The 'Undisciplined,' Interdisciplinary Problem:
PBL and the Expanding Limits of SMET Education

Mark E. Walls
Jackson State Community College

In many disciplines, knowledge and its paradigms are in flux. They are "decentering," to use the postmodernists' term. Pluralism, contextuality, and relativism are ideological forces changing how we think and teach. Core parts of our cultures— our politics, technologies, economies, philosophies, and histories— all inherently ambiguous, generally are acknowledged, even celebrated, as such. Certainly, modern problems across our cultures rarely are one-dimensional or discrete. Julie Thomson Klein considers this in an important work on interdisciplinarity, *Crossing Boundaries: Knowledge, Disciplinarities and Interdisciplinarities*. She acknowledges that contemporary problems defy rigid and absolutist thinking and require integrated frames of disciplinary reference. "The complexity of problems that professionals face in practice creates a sense of interdisciplinary necessity. . . . By their very nature," Klein writes, "they are open-ended, multidimensional, ambiguous, and unstable. Considered 'wicked' and 'messy,' the problems at the heart of many professional fields cannot be bounded and managed by classical approaches to the underlying phenomena" (1996, p. 40). Indeed, the borders of our problems are more than just close and contiguous. Problems integrate and join. They combine in complex permutations that can make discipline boundaries much less significant or meaningful.

The way our graduates practice their disciplines, then, should raise important concerns for educators. Some recognize the importance of showing how subject knowledge and its applications can be fluid and conditional, not frozen and absolute. In different ways, programs are preparing students to negotiate solutions for problems within the loose and shifting contexts of knowledge. For instance, describing reasons for a 1992 revision of Clemson University's civil engineering curriculum, Steve Sanders and Benjamin Sill explain that input their department sought from industry contacts emphasized "engineering graduates tend to see most problems as being well-defined, with a single, correct solution." Of course, Sanders and Sill point out, the "problems students encounter after graduation are often ill-defined, with multiple possible solutions" (1997, p. 108). The fact is that at their jobs graduates must choose from *among* courses of action. Also, while graduates must be effective critical thinkers, applying multiple and complex perspectives to issues, they must do more than just think critically for its own sake. They also must apply their thinking, must act upon it. They must make skillful decisions. They must produce real solutions to problems efficiently and practically, responsibly and ethically. Moreover, they must think and act and communicate with their colleagues on the job and within increasingly global contexts. College coursework, therefore, should encourage such collaboration and invite the kind of sophisticated, cross-disciplinary, flexible perspectives so vital in the so-called "real work world."

Authentic work-world problems related to course material help produce these perspectives. Such problems free students from *having* to learn or think in fixed ways. Perhaps as much as is possible, approaches like problem-based or case-based instruction avoid prescribing the terms of learning. Such approaches generally do not lead thought in ritual directions along well-trod cognitive paths. Problems with layers of context, circumstance, and consequence can expand the boundaries of technical pedagogy to involve perspectives and methods of various disciplines. By activating multidisciplinary and even more complex cross-disciplinary thinking (understanding issues in terms of other disciplines' conceptual frames), problem-based assignments expand associative and assimilative reasoning. They encourage products of mind that are much more than the sum of their parts. Through rich problems, knowledge becomes synergistic. It becomes an amalgamation of *experience* rather than an abstract, and often inapplicable, assemblage of *fact*. Certainly, to privilege personal experience over objective discipline information is to orient teaching and learning differently than has been the case in traditional pedagogy. It reflects a decentering of both the authority once assumed for singular disciplines and the relevance of discipline information for its own sake. It is important to remember that "having knowledge is different from having information," as James Davis has written, "and gaining knowledge today involves multiple perspectives and complex processes . . ." (1995, p. 39). In coursework, then, knowledge might be regarded more beneficially as a process than as a product. And problem-based assignments that unfold cross-cultural, multidimensional, interdisciplinary thinking advance this epistemological grounding.

Too frequently, though, too many students think the disciplines' aims and methods are divergent, if not at odds. This is not surprising, really, because for the most part, fields of study appear almost sovereign, sharply demarcated in core curricula. Many undergraduate courses seem generally not to reflect the intersections of the disciplines. Students miss the point, for example, that dilemmas in business are often resolved in sociological terms, or that the goals of engineering are realized variously as ecological, or economic, or medical, or marketing, or a great many other types of "solutions."

