AC 2010-1259: ENGINEERING EDUCATION: ORAL AND VISUAL COMMUNICATION

Patricia Carlson, Rose-Hulman Institute of Technology

Patricia A. Carlson (PhD) is a professor at Rose-Hulman Institute of Technology (Terre Haute, Indiana). She is the author of over sixty referred publications and presentation. She serves on the editorial board of the Journal of Interactive Learning Environments and Journal of Universal Computer Science. Carlson has used her experience in implementing technology into the classroom on two large-scale Lilly Endowment grants and on two National Science Foundation funded research projects. She is now the Director of the PRISM Project, a large-scale outreach program that helps Indiana teachers of middle school science, mathematics, and technology to integrate new information technology literacies into their classrooms.

Warren Hull, Louisiana State University, Baton Rouge

Warren R. Hull, Sr. is the Engineering Communications Coordinator at Louisiana State University. He earned a B.S. in Mechanical Engineering from Louisiana State University and an M.S. in Environmental Health from Harvard University. His engineering career spans over 40 years. He is a licensed Professional Engineer who was previously an engineering consultant, and is also a retired U.S. Air Force Colonel.

Dianne Raubenheimer, North Carolina State University

Dr. C. Dianne Raubenheimer received her PhD from the University of Louisville and is Director of Assessment in the College or Engineering and Adjunct Assistant Professor in the Department of Adult and Higher Education at NC State University. Within the College of Engineering she serves as the coordinator of ABET and other accreditation processes, acts as an assessment & evaluation resource/consultant to faculty in different programs, develops and implements assessment plans, and serves as the primary educational assessment data analyst on the Dean's staff. A particular interest is in helping faculty to develop and implement classroom-based assessment and action research plans to establish the effectiveness of instruction and to use the data to improve teaching and student learning. She is currently working with several engineering faculty, researching the impact of in-class use of technology on teaching and student learning. Dianne has also worked as an education consultant for a number of organizations and is currently serving as external evaluator on several grants.

Arlene Russell, University of California, Los Angeles

Arlene Russell is a Senior Lecturer at UCLA in both the Department of Chemistry and Biochemistry and in the Department of Education. She has been active in Chemical Education for over 30 years. She was a co-PI on the Molecular Science Project under which the Calibrated Peer ReviewTM (CPR) program was developed. Since 1999, she has led more than 50 CPR workshops for over 700 faculty from community colleges through research universities and has implemented CPR in her own classes varying in size from 14 AP high school students to 320 UCLA freshmen. She has been involved in national assessment activities for 25 years as chair of the California Chemistry Diagnostic Test committee, which develops and validates a national test for placement of students in entry–level college chemistry courses. She is the director of the Lower Division Undergraduate Laboratory Program and teaches the range of general chemistry courses in this area. At the graduate level she teaches technical writing and a seminar in Issues in Teaching in Higher Education for science and engineering graduate students and post-docs who are planning on academic careers. She is Chair-Elect of the Division of Chemical Education of the American Chemical Society. Her work in science education has been recognized by awards from the New York Film and Television Association for excellence in science videotape production; the

Smithsonian Institution for her educational innovation using technology, the Chemistry Manufacturing Association for her outstanding college chemistry teaching, and the UCLA Brian Copenhaver Award for Innovation for Teaching with Technology for the development and implementation of CPR.

Engineering Education: Oral and Visual Communication Using Enhanced Calibrated Peer Review™

Abstract: We report the intermediate results of an NSF Collaborative Grant among Louisiana State University (LSU), Rose-Hulman Institute of Technology (RHIT), and the University of California--Los Angeles (UCLA). This partnership is supported by a CCLI--Phase II grant to extend an established software platform (Calibrated Peer Review™) to include both oral and visual communication within engineering education.

Background

Calibrated Peer Review™ (CPR) is a web-based application that enables students to critically review other students' written assignments anonymously, but only after they have achieved a successful calibration level via online critiques of standardized assignments. The current project expands and enhances this widely used "learning by writing" tool to a more comprehensive "learning by communication" model that includes graphical/pictorial and oral presentation tools. The principal intellectual contribution of this collaboration is the development of new learning materials and teaching strategies, coupled with evaluation studies that contribute to reform-driven engineering education. The project seeks to develop a flexible application both for STEM and for non-STEM disciplines.

