AC 2011-647: NINE YEARS OF CALIBRATED PEER REVIEW IN RHETORIC AND ENGINEERING DESIGN

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Nine Years of Calibrated Peer Review™ in Rhetoric and Engineering Design

Abstract: The author draws from extended experience in using Calibrated Peer Review (CPR) in the teaching of rhetoric and engineering design. The work is based upon findings from three NSF grants (CCLI -- #9980867, CCLI-ASA -- #0404923, and Collaborative CCLI, Phase II -- #0816849), spanning a period from 2002 – 2011. The poster presents information in three categories. First, how is the CPR software platform designed to promote both content learning and to enhance communication skills? Second, how does CPR help technical instructors to design communication assignments that promote student learning? Third, how does the rich, *in situ* data collected by the system contributed to learning outcome assessments? The poster presentation is supplemented by handouts containing examples and more extended analysis of data.

1. What is Calibrated Peer Review?

Developed by the Division of Molecular Sciences at UCLA (through an NSF grant), CPR is an excellent learning environment that creates an electronic, asynchronous, discipline-independent platform for creating, implementing, and evaluating communication assignments (both written and visual), without significantly increasing the instructor's workload. The extensive data collected by the software can be used to measure learning outcomes, both as a part of a process and as a product. Where CPR is used in multi-sectioned courses, data can be merged. Currently distributed by UCLA (http://cpr.molsci.ucla.edu/), the system draws from the model of manuscript submission and peer-review in the conduct of scientific inquiry.[1] The pedagogical framework draws from the "writing across the curriculum" (WAC) movement's premise that verbal and visual composition are an analog for thinking and that communication assignments can be used to mediate student learning in complex problem-solving situations.[2]

1.1 CPR Components that Enable Learning -- Four structured workspaces perform in tandem to create a rich series of activities that reflect modern pedagogical strategies for using communication in the learning process. Table A summarizes these stages in a typical CPR session.

Table A: Four Structured Workspaces of CPR

SEGMENT	ACTIVITY	COMMENT
1	**Assignment and Text Entry:** Students are presented with a challenging communication task, with guiding questions to act as scaffolding for the demanding cognitive activities.	Instructors work with the authoring interface and are guided through the construction of a task that elicits active learning. For text, students compose using a word processor, and upload the finished text. Graphics and videos are supported in the upload.
	Calibrations: After electronic submission of their texts, students read through three "benchmark"	Modeled on the same process used in large scale writing evaluation projects, this segment mitigates the common objection to

2	samples and assign each a score based on a series of evaluative questions (a rubric). Students are then given a "reliability index" from 1 to 6, based on their demonstrated competency in these exercises.	peer review in the undergraduate classroom: that the experience reduces itself to the-blind- leading-the-blind.[3]
3	**Reviews of Texts Submitted by Classmates**: After becoming a trained-reader – and being assigned a credibility weighting – students read and provide written feedback on three anonymous peer submissions using the same rubric embedded in the calibrations. They also assign each essay a holistic score from 1 to 10.	Many years of classroom observations augmented by highly structured research on writing in a broad spectrum of learning situations indicate the power of peer review.[4] As early as the 1970s, Ken Bruffee and his colleagues demonstrated that students paid more attention to critiques of their writing when done by peers than when done by an instructor.[5] Looking at the other side of the coin, providing commentary on communication artifacts submitted by classmates also helps novice writers to sharpen their abilities to recognize aspects of their submission that meet the performance standards of the assignment.
4	**Self-Assessment:** As a final activity, students evaluate their own essay using the same learning template instantiated in the calibration and in the peer review segments.	As with segments 2 and 3, students use the same rubric (set of performance standards for the task). Only this time, they apply the standards to their own text. Having trained on benchmark samples, and then applied their expertise in evaluating peer text, students now engage in a reflective, final activity by assessing their own submission. Students are encouraged at this time to record comments to themselves that capture the evolving insights they have gained in the previous two segments. They are also invited to reflect on whether they have gained a deeper level of understanding for the assignment and its outcomes.

1.2 CPR Components that Facilitate Usage -- Though the multiple features make the system seem complex, following a typical session path demonstrates both CPR's power and its ease-of-use. Figure 1 – a conceptual overview – guides the discussion for the features and functions of CPR.