In practice, of course, the categorical and absolute boxes that formally package our disciplines stack within, not upon one another. In their applications, our specializations and interests frequently cross formal boundaries of academic domain and merge in new gene pools of thought and practice. Julie Klein accounts for new strains of knowledge born of commingling fields: new hybrid, hyphenated or compound disciplines like human ecology or ethno-musicology, biophysics, neuroendocrinology, and the like. "The interactions and reorganizations that [such] boundary crossing creates," writes Klein, "are as central to the production and organization of knowledge as boundary formation and maintenance." Interrelation among the traditionally exclusive disciplines, "stimulates the formation of trading zones of interaction, interlanguages, hybrid communities, and professional roles, new institutional structures, and new categories of knowledge" (Klein, p. 2).

But *in our classrooms*, these grand conditions of an evolving and enlarging interdisciplinarity are not prominent. Despite our era's valorization of pluralism and contextuality—paradigms for cross-cultural, cross-disciplinary sensitivity in the academy—undergraduate coursework generally retains a conventionally "bounded" or circumscribed character. Like beads of mercury, courses too frequently draw up into themselves, tight and intense, unable to de-center enough to blend with elements of other academic approaches, perspectives, or applications. Indeed, far too many humanities, science, and technology courses fail completely to acknowledge, much less engage, the practical interrelations of their subjects beyond the classroom. However, authentic problem-focused assignments dissolve the boundaries of understanding often prescribed by students' specialized areas of emphasis. To the extent such problems help students synthesize diverse frames of reference—certainly crucial to understand and accommodate on the job—these problems are fluid opportunities for thinking beyond ritualized and formulaic patterns associated with *the* traditions of *an* academic discipline.

James Davis acknowledges the limitations of circumscribing knowledge within the categorical and absolute constructs of the disciplines. "Disciplines use different paradigms, rules, and technologies to construct different reflections of reality," he writes (p. 36). The problem, Davis suggests, is that students regularly are not introduced to the fact that there are other terms by which reality can be understood and that any single discipline is quite naturally a limited and limiting mode of experience (pp. 36-37). In light of this condition of discipline-specific knowledge, Davis reiterates Joseph Schwab's argument from 1964 "that it is desirable, if not necessary that we so teach that students understand that the knowledge we impart may be incomplete, is relatively ephemeral, and is not mere literal, 'factual' truth" (p. 37).

Certainly, authentic work-world problems engage this kind of sophisticated understanding of a complex, multidimensional rather than one-dimensional reality. Problems integrate diverse approaches to knowledge. The measure of problem-based learning's ability to deregulate the terms of thinking, for instance, might be the extent to which an electronics student's circuitry design problem requires a business student's sensitivity to cost/supply relationships for alternative resistor devices, or the extent to which the problem involves a speech student's skill at defending the final circuit design, or a technical writing student's ability to document design variations, or an algebra student's ability to calculate current from values of voltage and resistance.

When electronics students orient their worlds of circuitry in terms of how much they cost to implement, or how efficiently they can be assembled, how logically justified, how clearly depicted, or how truthfully they can be marketed, then understandings result that engage the "transformative learning" Victoria Marsick describes. Such learning occurs when students "transform deeply held frames of reference to make sense of their experience in ways better suited to increasingly complex demands" (Marsick, 1998, p. 119). Learners thus engaged have a "higher-order capacity" and can "avoid becoming enmeshed in a point of view that leaves them blind to alternative, more encompassing viewpoints" (Marsick, p. 127).

While such transformative learning is an appealing goal, courses in the scientific and technological fields often seem closed to the conditions of interdisciplinary influence, perhaps more so than do courses in the humanities. Julie Klein accounts for the apparent "impermeability" of discipline borders in some science and technology fields that form "tightly knit, convergent communities" (p. 38). Summarizing C.F.A. Pantin's views in *The Relations Between the Sciences* (1968), Klein explains that these discipline communities "presumably have clear boundaries, circumscribed domains, and "neat" problems that are controlled through cognitive restriction and social consensus. . . . Most physical sciences, especially physics and chemistry, will exhibit strong linkage between research areas but lesser ties with other disciplines. In contrast, the humanities and social sciences are associated with greater permeability. They are considered more holistic, personal, value laden, and less codified. Loosely knit, divergent groups are thought to have a more fragmented, less stable, less theoretically specific, and more open-ended epistemological structure." (p. 39)

Of course, it should not be assumed, even in the humanities, that any epistemological open-endedness of a discipline is manifested in the coursework departments offer students. If synthesizing course information into negotiable—not intransitive—products of interdisciplinary, polyvalent thinking is a valuable but difficult goal for the humanities, it is an equally essential one yet, as Klein suggests, often a more problematic one for the "hard" sciences and technologies.