Project Objectives and Targeted Learning Outcomes

The basic objective of the project is to enhance the original CPR "learning by writing" model to a more comprehensive "learning by communicating" model which retains the discipline, class size, and course level independence of CPR. To achieve this objective, the investigators partner with a member of the original UCLA development team and several faculty members who are currently at the forefront of CPR implementations in engineering education. Five objectives guide this collaborative effort:

1. Create an enhanced version of CPR (Version 5), which both allows for the input and review of visual and video components by students and also permits the expansion of this functionality to the 2500 assignments that have already been developed by the 100s of faculty in the 950 institutions who have current CPR accounts on the UCLA server.

2. Develop pedagogically driven assignments for seven core engineering courses.

3. Train engineering faculty in the development and use of CPR visually rich assignments.

4. Assess the impact of the integration of writing and visual communication on course development, student performance, and student confidence in communication skills.

5. Offer a suite of faculty training workshops on the use of the CPR tool and process at national and regional ASEE conferences as a means to build a community of users in engineering.

Using Bloom's Taxonomy as a means to establish the desired cognitive and affective levels of learning, we focus on students gains in three proficiencies:

1. Students will demonstrate an ability to **evaluate** the effectiveness and quality of oral and visual presentations through direct comparisons with the results of expert and peer reviews.

2. Students will demonstrate that they can **synthesize** *(this encompasses composition, writing, rewriting and, by implication, speaking and preparing/revising visual presentations)* the results of their work in oral and visual presentations that achieve a minimum score of 80 (on a 100 point scale) when judged against criteria for quality and effectiveness (i.e., a rubric)

3. Students will demonstrate that they have **internalized the values** of self evaluation and continual improvement in their communication skills

Our guiding intent for the project is to further develop currently available materials and to propagate the methods for using CPR as a means of using active learning as a feedback loop for both student and instructor in engineering design.

UCLA Contribution: Original CPR and Software Enhancements

Developed at UCLA under a chemistry NSF systemic reform project, CPR™ is an excellent "learning environment" that creates an electronic, asynchronous, discipline-independent platform for creating, implementing, and evaluating writing assignments, without significantly increasing the instructor's workload. Furthermore, the extensive data collected by the "environment" can be used to measure learning outcomes. In fact, the flexibility and versatility of the platform make it very appropriate as a fine-grained tool for ABET accreditation criteria.

Original CPR Mediates Peer-Review of Writing

Four structured workspaces perform in tandem to create a series of activities that reflect modern pedagogical strategies for using writing in the learning process. A separate instructor interface and student interface provide customized reports on performance for individual assignments (see Figure 1).

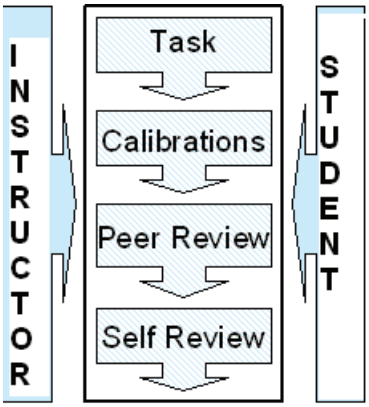

Figure 1: A Dynamic, Multi-staged Learning Environment

- *Task*: Students are presented with a challenging writing task, with guiding questions to act as scaffolding for the demanding cognitive activities. Web-linked resources (e.g., tutorials, samples, guidelines, or other handouts) may be embedded at this point. Students compose using a word processor, but upload the finished text as an HTML file. Some graphics and all tables are supported (as embedded links) in the upload.

- *Calibration*: Students read through three "benchmark" 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. This segment mitigates the common objection to peer review in the undergraduate classroom: that the experience reduces itself to the-blind- leading-the-blind.

- *Peer Review*: After becoming a "trained-reader" – and being assigned a credibility weighting – students read and provide written feedback on three anonymous peer essays using the same rubric as used in the calibrations. Students also assign each essay a holistic score from 1 to 10.

- *Self-Assessment*: As a final activity, students evaluate their own essay. As with calibration and peer review, students use the same "rubric" (set of performance standards for the task). 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. Through self-reflection, students gain a deeper understanding for the assignment -- its requirements and its outcomes.

