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Integrating Undergraduate Research into Engineering: A Communications Approach to Holistic Education

A communications approach to holistic education

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In the first issue of the new *Journal of Engineering Education*, Joseph Bordogna, Eli Fromm, and Edward W. Ernst called for an integrative, holistic approach to engineering education [1]. An opportunity for achieving this goal has presented itself in the current emphasis on undergraduate research. Undergraduate research, if properly structured, is inherently holistic, as it compels learners to analyze, synthesize, and apply strands of knowledge gained from classes, hands-on investigation, reading, mathematical reasoning, and open-ended problem solving. However, as social constructivist theory holds, learners benefit from support and structured guidance as they integrate and construct their holistic understandings. This process of knowledge construction is the foundation of life-long learning required for solving the

unique, continually evolving problems within a discipline. As knowledge construction depends on communication, holistic educational processes must integrate authentic communications principles and practice.

The Research Communications Studio (RCS) is a structured learning approach for teaching undergraduate researchers, over time, to do the authentic written, oral, and graphical communications tasks required by research while they are learning to do authentic research. The RCS, designed by a group of faculty from USC chemical, electrical, and mechanical engineering and communications (English), investigates communications as a tool for learning, thinking, and cognitive development. With NSF support, the RCS accommodates a diverse undergraduate population as well as the constraints imposed on research-intensive engineering departments.

In the RCS, mall groups of undergraduate researchers meet weekly with a communications faculty member, an engineering graduate student mentor, and a communications graduate research assistant. Each participant works closely with his or her engineering professor through enrollment in an independent study course and through the advisor's assignment of and evaluation of deliverables for credit. The project is built upon constructivist learning theory that recognizes the interdependence among communication, cognitive development, and metacognition. It investigates knowledge construction within a small-group context of distributed cognition, the concept that each group member's expertise is available to other group members.

In the RCS distributed cognition approach, thinking within the small groups is viewed "not as an action that takes place wholly inside an individual's head, but rather as an activity that is distributed among the individual, other people, the physical environment, and the tools the person uses, including language and such language structures as genres" [2]. Novice-expert status becomes relative as different group members contribute their knowledge. In the RCS groups, one who is more experienced or knowledgeable provides the leadership for another who is ready to develop that knowledge. Through an approach similar to the reciprocal teaching model described in *How People Learn* (HPL) [3], the RCS teaching-learning model operationalizes Vygotsky's *"zone of proximal development*" *(ZPD)* as it helps students acquire the metacognitive abilities that support learning/cognition.

During its first two years, RCS staff collected a comprehensive body of data on operations--including videotapes of most small-group sessions, staff meetings, and a participant focus group--which is too extensive to report in this article. Reported here are results of selected responses from the faculty advisor, mentor, and undergraduate participant surveys developed,

validated (with feedback from engineering experts), conducted, and analyzed by the Office of Program Evaluation (OPE) for gaining the perspectives of these three groups. In addition, a preliminary analysis of participants' reflections (written after each weekly session to articulate what they learned) provides valuable triangulation of data from the surveys. Results and discussion of each data source are categorized by the theoretical foci: cognition, communication, distributed cognition, and metacognition.

Data from surveys indicate that engineering faculty members, graduate student mentors, and undergraduate participants were very positive about the progress participants made in cognitive development and communications abilities, and that the structure of RCS sessions facilitated learning in the distributed cognition environment. Analysis of participants' reflective writings shows the development of metacognitive abilities necessary for self-directed, life-long learning.

More specifically, a high level of satisfaction was reported by Faculty, Mentor, and Participant surveys. Faculty members said their RCS students were able to think more scientifically (*mean* = 3.67 on a 4 point scale), understand scientific research (*mean* = 3.56), synthesize information from diverse sources (*mean* = 3.67), and take more initiative in framing and solving research problems (*mean* = 3.56). As a result of RCS participation, both engineering faculty members and engineering graduate mentors agreed that the RCS helped improve the quality of undergraduate research and design-based learning (*mean* = 3.44 and 3.75, respectively). The two groups strongly agreed that RCS helped students meet audience needs when they communicate (*mean* = 4.0 each group). The RCS undergraduate researchers gave high marks to their learning experiences in the RCS (*mean* = 3.38 average on 12 items). All of these data are reported in more detail in the article.

The RCS demonstrates the synergy between communications and research-based learning. As the Boyer Commission notes, "No idea is fully formed until it can be communicated . . . The organization required for writing and speaking is part of the thought process that enables one to understand material fully" [4]. The RCS staff members continue to search for ways to articulate this idea: that engaging undergraduate researchers in communicating about their research on a regular basis is a profoundly effective way to help novices develop engineering expertise (in knowledge of subject matter and in ability to communicate that knowledge) and the capacity for life-long learning. We also continue to seek ways to adapt the RCS approach more broadly into engineering education.

References

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