Toward the end of enabling such thinking, particularly in the sciences and technologies, it is important for course designers to construct somewhat unconstructed problem-based assignments. If, as constructivist education maintains, it is appropriate and essential to grant learners certain individual productions of knowledge, then (with adjustments for aims and applications) problem-based assignments like case studies might be designed to give learners more of an unstructured, truly open encounter. In this respect, a problem becomes something like a poem: fluid, evocative and relative, a bit like a Taoist aphorism. As with poetry, which can be formed as odes, sonnets, ballads, lyrics, etc., there may not be escape either from conventions that "mark" the format of some materials—components like the objectives, purpose statement, student questions, instructor's guide, bibliography, and such in case studies—or from characteristics of case study types (dilemma cases, appraisal cases, and case histories, as Clyde Herreid [1994] has described). But like a poem, the goal of the case text or problem—both the form and content—should be escape from ritualistic, standardized, or formulaic thinking that lingers in classrooms still: vestiges of a time when education reflected, quite exclusively, positivistic assumptions that reality, and knowledge of it, was consistent, definite, absolute, and independent of subjective human experience.

The attraction to such a view of reality may be easy to understand. It can be a comfortable, convenient perspective that simplifies the terms of being into straightforward, direct and distinct constructs. According to some, despite educational reform movements from the late 1950's on, American education—its resources, texts, materials and methods—has largely been frozen in practices that treat knowledge as though it were only simple and one-sided, as firm, factual, and unmistakable collections of Truth. It was just this kind of knowledge that Matthew Arnold, the great British poet, essayist, social critic (and public school inspector for 35 years) found dangerous in his 1882 lecture "Literature and Science." In this lecture, Arnold defended interdisciplinary, humanistic education against proposals to make "practical scientific knowledge," (p. 458) as it was conceived in the late nineteenth century, "the staple of education for the bulk of mankind" (p. 461). Arnold characterized the conflict over which sort of education could best serve modern life as one between positivism's basis in objective, self-evident, independent facts, and humanism's essence in subjective, negotiable, interrelated ideas.

Summarizing the sharp dichotomy at the time between the sciences and humanities, Arnold identified the empirical "reality" of the subjects of scientific study—tangible, finitely "knowable" phenomena—as an appealing, though flawed, foundation for knowledge. He wrote that "This reality of natural [i.e. scientific] knowledge it is, which makes the friends of physical science contrast it, as a knowledge of things, with the humanist's knowledge, which is, say they, a knowledge of words" (p. 462). But Arnold found this knowledge of the "positive science" (p. 459) of the time, appealingly concrete as it was, to be limited and inadequate for meaningful education if acquired and valued for its own sake or as mere "pieces of knowledge " that are "not put for us into relation with our sense for conduct, our sense for beauty" (p. 465) or with the various other "senses" or dimensions of human experience through which our graduates relate their worlds. Certainly for us today—as it was for Matthew Arnold—until absolute and invariable facts are joined to the multifarious domain of circumstance and context, they are, as Arnold put it, "after a certain while, unsatisfying, wearying" (p. 465).

Writing about the use of problem-based learning in medical education, H.J. Walton and M.B. Matthews describe such educational programs as having "curricular organization around problems rather than disciplines [and] an integrated curriculum rather than one separated into . . . components." They explain that "a curriculum is, or should be more than the sum of its parts. It derives its educational energy as much from the bonding of its constituents, as it does from the internal characteristics of the elements themselves. In these terms then," they write, "a curriculum is more than a cluster of topics, just as a house is more than an assemblage of bricks and mortar" (1989, p. 554). Whether in medicine or marketing, physics or philosophy, engineering or English, teachers must do more to show the chaotic nature of actual problems students will use their educations to solve. Teachers must help students see that, as with a home, the solutions they create will be more than "an assemblage" of discrete parts. This means instruction must not privilege discipline information or method in isolation, or outside of a context, or, as one medical educator has put it, distinct from "goals for students that are much broader than the acquisition of content" (Camp, 1996).

