	9.2/15	61%
Spring 2000	Used	15.1/20	71%

Table 2. Average Scores by Quintile on Midterm, Economics 200, Fall 1999, California State University, Northridge

	Quintile				
	1	2	3	4	5
CPR use	15	29.4	38.8	49.4	66.7
No CPR use	8.3	17.7	27.2	39.6	57.8

Table 3. Self-Reviewing Skills of General Chemistry Students

Assignment	Text score	Winter 2001	Spring 2001
		Accurate self-review	Accurate self-review
1	<6	48%	36%
	>6	89%	92%
2	<6	68%	70%
	>6	81%	89%
3	<6	77%	
	>6	91%	

Reviewing also results in learning gains. An indication of the learning that occurs in the reviewing stage of a CPR assignment can be seen in Table 3. Even at the beginning of the term, more than one-third of the students who submitted poor essays (<6) learned from the calibration process. By the time they came to the self-assessment stage, they recognized and confronted their mistakes and accurately evaluated their own essays, which they had written the previous week. Repeated practice at reviewing shows continuing gains throughout a term. It follows that they do better on final exam assessments.

In fact, all students learn how to review critically. A national study of 10 courses in multiple disciplines shows that students' ability to review and evaluate content for accuracy, argument, and logic improves regardless of whether CPR assignments are implemented at the high school, community college, comprehensive college, or research university (Figure 1).

CPR Impact on Higher Education

By the end of the Molecular Science Project, CPR had begun to grow beyond the partner institutions of the project. In 2001, the user-base consisted of 101 colleges and universities. In these institutions, CPR had served more than 520 courses, enrolling more than 16,000 students, and the library consisted of approximately 175 assignments. Usage has

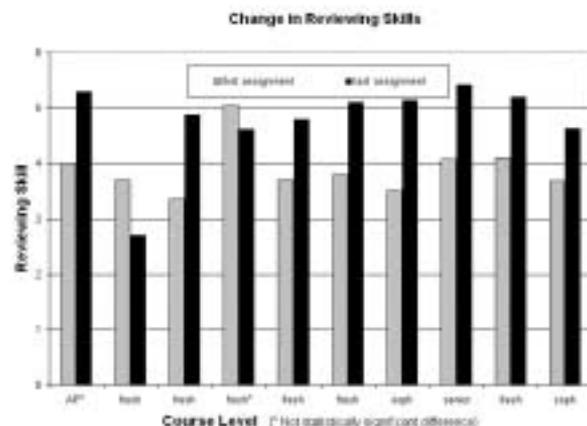


Figure 1. Cross-discipline study of change in student CPR reviewing skills in eight schools (Chemistry: Advanced Placement, Preparatory, General [4], Organic, Environmental; Remedial English; Economics). fresh, freshman; soph, sophomore; AP, advanced placement.

grown exponentially since then. A March 2004 "State of CPR" report shows a cumulative use of the program by 500 institutions, supporting more than 1,900 courses, which had enrolled over 72,000 students.

Perhaps more important, however, is the growth in the library, which had expanded to 1,275 assignments. The task of writing an assignment is not trivial. It requires significant intellectual effort to transform one's discipline into stimu-

Table 4. Distribution of CPR Assignments by Discipline (March 2004)

STEM fields	Assignments	Non-STEM fields	Assignments
Chemistry and biochemistry	430	Composition and writing	193
Life sciences	199	Economics and management	58
Science writing	67	Medicine	41
Geology	42	Communications	13
Math and statistics	30	High school	13
Science ethics	23	Education	9
Psychology	19	History	9
Physics and astronomy	17	Business law	6
Science education	14	Nursing	3
Engineering	12		
Computer science	7	Other	66

lating, engaging, and widely applicable instructional materials for all levels of students. In workshops, where faculty dedicate time to this endeavor, creating an assignment takes at least 8 hours. Collectively, this library represents an enormous national scholarship of teaching from faculty who are using CPR in their courses. Table 4 summarizes this creative effort.

The large set of chemistry assignments, a result of national dissemination of the chemistry reform projects (10), is providing a ready source for faculty to easily adopt field-tested CPR materials. Other faculty-development efforts, led by attendees of the NSF workshops or by the CPR development team, have introduced CPR to a broad-based commu-

nity. Slowly, networks of faculty in each discipline are developing and sharing assignments. They are being nurtured and supported by a task force representing the disciplines in the left column of Table 4.

CPR is currently delivered from the University of California, Los Angeles (UCLA), servers and is offered to the academic community without cost. Any instructor may "register" through the homepage website. Technical assistance is provided through email and a listserv. Workshops are given frequently to inform faculty on ways to use the program and on authoring techniques to develop well-crafted assignments that enhance student learning.

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