

# Multidisciplinarity and 21st Century Communication Design

Brad Mehlenbacher

Adult & Higher Education / Educational Leadership & Policy Studies  
North Carolina State University  
Raleigh, NC 27695-7801  
1.919.515.6242  
brad\_m@unity.ncsu.edu

## ABSTRACT

This paper addresses recent calls for the importance of multidisciplinary research and action in communication design. The impetus for multidisciplinary perspectives toward communication design is technological change, rapid developments in work products and processes, and the perception that emerging issues in the workplace demand additional competencies and knowledge. Terminology related to multidisciplinarity, such as disciplinarity, cross-disciplinarity, interdisciplinarity, and transdisciplinarity, is defined. Since ACM SIGDOC members are distributed across academic and nonacademic fields and institutions, the focus will be on discipline as epistemology and as language with the goal of explicating common frameworks and terminology for better articulating communication design and work.

## Categories and Subject Descriptors

H. [Information Systems], H.1. [Models and Principles], H.1.0. [General].

## General Terms

Design, Documentation, Human Factors, Theory.

## Keywords

Communication, Cross-disciplinary, Design, Education, Interdisciplinary, Multidisciplinary, Transdisciplinary, Work.

## INTRODUCTION

Since the reorientation of SIGDOC from its historical focus on computer documentation to its broadened scope of communication design in 2004, numerous discussions have centered around the importance of multidisciplinarity to the future of the field [49, 50]. This realignment, from “human factors to human actors” [6] is a significant one and draws on general movements in the arts, sciences, and applied sciences toward developing global, collaborative, holistic, and culturally sensitive workspaces and knowledge workers. Indeed, Scenters-Zapico and Cos [58] argue that a radically comprehensive approach to

problems and processes is demanded by the 21st century “with the triumphs going to rhetoricians skilled in many disciplines’ knowledge and talents. As the Athenians had to process what we might today call ‘multidisciplinary knowledge and skill’ in order to survive and thrive in a demanding democracy, so students today must possess the multidisciplinary knowledge and technical skills to succeed in a multimedia age” (p. 64). It is therefore not surprising that innovative curricular developments in the humanities are aligning themselves with developments in digital media [40, 68] and that computer science and engineering programs are grounding themselves in communication, social, ethical, and environmental studies [7, 33, 34, 69].

These shifts in disciplinary focus, relationships, and work processes are being driven by accelerated technological change and radical shifts in the nature of communication design work. Resulting demands for an increasingly flexible, creative workforce able to work across organizational and conceptual boundaries [24], in turn, are driving us to re-examine traditional means of structuring knowledge, learning, and disciplinary expertise.

## FUTURE COMMUNICATION DESIGNERS

One indication of the rate of change being experienced by professionals who design communication is how quickly our work and our work contexts become obsolete. Thus, only ten years ago, Zachry [71] observed that, “In this time, countless professionals have devoted themselves to developing manuals, reference sheets, guidebooks, keyboard templates, online help systems, etc. that — to varying degrees — have been used and abandoned as technologies change” (p. 22). In less than thirty years, communication designers have gone from documenting Fortran compilers [42], through cognitive analyses of documentation users’ tasks with minimalist manuals [10, 29] through SGML markup challenges [26] to DITA [2], Wikis [23], and visual representations of the activities of communication designers themselves [32].

As the products and processes that we design have changed, so too have the environments within which we work. As Spinuzzi [63] notes, our “distributed work [is] coordinative, polycontextual, cross-disciplinary work that splices together divergent work activities (separated by time, space, organizations, and objectives) and that enables the transformations of information and texts that characterize such work” (p. 266).

Divergent work activities necessitate a flexible workforce, one that adapts to novel situations and challenges quickly and creatively for, as Stinson [64] points out,

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*SIGDOC '09*, October 5-7, 2009, Bloomington, Indiana, USA.  
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Increasingly, employees are being called on to continually expand their capabilities, not to do more work, but to do more complex work, to make more decisions and make them more independently. This implies that people need to be continually developing competencies — not just job skills, but also intellectual skills. It implies that learning opportunities need to be available to them anytime and anywhere, and that learning needs to be available just-in-time as needed for their use (p. 167).