Teachers can avoid such limitations by using "ill-structured" problems like those advocated by The Illinois Mathematics and Science Academy Center for Problem-Based Learning. Through such problem assignments students "develop critical thinking, problem solving, and collaborative skills as they identify problems, . . . formulate solutions and determine the best 'fit' of solutions to the conditions of the problem" (CPBL, 1998). In the ill-structured problem, students may "not have most of the relevant information needed to solve the problem at the outset. Nor will they know exactly what actions are required for resolution. After they tackle the problem, the definition of the problem may change. And even after they propose a solution, the students will never be sure they have made the right decision. They will have had the experience of having to make the best possible solution based on the information at hand" (Stepien and Gallagher, 1993).

Problem-oriented assignments present students with dilemmas that require more than simplistic, fixed recollections of discipline "information." The authentic issues and tasks that form authentic problems shift the terms of learning from the static to the dynamic. These tasks de-emphasize the one-dimensional, "frozen information" that often *teachers provide* to students. Instead, these tasks emphasize the multidimensional, "fluid encounter" *students experience* among the contexts, conditions, and applications of information. Such assignments portray the worlds of work and human experience after college to be round, not flat, and the forces of skill and knowledge that spin these worlds to be dynamic, not static.

An earlier version of this paper was presented at the 1999 SEATEC Forum at Nashville, TN.

References

Arnold, M. (1882) Literature and science. In M. Allott & R. Super (Eds.). (1986). The Oxford Authors: Matthew Arnold (pp. 456-471). Oxford: Oxford UP.

Camp, G. (1996). Problem-based learning: A paradigm shift or a passing fad? Lkd. Medical Education Online at "Feature Articles." <http://www.med-ed-online.org/issue.htm> (2001, March 6).

Center for Problem-Based Learning, Illinois Mathematics and Science Academy. (1998, July 1). CPBL Work. Lkd. Center for Problem-Based Learning Homepage at "What is the Center for PBL." <http://www.imsa.edu/team/cpbl/cpbl.html> (2001, March 6).

Davis, J. (1995). Interdisciplinary courses and team teaching: New arrangements for learning. American Council on Education Series on Higher Education. Phoenix: Oryx.

Herreid, C. (1994, February). Case studies in science—A novel method of science education. Journal of College Science Teaching, 23 , 221-229.

Klein, J.T. (1996). Crossing boundaries: Knowledge, disciplinarities, and interdisciplinarities. Charlottesville: UP of Virginia.

Marsick, V. (1998). Transformative learning from experience in the knowledge era. Daedulus, 127, (4), 119-136.

Sanders, S., and Sill, B. (1997). Creative problem solving. Proceedings of the 1997 ASEE Southeastern Section Meeting: Innovative Engineering for the Next Century. 108-112. Marietta: Southern Polytechnic State University.

Stepien, W., & Gallagher, S. (1993). Problem-Based learning: As authentic as it gets. Educational Leadership 50 (7), 25-28. (EBSCOhost Document Reproduction Service No. 9306035029).

Walton, H.J., and Matthews, M.B. (1989). Essentials of problem-based learning. Medical Education, 23, 542-558.

Mark Walls, Associate Professor of English at Jackson State Community College in Jackson, Tennessee, teaches literature, composition, technical writing, and print media courses. He also has worked with oil and gas-extraction service companies in Louisiana and has industry experience with the Saturn Corporation and with Motorola Communications and Electronics, Inc. From 1996 to 1998, he worked with teams designing telecommunications and electronics case study materials as a member of the Tennessee Exemplary Faculty for Advanced Technological Education (TEFATE) group, a faculty development project funded by the National Science Foundation. Affiliated now with the South East Advanced Technological Education Consortium (SEATEC), Mr. Walls continues to develop case study training materials for courses in the technologies. He is especially interested in how oral and written communication enable cross-disciplinary thinking in problem-based learning.