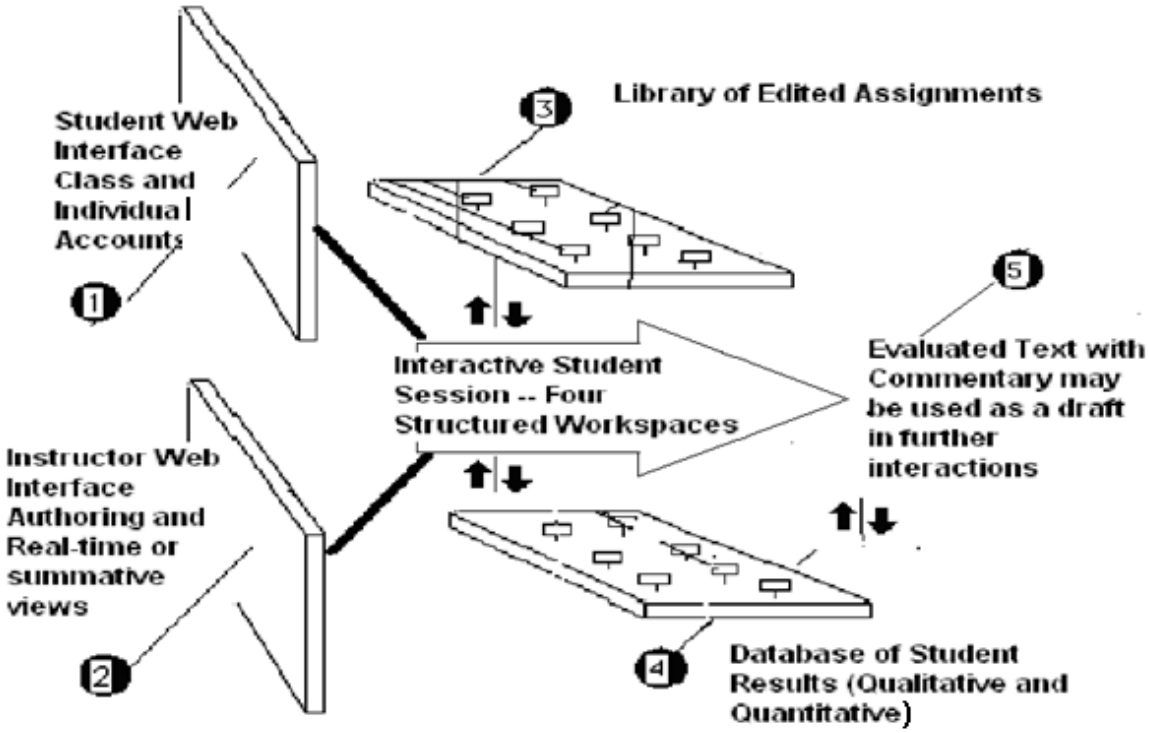

Figure 1: Conceptual Overview of CPR™

Item 1 The student interface guides the learner through all four segments in a seamless fashion. All components – from assignment and resources to peer feedback and consolidation of performance indicators – are viewed in a unified framework.

Item 2 The instructor interface contains a number of convenient features. An authoring space guides the construction of assignments. A progress function gives reports on the ongoing activities of a class or a single student in real-time. A number of tools handle anomalies – such as accommodating a student who misses a deadline for valid reasons or downloading data to a spreadsheet application for further analysis.

Item 3 The central library (maintained by UCLA) contains a number of edited assignments contributed by a network of CPR users throughout the country. Attributions are made to authors when an assignment is used elsewhere. Contributors may view usage patterns for their assignments.

Item 4 Class and student accounts are stored on a local server, making the system FERPA compliant. Quantitative reports are calculated through a complex set of algorithms and returned to both student and instructor. Qualitative feedback is also available to both student and teacher.

Item 5 The results (comments and communication artifact) may be considered as finished, or they may be used in further iterations, or as the foundation for another linked assignment. This articulation among assignments facilitates using a spiral curriculum approach within a course, or across a set of courses.[6,7]

2. Designing CPR Assignments to Promote Learning

A CPR session contains two very distinct types of instructional activities: (1) the student constructs a communication product to fit a fully-specified rhetorical situation and (2) the student participates in a collaborative, evaluative exercise that culminates in self-reflection. Such activities facilitate the movement from novice to professional for students by explicitly modeling strategic processes characteristic of expert behavior.