Numerous researchers and associations have developed arguments about just what these “intellectual skills” need to be. Partnership for 21st Century Skills [46] adds to the traditional list of subject areas (e.g., English, Mathematics, Science), the following 21st century themes:

- Global awareness
- Financial, economic, business and entrepreneurial literacy
- Civic literacy
- Health literacy.

These “core subjects” are augmented by learning and innovation skills, information, media, and technology skills, and life and career skills. Burkhardt, Monsour, Valdez, Gunn, Dawson, Lemke, Coughlin, Thadani, and Martin [15] report that general knowledge of scientific, economic, multicultural, and global principles are critical for “Digital-Age Literacy” (p. 15).

Thomas and McShane [66], as well, emphasize the host of literacies that future communication designers need to incorporate:

- Basic literacy
- Rhetorical literacy
- Social literacy
- Technological literacy
- Ethical literacy
- Critical literacy (p. 415).

Felder [25] argues that future graduates “who continue to find jobs in the new economy” will need to be

- Creative researchers, developers, and entrepreneurs who can help their companies stay ahead of the technology development curve;
- Designers capable of creating products that are attractive as well as functional;
- Holistic, multidisciplinary thinkers who can recognize complex patterns and opportunities in the global economy and formulate strategies to capitalize on them;
- People with strong interpersonal skills that equip them to establish and maintain good relationships with current and potential customers and commercial partners;
- People with language skills and cultural awareness needed to build bridges between companies and workers

in developing nations (where many manufacturing facilities will continue to be located);

- Self-directed learners, who can keep acquiring the new knowledge and skills they need to stay abreast of rapidly changing technological and economic conditions (p. 96).

Of course many of these multidisciplinary intellectual skills demand manuscript-length treatments of their own. Such treatments are going to become increasingly necessary if academic and nonacademic advocates hope to move beyond superficial pronouncements about the future of the field. One way of keeping the discussion pragmatic and grounded in real communication design work is to focus on the nature of problems in the new economy.

## DEFINING WICKNESS

Problems with ill-defined parameters and outcomes governed by uncertainty and constant change have been defined as “wicked.” Kukla, Clemens, Morse, and Cash [35] summarize wicked problems as follows:

1. **There is no definitive formulation of the problem.** Because these systems are large and constantly changing, the person solving the problem does not have all the information needed to understand the problem fully.
2. **There is no stopping rule to tell when the problem is solved.** The problem solver can never conclusively answer the question “Have I done enough?”
3. **There is no immediate nor immediate test of whether the system design is successful.** The system design process has unbounded consequences, and there is no way to conduct comparative analysis.
4. **There is no single, identifiable “cause” of a problem.** The problem may be a symptom of other problems, and the solution will change depending on how the problem is formulated (p. 43).

Buchanan [11] traces the origins of the term, wicked problems, to Horst Rittel [55] who, according to Churchman [19], defined them as “that class of social system problems which are ill-formulated, where the information is confusing, where there are many clients and decision makers with conflicting values, and where the ramifications in the whole system are thoroughly confusing. The adjective ‘wicked’ is supposed to describe the mischievous and even evil quality of these problems, where proposed ‘solutions’ often turn out to be worse than the symptoms” (p. B-141). Buchanan [11] notes that Karl Popper first used the term “wicked” to characterize complex problems whereas Churchman [19] was intentionally emphasizing the moral dimensions of design and planning. For Buchanan [11], *indeterminacy* is the key attribute of wicked problems and, therefore, wicked problems are nonprogrammable and must be interpreted rhetorically (p. 16).

Contemporary communication design work is collaborative, distributed, and wicked, involving as it does frequent problem finding, problem identification and setting, and structured, informational and persuasive reporting. And, unfortunately, as Perkins [47] asserts, “Conventional education does virtually all problem setting for students, deciding which problems are worth doing and, often, in what order.... The surprising thing is not that

learners commonly miss ‘real-life’ applications, but that from time to time students find some” (p. 113).

Schön [59] defines problem setting as “a process in which interactively, we *name* the things to which we will attend and *frame* the context in which we will attend to them” (p. 40). Importantly, the more contingent our situation, the more difficult the act of identifying the appropriate problem; as Schön [59] asserts, “when the ends are confused and conflicting, there is as yet no ‘problem’ to solve” (p. 41).

