Companion Note

Case Studies for Teaching Technology: Contexts for Course Content

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There is growing interest in using problems from the "real worlds" of work and community experience to improve learning. Various institutions and educational initiatives, centers, and projects now model problem-oriented learning approaches that develop content knowledge, critical thinking skills, and "personal qualities [like] responsibility, sociability, self-management, and integrity/honesty" (SCANS 2000) in authentic contexts. The growth of such programs attests to a frustration with the results of traditional pedagogy. It also marks a growing conviction that replicating the chaotic terms of work-world thinking for students prepares them more honestly and more fruitfully for careers and for life. Increasingly, then, teaching practice is assuming the challenge of unfolding the intrinsic disorder of real problems. Problem-oriented approaches like case-based instruction embrace the intellectual fogs that settle around dilemmas with genuine layers of circumstance and consequence. Practitioners of case-based or problem-oriented instruction value not so much the solutions or products of thought, but the processes of critical inquiry that engage the ambiguities, instabilities, inconsistencies, and confusions of real-world problems.

Such problems accomplish what Bill and Margaret Naumes in the preceding article value about case studies as learning resources: they "develop higher-level skills by involving students in the complexities of organizational life." Originally, beginning in the 1950's, professional schools in medicine used realistic problem-solving to involve students in the complexities of their discipline. Business schools, notably Harvard's, developed a case study genre that combined the descriptive and documentary aims of research with the pedagogical use of real business dilemmas and examples. Today, case study formats and problem-oriented assignments are evolving to meet purposes and aims across the disciplines and across educational levels. Fundamental to all incarnations of this teaching strategy, though, is the belief that the dynamics of problems can shape the "higher-level skills" the Naumeses value.

Web sites for groups that advocate problem-based learning allude to the formative power of problems. Site descriptions of problem-based learning suggest some structural connection or parallel between the irregularities of real-world problems and the dynamic convolutions of critical thought. A link on the Samford University Problem-Based Learning Initiative's homepage, for example, considers problems to "form the organizing focus and stimulus of learning" (Samford University, 2000). Similarly, the site for The Illinois Mathematics and Science Academy's Center for Problem-Based Learning states that "the ill-structured problem, which is messy and complex . . . changing and tentative . . ." is the "organizing center" of problem-based approaches (C.P.B.L., 1999). The University of California, Irvine, Problem-Based Faculty Institute associates a chaotic flux and transition of thought—not some linear stability and continuity—with the experience of problem assignments: "Problem-based learning," the institute's web site notes, ". . . is process-centered more so than product-centered" (U.C. Irvine, 2000). The point is that well-funded programs across disciplines and educational levels embrace a model of cognition privileging multidimensional, sensorial, experiential, contextual, and holistic engagement with subjects. Such learning is a naturally turbulent and deregulated intellectual experience.

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It may be worth asking, then, whether reconstituting paths to knowledge and understanding actually reconstitutes that knowledge and understanding, itself. Certainly, many educators no longer regard the disciplinary "knowledge" that marks expertise to be museum-like collections of classical [arti]facts and truths students must appropriate somehow. But what does current pedagogy's de-emphasis of objective course information mean for the subject contents of so-called "hard" technologies, for which principles like Ohm's Law, after all, are physical properties that either are or are not mathematically legitimate or objectively "given?" How do we reconcile the technologies' basis in what is determinate and specific with an instructional paradigm that has an "organizing center" in what is indeterminate and relative? If we admit a stereotype, how do empiricists—engineers, scientists, technicians, those who negotiate the quantitative terms of a tangible domain—abide the qualitative realm of poets and philosophers?

Chetan Sankar recognizes the predicament at the heart of this incongruity in a comment posted on a "knowledge mining" web site for a case study design forum last year at Vanderbilt University. Sankar emphasizes that technically precise decisions based on empirically absolute data are, of course, integral to engineering, and are unlike some "managerial decisions [that] are based on 'vague facts,' " and that permit problem solvers to make "decisions that are not precise." He contrasts the sort of loose and vague problems leading to such decisions with the kind of technical problem in the award-winning *Della Steam Plant Case Study*(Raju and Sankar, 1998) he co-authored with P.K. Raju. In that case study, engineers troubleshoot a vibrating turbine experiencing “either an oil whip or oil whirl . . . [which] it is critical for the engineers and technicians to recognize.” His point is an important one: what “technical people face is that . . . they are responsible for the technical issue that has a right or wrong answer.” He adds that “To integrate the dynamic indeterminacy of [the] organization [of case study problems] with the deterministic features of technical problems is the challenge for . . . those of us who are involved in creating the case studies for technical people” (Knowledge Mine, 1999).