Software Enhancements for Visual Communication

UCLA is contributing to this collaborative grant in the development of CPR5. One of the major new features in CPR5 is the addition of a tool that allows students to upload a file in addition to submitting a written text. Restrictions on the size or type of file may be imposed by the instructor, but are not limited by CPR5. When an instructor sets up an assignment for a class CPR prompts the instructor to

1. elect not to give students the upload ability,
2. require an uploaded file be a mandatory component of the assignment, or
3. make the file an optional part of a student's submission.

The team at UCLA has beta tested CPR5 under all three conditions. Any files that students upload as well as their textual and review work reside on an institution's installed CPRLocal server. The tool was designed with the expectation that in most cases, an uploaded file will be a visual such as a graphic, or figure that enhances a text-based document. If the assignment, however, is only the uploaded file such as a PowerPoint presentation or a poster, the instructor simply specifies 0 as the minimum word count and requires that a file be uploaded.

Like the recently released CPR4, CPR5 accesses the CPR Central Library of assignments on a server at UCLA for the material for courses. Assignment authors store their work on this secure server. The indexed library is searchable by author, topic, discipline, and keyword. All uses and

modification of assignments are tracked and can be used by an author to document Scholarship of Teaching, or by a user to see the evolution or different approaches to a given topic.

Other features of CPR5 under development include a demonstration workshop CPR installation at UCLA, which will allow easy access to faculty who want to host a workshop and a new generation of the scoring code which will decrease the computing time instructors wait for results to be calculated.

LSU and RHIT Contributions: A Library of Field-Tested Assignments

LSU and Rose-Hulman Institute of Technology are currently constructing a library of field-tested assignments for visual communication and oral presentations in engineering education. These assignments will be available in the CPR Central Library hosted at UCLA.

For each assignment, a student work her way through the four stages of a typical CPR session: (1) compose and upload an artifact in response to a specific set of requirements, (2) work through a training session, including examples, (3) provide peer review for three classmates, (4) self-evaluate her own submission.

At the completion of the grant, we will have a repertoire of assignments that fall into four basic categories:

- *PowerPoint Slides*: These modules invite students to think in terms of information design when constructing visuals for an engineering presentation. In a typical exercise, students are led through an exercise to identify both audience and purpose. They then examine a gallery of examples appropriate for their own rhetorical situation. Examples are drawn from noted practitioners in technical communication (for example, Michael Alley's collection of materials available at http://www.writing.engr.psu.edu/handbook/visuals.html .)[1]

- *Poster Presentations:* These modules represent longer, more complex exercises in visual communication. Posters give students an authentic task that mimics a rhetorical situation encountered in engineering practice. Additionally, posters ask that students use an artifact (the poster) successfully to convey information and to mediate conversation with a small audience. In these sessions, students practice a range of skills, including (1) information synthesis, (2) selecting and sequencing detail, (3) graphics and layout, and (4) techniques for multi-modal communication. (For additional information on using CPR to peer review posters, see Saterbak and Volz.[2])

- *Oral Presentations*: These modules address central issues for presentational skills and engineering education. The suite contains units for specific types of talks, all drawn from engineering practice. Students do the talk in front of an audience and are video-taped. Peer review covers requisites for good public speaking, including (1) content, (2) organization, (3) delivery, and (4) audience engagement.

- *Visual Representation of Data*: Based on the work of James Hartley[3] and Edward G. Tufte[4], this component features a suite of short CPRs similar to the exercises presented in Robert L.

Harris' *Information Graphics: A Comprehensive Illustrated Reference*.[5] Each short module features a scenario or context (including an audience and purpose), a set of data and/or information, requirements for display, and a selection of graphical types from which the student can chose an optimal form.

By the end of the project, each of these modules will be available in the CPR Central Library. The assignments may be used "as is," or they may be easily adapted to accommodate local circumstances.

Assessment Plan and Preliminary Results

The project has an external evaluator, Dr. C. Dianne Raubenheimer, Director of Assessment at NC State University.

The evaluation plan includes the following activities:

1. Revising rubrics for assessing student's oral and visual communication products, starting with rubrics used in the LSU and RHIT engineering programs, and building a focus on anticipated student learning outcomes.

2. Collecting baseline data, where possible, before implementation of the CPR program (using the revised rubrics).

3. Using these rubrics to collect post-CPR implementation results, on the level of achievement of various anticipated student learning outcomes.

4. Surveying student perceptions and opinions about the CPR program.

5. Conducting pre- and post-surveys of students' self-rated skill levels and self-confidence in achieving the anticipated learning outcomes relating to oral and visual communication.