Brewer [9] views the problem as being much larger than the students being graduated today. Focusing on environmental problems and their potential solutions, he [9] states, “Universities and other knowledge institutions are obvious sources of creativity and innovation, and in truth these have provided some of both. Main concerns center on the small amount and slow rate of each, as reflected in the enormous and unresolved difficulties of achieving sustainable development, ecosystem management, integrated assessments of exceedingly complex bio-geo-chemical systems and processes, and clarity about human-intentional interventions on global and regional — as well as local — scales” (p. 328).

To begin to understand why disciplines as constructs have been designed poorly to address these and similarly complex work processes, products, and problems, it is important that we agree on what exactly we mean when we talk about disciplinarity.

## DELINEATING DISCIPLINES

Of instruction and learning across departmental boundaries and expertise, Spinuzzi [62] notes, “Too often, workers receive support for vertical learning through multiple channels — formal training, documentation, etc., to help them master their trades, fields, and disciplines. But support for horizontal learning, learning across workplace boundaries, is restricted to informal, contingency-oriented channels.”

Similarly, our educational system is designed around the disciplinary boundaries where deep knowledge of a given field (e.g., English, Mathematics, Engineering, etc.) informs the curricula and organizational structures of our educational institutions. A discipline can be defined as a branch or department of knowledge (either a science or an art) aimed at practice or exercise rather than as developing abstract theory traditionally associated with a doctrine. Nikitina [43] extends the notion of a discipline, describing three interrelated meanings: “(a) *discipline as culture*, referring to an academic or department affiliation or to a collaboration of people within the institutional structure; (b) *discipline as epistemology*, referring to the shared methodological tools and ways of knowing; and (c) *discipline as language*, referring to communication that uses a similar language or symbol system” (p. 393).

Notably, disciplinary knowledge formation and dissemination have a considerable history in the North America. Abbott [1] has observed that the number of academic disciplines has remained remarkably stable during this century, concluding that “The American system of disciplines thus seems uniquely powerful. Because of their extraordinary ability to organize in one single structure research fields, individual careers, faculty hiring, and undergraduate education, disciplinary departments are the essential and irreplaceable building blocks of American universities (p. 210). Petraglia [49] adds,

Thus the need to be accorded disciplinary status is not a nicety but a necessity in the modern academy; it is accompanied by perceptions of methodological rigor and theoretical integrity, and it is ultimately rewarded with material resources, tenure lines, and publishing opportunities. The reasons for this center on the regulating and commoditizing nature of disciplines and the global expansion of a knowledge economy that, far from stumbling, seems to be more ideologically unchallenged than ever before. We have yet to find any real “cure” for disciplinarity’s obvious shortcomings. Though we may rail against the arbitrariness and restrictiveness of disciplinarity, we continue to play by its rules, for they are, both figuratively and literally, the rules of the academy (p. 155).

Thus, disciplines are organized around similar (agreed upon) topics, methods and objects of inquiry, and credentialing processes for incoming and existing members. The Oxford English Dictionary describes a discipline as a particular “department” of learning or knowledge informed by collective rules that shape “proper conduct and action.” In the workplace, as well, disciplinary influences play out in the departmental structures of many contemporary companies. Engineering design, programming, human factors, and project management often occupy profit center status, whereas communication design (if it is even organized as a “center”) falls with marketing, instructional design, and usability testing and evaluation into the cost center category. Although innovative organizations have made attempts to undermine this orientation, many communication designers continue to describe these types of institutional organizations.

When we refer to interdisciplinary research or action, then, we are describing an interaction between or blending of two or more areas of learning. Cross-disciplinary research or action involves two or more disciplines employing the methods, understandings, or activities of the others without necessarily merging their resources. Interdisciplinary relationships involve cooperation and integration of practices and understandings whereas cross-disciplinary interactions may involve cooperation but do not necessitate integration.

Multidisciplinary research or action, similar to interdisciplinary engagement, requires that separate disciplinary understandings be combined or integrated. Not only have researchers doing multidisciplinary research struggled in the academy for status and centrality against the forces of disciplinarily-located educational efforts, but the academic disciplinary structures that are designed to solve particularized problems have also resisted the types of co-responsible ownership that have resulted from emerging technologies. Indeed, these developments have challenged constructs as fundamental as collaboration, information, learning, communication, methodology, and instruction [70].