Strategies are powerful manipulations by which the problem-solver (1) defines the task and makes analogs to other similar situations, (2) prunes away extraneous elements or eliminates "noise" from the problem space, (3) mediates state transformations, such as clustering specifics and making super-ordinate categories, and (4) links new knowledge with prior knowledge. As indicated in Table B, the author suggests three generalized types of communication tasks for engineering education (each focused on strategy acquisition for a specific type of higher-order performance). These assignments are sequential, and all culminate in – and contribute to the quality of – the final course artifacts for teaching the design process (devices /prototypes and attendant documentation, which are the traditional end-product of most engineering design courses).

Crafting a communication assignment that guides students through a series of higher-order mental manipulations is not an easy task. However, the authoring functions of CPR and reification of the dynamics of the four structured workspaces provide an instructor with a mental model for the process. This framework for the entire process aids instructors in developing assignments that both model behavior as well as imparting course content. Gains in one area are consolidated and carried forward to the next workspace so that students are continuously challenged but never overwhelmed.

3. Using CPR Data for Outcomes Assessment

As illustrated in Table C, the complete CPR data log captures a number of evaluation items. Students' names are listed alphabetically and numbered in the far left column (in this example, names have been removed for confidentiality). The row associated with each name reports scores on specific segments of the CPR session. At the bottom of the report, class averages are given for each of the twelve categories. (The accompanying key indicates what each of these numbers represents.)

Table B: Four Types of Communication Assignments for Engineering Design

Exploratory Activities (CPR mediated)	Heuristics for Higher-Order Mental Manipulations (CPR mediate)	Document Components (CPR mediated)	Final Artifact(s)
Assignments to foster discovery. Activities that promote "problem finding," identifying alternatives, exploring requirements, and acknowledging constraints. For example, various exercises in structured brainstorming, lateral thinking, and synectics.[8, 9]	**Assignments that reflect the "rationalization" of the design process.** Practice with methods of synthesis and analysis that foster conceptualizing systems, solutions, and products. For example, students might be asked to use graphical representations that provide a synoptic overview, such as constructing a GANTT chart or comparing and contrasting alternative solutions using an entity/attribute matrix.	**Assignments that enact the more "formal" aspects of design and the rhetorical specifications of design documents.** For example, expectations for a social impact statement, the methods for composing a technical description, or data-representation options for a needs assessment exercise.	The final product (device and documentation) is evaluated by the instructor. These products are the end learning outcomes of a composite of episodes, many of which were mediated by the CPR system.

Table C: Sample of Instructor's Report from a CPR Session

S1.	99.33	9.33	9.33	100.00	79.17	0.33	10.00	6	0.37	40.00	0.33	40.00
S2.	95.34	8.67	8.67	66.67	66.67	1.00	6.67	4	1.57	40.00	0.33	40.00
S3.	98.01	8.01	8.01	100.00	66.67	0.00	10.00	6	0.72	40.00	0.01	40.00
S4.	90.35	3.68	3.68	100.00	70.83	2.33	6.67	4	1.18	40.00	1.32	40.00
S5.	97.01	7.01	7.01	100.00	70.83	1.33	10.00	6	1.15	40.00	0.99	40.00
S6.	95.66	8.99	8.99	66.67	70.83	1.67	6.67	4	0.73	40.00	0.99	40.00
Class Averages												
Categories	Overall Grade	Text		Calibrations					Reviews		Self-Assessment	
		Rating	Score	% Style	% Content	Avg. Dev.	Score	RCI	Avg. Dev.	Score	Dev.	Score
Class Averages	87.46	7.83	7.83	87.04	68.13	1.22	7.90	4.87	0.86	37.95	0.96	30.70