6. Conducting interviews with faculty about previous and revised courses, using a common interview protocol.

7. Interviewing project administrators and CPR developers about project accomplishments.

8. Reviewing the library of field-tested assignments for completeness and representation across categories.

9. Conducting focus interviews with students in selected courses.

10. Summative faculty survey, assessing experiences with using the CPR program and how it impacted student learning.

11. Examining student CPR scores and other data gathered in the CPR system.

12. Reviewing project documentation (e.g. minutes of meetings and workshops and project reports) for accomplishment of goals and timelines.

13. Collecting additional data as needs arise.

14. Analyzing results, presenting findings and writing formative and summative reports.

Preliminary Results

Critical Thinking Assessment (CAT) instruments

This CPR project was offered a free set of Critical Thinking Assessment (CAT) instruments, as part of the dissemination efforts of a NSF CCLI project funded project. The CAT instrument measures student's critical thinking skills, including (a) the ability to evaluate information, (b) creative thinking, (c) problem solving ability, and (d) communication skills.

A control and experimental group of students were solicited to complete the test, with students in the experimental group having used CPR for writing assignments several times during a quarter, while the control group had not used CPR for this purpose. Results showed that overall, there was no difference between the experimental and control groups, although the RHIT students had a significantly higher overall score as compared with a national group of students. Our conclusion is that the CAT instrument does not specifically measure the student learning outcomes and skills being developed by CPR.

Student data

Other evaluation data will focus more specifically on oral and visual communication skills. Spring and fall 2010 are the main periods for collecting this evaluation data, including student surveys and student performance data. It is too early to report these results here.

One pilot survey was conducted with students at RHIT at the end of a quarter in the fall of 2009. Students rated their presentation skills before producing a YouTube video presentation and after reviewing the presentations of other students and after reviewing their own presentation. These results are presented below (Table 1). Students responded on a Likert scale, ranging from 1 (lowest) to 5 (highest).

Table 1: Fall 2009 student survey results

	Question	Mean	S.D.
Prior to making the video	1. I thought carefully about what message I wanted to convey in my talk	3.94	0.89
	2. Making the YouTube video forced me to organize my thoughts ahead of time.	3.20	1.21
	3. It was important to practice the speech before making the video.	3.71	1.14

	4. I thought about how I was going to engage the audience.	3.49	1.00
After evaluating the videos of other presenters	5. I identified ways that others could have better prepared the content of their talks.	4.06	0.83
	6. I identified ways that others could have been more organized for their talks.	4.23	0.80
	7. I identified ways that others could have improved the delivery of their talks.	4.31	0.78
	8. I identified ways that others could have better engaged with the audience.	4.26	0.81
After evaluating my own video	9. Reviewing my own video helped me to think about how to better prepare the content of a talk.	4.29	0.94
	10. I found some ways to be more organized when making a presentation.	3.94	0.98
	11. I thought of ways to improve the delivery of a talk.	4.31	0.62
	12. I can suggest how to better engage with the audience in future.	3.94	0.83
	13. Overall, the YouTube activity helped me to become a better presenter.	4.00	0.89

After the experience, students had higher ratings of their abilities to prepare the content, organize and deliver a talk, and engage with the audience.

A paired samples t-test was conducted, matching the ratings of comparable questions before making the video and after reviewing videos. These results are presented in Table 2.

Table 2: Paired Samples T-Test Results

		Paired Differences		Significance	
		Mean	Std. Deviation		
Pair 1	Q1 - Q5	-.11	.900	.458	
Pair 2	Q2 - Q6	-1.03	1.175	.000	
Pair 3	Q3 - Q7	-.60	1.035	.002	
Pair 4	Q4 - Q8	-.77	1.031	.000	
Pair 5	Q1 - Q9	-.34	.838	.021	
Pair 6	Q2 - Q10	-.74	1.067	.000	
Pair 7	Q3 - Q11	-.60	.976	.001	
Pair 8	Q4 - Q12	-.46	.980	.009	

The only pair of questions that was not statistically significant was Q1-Q5 (I thought carefully about what message I wanted to convey in my talk versus I identified ways that others could

have better prepared the content of their talks). There were significant differences in all other pairs of questions before making the video and after reviewing videos.