Finally, transdisciplinary research or action, according to Hirsh Hadorn, Biber-Klemm, Gossenbacher-Mansuy, Hoffmann-Riem, Joye, Pohl, Wiesmann, and Zemp [33], aims “to grasp the complexity of the problems, to take into account the diversity of scientific and societal views of the problems, to link abstract and case specific knowledge, and to constitute knowledge with a focus on problem-solving for what is perceived to be the common good” (p. 19). At the heart of transdisciplinary research or action is the goal of integrating understandings, approaches, data, methods,

and arguments from more than one discipline with the ultimate goal of solving significant, real-world problems. And the first, critical stage of transdisciplinary research is to actually identify the problems since, as Schön [59] and Pohl and Hirsh Hadorn [52] remind us, “Problems cannot be considered as given” (p. 429).

## DESIGNING MULTIDISCIPLINES

Assuming that problems must be invented or discovered, and that traditional disciplinary delineations of knowledge are falling short of preparing future communication designers for the complex work that is expected of them, some researchers argue that the language of design offers a powerful potential direction [5, 13, 39, 60]

Indeed, researchers have brought various perspectives to the exploration of alternative methodological approaches modeled after design rather than notions borrowed from de-contextualized science (11, 12, 38, 61), such as cognitive design [53], design research [3, 20, 21], practice-based research [37], sociocultural instructional design [28], and learner-centered design [44, 54]. Design is by nature multidisciplinary and invites an inevitable tension between generality and specificity, between the sciences and the arts, between seeing and performing, and between problems that are well-structured and problems that are wicked.

Buchanan [11] stresses the importance of this design orientation, writing “The power of design as deliberation and argument lies in overcoming the limitations of mere verbal or symbolic argument — the separation of words and things, or theory and practice that remains a source of disruption and confusion in contemporary culture. Argument in design thinking moves toward the concrete interplay and interconnection of signs, things, actions, and thoughts” (p. 20). Hannafin and Kim [31], as well, call for integrated approaches to educational design that explicitly connect theory to practice:

Since discipline-specific frameworks are inherently insulated, it has proven difficult to aggregate findings across fields and define questions and associated methods that are truly unique to individual disciplines. The questions are often unique to a discipline, but design and use of the Web are not. When it comes to Web design, our disciplines have far more linking than separating them; we have yet to leverage that shared interest. Web-based teaching and learning researchers need common design principles across disciplines that can be elaborated and refined within disciplines (p. 350).

Developments in technology and computing, then, need to be grounded in human action and communication to become meaningful. But technology and computing, in turn, alter our perceptions of what skills, knowledge, and attitudes are necessary for defining what it means to act and to communicate meaningfully and effectively. Thus, with the widespread use of powerful mechanisms for exploring digital library repositories, Thelwall [65] stresses that “search skills in education [are] widely recognized, becoming a part of information literacy and triggering the publication of entire books devoted to various forms of online searching.” Moreover, contemporary reviews of the literature — grounded as they are in heightened online archiving and search capabilities — can be expected to draw on multidisciplinary resources much more routinely and this “increased serendipity,” to use Thelwall’s [65] expression, will require researchers with

both multidisciplinary skills in evaluating out-of-field research and who are comfortable with collaborative models of researching and writing.

As well, academic institutions, where disciplines take their basic shape, need to look outwards strategically to nonacademic, knowledge-driven organizations. Cheney, Wilhelmsson, Zorn, and Theodore, Jr. [18] recommend that engaged scholarship involves the following ten strategies:

1. Engage in popular as well as academic concepts
2. Move out into the world
3. Consider multiple perspectives
4. Place the human, the moral, and even the spiritual alongside the technological, the financial, and the productive
5. Question our cherished concepts and practices
6. Choose problems and issues that matter
7. Reach audiences other than ourselves
8. Find or create models of socially responsible organizations and promote them
9. Embrace an action learning approach
10. Seek out connections not only with the powerful but also with the disenfranchised.