Granting the empirical foundations of science and technology, one way to meet this challenge is to emphasize the multidisciplinary, interpersonal, cross-cultural, and even transnational networks of issues attending technological problems. Students must see that scientific and technological practices do not occur in vacuums. Perhaps a role that problem-oriented case studies can serve for technological education, then, is to introduce to the technologies what Samford University president Thomas E. Corts, writing about Samford’s PBL initiative, associates primarily with “the ‘softer,’ less black-and-white disciplines.” For one thing, he acknowledges the “human volatility and unpredictability [that] are more dominant variables” in the liberal studies. He also attributes to liberal studies, “the concept of [a]‘problem’ [that] has fewer specific variables that can be manipulated with clinical accuracy and precision ” than is the case with problems in the technologies (Corts, 1998, p.3).

Perhaps for technological education then, problem-oriented learning can join the crisp details of technical information and the straight lines of scientific method with the sinuous and sometimes soft edges of a problem’s circumstances and implications. Case studies and problem-based assignments can involve technology students in the capriciousness of human nature, the ambiguities of communication, the paranoia of choice, the ethics of rule and law, the moralities of conduct, the aesthetics of design, the politics of regulation, the economics of profit and loss, and the prejudices of difference. Case studies that engage students in the conditions and applications of technical information help prevent the sort of limited understandings that Matthew Arnold attacked in his 1882 lecture “Literature and Science.” Arnold’s objection to information in isolation—to knowledge that excludes connections with patterns (or “powers,” as he called them) of meaning and experience intrinsic to the building up of human life (Arnold, 1882, p.463)—sounds just like what we have heard before about the tyranny of absolute facts: “everyone knows how we seek naturally to combine the pieces of our knowledge together, to bring them under general rules, to relate them to principles, and how unsatisfactory and tiresome it would be to go on forever learning lists of exceptions, or accumulating items of fact which must stand isolated” (Arnold, 1882, p.463).

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For those of us writing cases for the technical fields, the practical questions become these: How can case studies foster understandings that are expansions of what our own training and experience with issues predisposes us to validate? How can we design an experience in learning that can transcend our own expectations for student approaches to problems? How may case problems enable dynamic contextualizations of information rather than simple objectifications of it? In short, how can we encourage the sort of natural combination of “the pieces of our knowledge together” that Arnold distinguishes from the sort of knowledge comprised of information that “must stand isolated?”

To begin to answer these questions, on January 21, 1999 the Southeast Advanced Technological Education Consortium (SEATEC), a National Science Foundation case study development project, hosted a forum at Vanderbilt University on the characteristics of effective case studies for technical disciplines. Some clear expectations for case design emerged from the nine panelists’ presentations and their discussion of problem structure in case studies. Panelists’ formal papers for this meeting (Bransford et al., 1999) support the ideal of a multidimensional, open-ended sort of case problem and acknowledge the value of collaborative problem-solving. Additionally, most panelists identify a need for interdisciplinary orientations of case problems. As Harvey Goodman writes, “Problems that workers generally face require them to synthesize their knowledge on a variety of subjects.” Noting that no single definition exists for case studies, James Camerius cites a range of definitions, one of which claims a case is a “multifaceted investigation,” and he describes traditional case studies as “includ[ing] problems from many different fields.” Elizabeth Mathias, with the SCANS 2000 project at Johns Hopkins University, explains that “effective case studies should . . . draw knowledge and applications from many disciplines” and that SCANS 2000 module developers “found that students needed an array of academic knowledge to solve the problems” developed by the project. Similarly, P.K. Raju and Chetan Sankar advise that technical case studies “integrate technical, managerial, and ethical issues,” and they offer a student’s positive comment that their *Della Steam Plant Case Study* (Raju and Sankar, 1998) “exposed [students] to other issues besides mechanical engineering.”