Key to Data Columns

Column Category	**Definition**
Overall Grade	Totals from major categories TEXT, CALIBRATION, PEER, and SELF REVIEW; based on 100 points
Text Rating	Holistic Score (1-10); Avg Weighted Score given by 3 classmates
Text Score	Weighted score converted to a percentage of total component points, as set by the instructor
Calibration % Style	Percentage of calibration questions correct in this category
Calibration % Content	Percentage of calibration questions correct in this category
Calibration Avg. Dev.	Average Deviation on scores given for all three benchmark texts
Calibration Score	Style + Content +Retake + Avg Dev = a percentage of the total component points, as set by the instructor
Calibration RCI	Reader Competency Index: Complex Algorithm explained at CPR website http://cpr.molsci.ucla.edu/
Reviews Avg. Dev.	Student's holistic review compared to average of 2 other reviewers. (Summation of 3 reviews)
Reviews Score	Weighted score converted to a percentage of total component points set by instructor
Self-Assessment Deviation	Self-assigned holistic score compared to the average of 3 classmates' ratings
Self-Assessment Score	Weighted score converted to a percentage of total component points set by instructor

In addition to empirical data, the CPR system also stores (and displays on request) all the peer-provided, text-based commentary for each student, from each session. Viewing both the empirical and the narrative feedback from CPR sessions is very informative for the instructor.

The handouts that accompany the poster give examples of using CPR data to measure empirically a range of questions about student performance.

Example One: Does the calibration (training) carry over to the peer-review phase? The author's experience demonstrates that students who perform well in the calibration phase are able to apply that learning to a set of student-authored submissions.

Example Two: Does the CPR assignment accommodate both higher and lower aptitude students? Partitioning a sample population (by using the text score of the students' submission) gives opportunities for examining aptitude-treatment type interactions within a population.[10] Such information may help instructors to improve the efficacy of their assignments.

Example Three: A series of student CPR results acts – *de facto* – as a form of electronic portfolio. These data can be examined for individual students, for aggregates, or for entire classes or cohorts.

4. Conclusion

Our experience with Calibrated Peer Review in several courses at Rose-Hulman Institute of Technology suggests that this robust instructional technology partners both with the instructor and with the student to increase competence, creativity, and confidence in exploratory inquiry and reasoning. [11]

The presentation describes some advantages of using CPR as a platform for integrating peer review into engineering education. However, any instructor considering CPR for course adoption will also want to know about such pragmatic issues as ease of use, return on time investment, and student reaction and learning gains.

4.1 Investment of Course Time -- Each instructor decides how much emphasis can (or should) be given to CPR assignments in a given course. A few caveats are appropriate here. First CPR sessions work best if the writing assignment is relatively short and compact (say, two, three, or four paragraphs). Second, the assignment should involve problem solving, critical thinking, or concept formation. Furthermore, the objectives of the assignment should be well-formulated and clearly reflected throughout the CPR session. In our several years of combined experience with the system, we have found CPR most appropriate for *drafting* key components of longer exercises. On average, students in our classes worked directly with the CPR environment for no more than two or three hours per week. (Assignments were treated a homework and did not require classroom time.) Given the return in learning, we believe the time-on-task was extremely productive.

4.2 Overhead for Instructors -- Authoring a CPR session is labor-intensive for the first couple of times. However, once the instructor builds up some expertise and a small library of adaptable assignments, the task becomes easier. Depending on the individual and the complexity of the assignment, a session may take four to five hours to prepare. In our experience, the return on investment comes in being able to treat written work seriously without burying oneself in stacks of grading or returning documents with copious commentary, which students may all-too easily ignore, misinterpret, or misplace

4.3 Student Reactions -- Our students usually find the first CPR session challenging. Seldom – especially in an engineering course – have they been held accountable for the process of writing to this degree. (Even in classes where instructors require peer critiques of documents, it is difficult either to mentor or to monitor students at this fine-grained a level.) However, our experiences show that over the ten-week quarter, students come to value the CPR experience. Because each CPR assignment highlights a critical component of the larger, final proposal, students learn the iterative nature of composing a quality piece of writing. They also come to trust their peers' judgment and to value the guidance they receive from fellow students.

Anecdotal evidence suggests that almost all students are positive by the end of the course. Even those who struggle will admit that they better understand how to write a project proposal and that many of the nuances they have learned come from scrutinizing the submissions of fellow students.

We have found no system available today that duplicates the powerful features of CPR as a complex, highly orchestrated cognitive tool for mediating peer review.[12]

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