These strategies are similar to Bazerman’s [4] argument for “rhetorical self-consciousness” or the high-level ability to

1. Consider your fundamental assumptions, goals, and projects,
2. Consider the structure of the literature, the structure of the community, and your place in both,
3. Consider your immediate rhetorical situation and rhetorical task,
4. Consider your investigative and symbolic tools,
5. Consider the processes of knowledge production, and
6. Accept the dialectics of emergent knowledge (pp. 323-329).

Finally, Brewer [9] summarizes that an interdisciplinary and problem-centered orientation would entertain the following types of guiding questions:

- What goal values are sought and by whom?
- What trends affect the realization of these values? Or, where did the problem originate?
- What factors are responsible for the trends? Or, what are the driving or influencing conditions?
- What is the probable course of future events and developments — especially if interventions are not made?
- What can be done to change that course to realize or achieve more of the desired goals, and for whom? (p. 328)

Viewing multidisciplinary as an individual, group, organizational, and inter-institutional goal, then, rather than as something that individuals alone should be responsible for developing is paramount. Although individuals can be highly motivated to work and to learn, forcing them to develop informal horizontal networks to meet the demands of their workplaces (without reward) is an approach that has had only marginal success over the last thirty years.

## CONCLUSIONS

It seems disingenuous in anticipating future educational and workplace trends in communication design to ignore current economic realities which some have described as “deeper than the White House initially projected” [41] with national unemployment rates at 9.5 percent, the highest since 1983, and similar numbers in European Union countries [14].

In addition to putting the myth of neoliberal, sociotechnical progress in check [24], our difficult economic times make clear that organizations and individuals need to re-evaluate their relationship to one another. Certainly, the incorporation of technology into and employee training for the workplace has been driven by notions of improved productivity [16, 56] but these imperatives may require reevaluation and revision. Over a decade ago Castells [17] anticipated that “no systematic structural relationship” exists between technology and employment levels (p. 263) and Landauer [36] has argued persuasively that technology has improved workplace productivity less than one percent over the last twenty years.

Moreover, pragmatic views of the role of training and education in the workplace — views that separate learning from work — have produced a specialized workforce and compartmentalized industries that are slow to change and resistant to novel problem situations, the very things that are driving calls for multidisciplinary reform. As Tomlinson-Keasey [67] maintains, “As more workers depend on knowledge throughout their careers, knowledge must necessarily be acquired past the traditional age at which schooling ends and often in educational settings outside of traditional classrooms. A conservative estimate is that meeting the needs of ‘knowledge workers’ in traditional settings would require the addition of 250,000 students per year to college and university campuses” (p. 135).

Multidisciplinary and learning, therefore, should not be interpreted as academic issues with no relevance to the workplace or to our everyday lives. Imagining work-related learning that produces sustainable creativity, well-being, and organizational health and productivity should not continue to be viewed as extraneous, resource-intensive, time-consuming, and anti-productive. As we have learned the challenging way, specialized, compartmentalized, and vertical models of success tend to be myopic and deleterious for everyone involved.