Surely, it might be said, much of the “real-life context[uality]” (Camerius, Goodman), actuality or “realism” (Raju and Sankar), and “relevancy” (Mathias, Smith) the SEATEC panelists advocate for case design goes far beyond verisimilitude for its own sake or just accurate recording of an historical case situation. What it is about the true accounting of a real-life case event that makes it so useful to learners is that an actual case likely reflects the “integration of broader aspects, including technical, economic, social, ethical, and environmental,” one of Karl Smith’s criteria for an effective case study. Ideally, a key goal of the case study is to produce in learners an expanded perception, an enlarged comprehension that transcends the immediate terms of some technical problem—whether simulated or actual. This seems most possible when the problem is multidimensional and crosses disciplines. Such interdisciplinarity makes the case relevant and interesting to students. In no small part, it is what is "realistic" about a case and is, as well, what often gives a case its "open-ended" (Smith), "judgement"-oriented (Hornaday), "messy," "ambiguous" (Mathias) character.

Generally, panelists' forum papers acknowledge that cases should provide a degree of dynamic indeterminacy, whether through the multiplicity of collaborative, team problem-solving or through the realistic, natural ambiguity of the problem, itself. Harvey Goodman recognizes that "Many of the more interesting problems have more than one solution, in which case there are likely multiple perspectives on how to address the problem." Elizabeth Mathias points out that "ambiguity becomes a useful teaching/learning tool." Noting that "case studies should present the reader with a situation that requires a choice between alternative courses of action," James Camerius prefers that a problem have "no one right choice or at least no obvious one right choice." The point seems to me to be expressed by the engineering manager who sponsored Raju's and Sankar's *Della Steam Plant Case Study* project (Raju and Sankar, 1998): "There may not be one right answer in the case study. The value comes from evaluating the options presented in the case study, not from obtaining the correct solution."

In other words, the more a case problem opens to options—to diverse perspectives, to collaborations, to multiple disciplinary frameworks—the more fruitful it may be as a learning resource for technical students who must meet expectations like those identified for engineers by J.W. Prados, whom Raju and Sankar quote in their paper: "Success as an engineer requires, in addition to strong technical capabilities, skills in communication and persuasion, ability to lead and work effectively as a member of a team, and understanding of the non-technical forces that profoundly affect engineering decisions." The point is that education must involve technology in its multiplex relations with other domains.

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An irony for empirical science is that while its solutions to problems certainly follow from objective procedures and data, objectivity is quite often problematic. Arguing for "intellectual cross-training" for students, Thomas Cech juxtaposes the humanities' "diverse and mutually contradictory 'data,' " its rich perspectives, with the popular view about the information of science: "While scientific data are commonly thought to exist on a different plane—absolute, precise, unambiguous, and above reproach—such is rarely the case" (Cech, 1999, p.210). Cech argues that "scientists need the same skills as humanists" to negotiate the "random error and systematic deviations" of statistics, the impact of experimental design choices on results, or the influences of expectation and of prior research upon interpretation (Cech, 1999, p.210). Case studies that present authentically interdisciplinary and ambiguous problems can sensitize students to the personal, interpersonal and socio-cultural forces that influence our use of scientific knowledge. Indeed, for the past two decades, the preoccupation of reform movements in science-education has not been with the products of education but with education's processes—not, that is, with canons of knowledge, but with cognitive paths to it. Pricilla Laws writes that this shift in focus is expressed by views that "instruction should be replaced by active learning opportunities." Science-education reformers, according to Laws, argue that "a conceptual understanding of science and the processes of experimentation and theory-building are more important than a broader knowledge of accepted facts and theories." Significantly, too, reformers believe the use of course information or topics "should provide a foundation for self-actuated learning and be relevant to social issues and the workplace," and that the collaboration and communication skills thus acquired should "help students 'learn how to learn' " (Laws, 1999, p. 219). As an important part of this trend for education in the sciences and technologies, problem-oriented case studies help move education from disciplinary inculcation of subject matter to interdisciplinary, intercultural, and interpersonal experience with real-world thinking.

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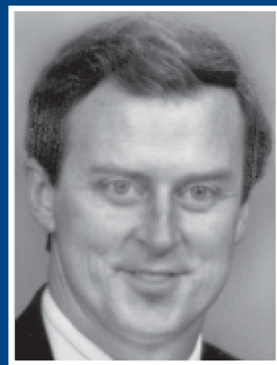

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