Some responses to an open ended question asking students if there was anything else they wanted to tell about their experience provided comments about the perceived value of the assignment:

"I found that using the YouTube videos through CPR allowed me to give a more thorough critique of the presentations. Using this method, I could watch the video more than once and pick out specific elements rather than having to notice everything in one sitting."

"It really helped me to see how I can improve. It's hard to correct yourself when someone is simply telling you how you can improve. It was very nice, especially being a visual learner, to be able to really look at myself and compare myself to the other people in my class."

"The YouTube assignment really helped me as an overall public speaker in one aspect only because many times when you see yourself present and realize what you are like up at the podium, you can correct your posture, voice, enthusiasm, etc."

However, some students still found the prospect of making presentations a daunting one.

"Oral presentations for some reason never help me to improve. When I stand up in front of a class, my hands get sweaty, my face gets red, and I just want it all to be over. It is really hard for me to speak in front of people, but I can talk to whoever I want one on one."

Conclusion -- Why Use CPR in Your Engineering Classroom?

It has long been recognized that simply developing technical expertise in a discipline does not adequately prepare a graduate for future success in a professional setting. Employers have insisted that graduates in engineering must also have mastered requisite communication skills in order to become a valued member of their organizations.[6] This view has been implemented into Criterion 3 of the Accreditation Board for Engineering and Technology (ABET) Program Outcomes and Assessment; that is, "the necessity for engineering graduates to demonstrate the ability to communicate effectively."[7]

A decade has passed since ABET's *Engineering Criteria 2000* was established. ABET's revised requirements, changing realities of the workplace, and the growing awareness of language in the learning process all place added emphasis on communication (written, oral, and visual) in today's engineering curricula. However, most instructors of engineering design believe themselves to be hard-pressed to incorporate additional assignments into courses already filled with content materials.

CPR offers several proven advantages for helping both instructors and students integrate rich and expanded communication assignments into their courses.

Supports the Best of Reform-Driven Engineering Education: Both communication and peer review are proven methods for improving concept learning. Yet each can be extremely time-consuming and labor-intensive. CPR helps remove many of the barriers to successful use of these high-potential approaches. Also, students work asynchronously in CPR and extend the boundaries beyond the limitations of available class time.

Represents Educational Technology at Its Best: Four structured workspace teach powerful strategies. Students practice evaluating samples of the assignment during the calibration phase, and then score their colleagues' submissions using the same guidelines. Students also provide written commentary, coaching their peers toward improvement. As a last exercise, students apply the same assessment criteria to their own submission.

Evaluates Learning Outcomes for ABET-Style Assessment: CPR collects a range of *in-situ* observations on student behavior during each session. These data can be exported to a spreadsheet and analyzed for various trends and patterns.

A Central Library of Assignments that May be Customized for Local Needs: Instructors set up the content and activities within each CPR session. Sound instructional design guides each unit, starting with selecting desired learning outcomes and mapping the rubric (performance standards) to these expectations. Moreover, CPR's sophisticated algorithms for scoring performance on each of the four phases can be set by each instructor.

Acknowledgement:
This material is based upon work supported by the National Science Foundation (Division of Undergraduate Education, CCLI-Phase II) under Grant Nos. 0817515, 0816660, 0816849, and 0817015. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

References

1. Alley, M., *The Craft of Scientific Presentations*. New York: Springer-Verlag, 2003.
2. Saterbak, A. and Volz, T., "Implementing Calibrated Peer Review to Enhance Technical Critiquing Skills in a Bioengineering Laboratory," *Proceedings*, ASEE Conference and Exhibition, Pittsburgh, PA, 22-25 June, 2008, Session 117.
3. Hartley, J., *Designing Instructional Text*. London: Kogan Page, 1993.
4. Tufte, E. R., *The Visual Display of Quantitative Information*, 2nd Ed. Cheshire, CT: Graphics Press, 2001.
5. Harris, R. L., *Information Graphics: A Comprehensive Illustrated Reference.* New York: Oxford University Press, 1999.
6. Davis, D.C., Beyerlein, S. W., & Davis, I.T., "Development and Use of an Engineering Profile," *Proceedings*, ASEE Annual Conference and Exhibition. Portland, OR, 12-15 June, 2005. Session 3155.
7. Engineering Accreditation Commission, Accreditation Board for Engineering and Technology (ABET), Inc., *Criteria for Accrediting Engineering Programs Effective for Evaluations During the 2005-2006 Accreditation Cycle,* November 2004.