## REFERENCES

- [1] Abbott, A. (2002). The disciplines and the future. In S. Brint (Ed.), *The future of the city of intellect: The changing American university* (pp. 205-230). Stanford, CA: Stanford UP.
- [2] Baptista, J. (2008). Pragmatic DITA on a budget. *SIGDOC'08: Proceedings of the 26th Annual International Conference on Design of Communication*. NY, NY: ACM P, 193-198.
- [3] Barab, S. A., & Squire, K. (2004). Design-based research: Putting a stake in the ground. *Journal of the Learning Sciences*, 13 (1), 1-14.
- [4] Bazerman, C. (1988). *Shaping written knowledge: The genre and activity of the experimental article in science*. Madison, WI: U of Wisconsin P.
- [5] Benyon, D., Turner, P., & Turner, S. (2005). *Designing interactive systems: People, activities, contexts, technologies*. Essex, UK: Pearson Education.
- [6] Bødker, S. (2008). Design for reconfiguration. *SIGDOC'08: Proceedings of the 26th Annual International Conference on Design of Communication*. NY, NY: ACM P, 263-264.
- [7] Brady, A., Johnson, R. R., & Wallace, C. (2006). The intersecting futures of technical communication and software engineering: Forging an alliance of interdisciplinary work. *Technical Communication*, 53 (3), 317-325.
- [8] Bransford, J. D., Barron, B., Pea, R. D., Meltzoff, A., Kuhl, P., Bell, P., Stevens, R., Schwartz, D. L., Vye, N., Reeves, B., Roschelle, J., & Sabelli, N. H. (2006). Foundations and opportunities for an interdisciplinary science of learning. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 19-34). Cambridge, UK: Cambridge UP.
- [9] Brewer, G. D. (1999). The challenges of interdisciplinarity. *Policy Sciences*, 32 (4), 327-337.
- [10] Brockmann, R. J. (1990). The why, where and how of minimalism. *SIGDOC'90: Proceedings of the 8th Annual International Conference on Systems Documentation*. NY, NY: ACM P, 111-119.
- [11] Buchanan, R. (1992). Wicked problems in design thinking. *Design Issues*, 8 (2), 5-21.
- [12] Buchanan, R. (1995). Rhetoric, humanism, and design. In R. Buchanan & V. Margolin (Eds.), *Discovering design: Explorations in design studies* (pp. 23-66). Chicago, IL: U of Chicago P.
- [13] Buchanan, R. (2001). Design and the new rhetoric: Productive arts in the philosophy of culture. *Philosophy and Rhetoric*, 34 (3), 183-206.
- [14] Bureau of Labor Statistics (2009). International unemployment rates and employment indexes, 2007-2009 (seasonally adjusted). *International Labor Comparisons*. Washington, DC: U.S. Department of Labor. Available online: [http://www.bls.gov/fls/intl\\_unemployment\\_rates\\_monthly.htm](http://www.bls.gov/fls/intl_unemployment_rates_monthly.htm)
- [15] Burkhardt, G., Monsour, M., Valdez, G., Gunn, C., Dawson, M., Lemke, C., Coughlin, E., Thadani, V., & Martin, C. (2003). Literacy in the digital age. *enGauge 21<sup>st</sup> Century skills for 21<sup>st</sup> Century learners Report*. Naperville, IL: North Central Regional Educational Laboratory (NCREL) and the Metiri Group. Available online: [http://www.grec.ky.gov/SLC\\_grant/engauge21st\\_Century\\_Skills.pdf](http://www.grec.ky.gov/SLC_grant/engauge21st_Century_Skills.pdf)
- [16] Capper, J. (2001). The emerging market for online learning: Insights from the corporate sector. *European Journal of Education*, 36 (2), 237-245.

- [17] Castells, M. (1996). *The information age: Economy, society and culture. Vol. 1. The rise of the network society*. Oxford, UK: Basil Blackwell.
- [18] Cheney, G., Wilhelmsson, M., Zorn, T., & Theodore, Jr., E. (2002). 10 strategies for engaged scholarship. *Management Communication Quarterly*, 16 (1), 92-100.
- [19] Churchman, C. W. (1967). Wicked problems. *Management Science*, 14 (4), B-141-B-142.
- [20] Collins, A. (1996). Design issues for learning environments. In S. Vosniadou, E. De Corte, R. Glaser, and H. Mandl (Eds.), *International perspectives on the design of technology-supported learning environments* (pp. 347-361). Mahwah, NJ: Lawrence Erlbaum.
- [21] Collins, A., Joseph, D., & Bielaczyc, K. (2004). Design research: Theoretical and methodological issues. *Journal of the Learning Sciences*, 13 (1), 15-42.
- [22] Cooper, G., & Bowers, J. (1995). Representing the user: Notes on the disciplinary rhetoric of human-computer interaction. In P. J. Thomas (Ed.), *The social and interactional dimensions of human-computer interfaces* (pp. 48-66). Cambridge, UK: Cambridge UP.
- [23] Costa, C. J., Nhampossa, J. L., & Aparicio, M. (2008). Wiki content evaluation framework. *SIGDOC'08: Proceedings of the 26th Annual International Conference on Design of Communication*. NY, NY: ACM P, 169-174.
- [24] Couldry, N. (2008). Reality TV, or the secret theater of Neoliberalism. *Review of Education, Pedagogy, and Cultural Studies*, 30 (1), 3-13.
- [25] Felder, R. M. (2006). A whole new mind for a flat world. *Chemical Engineering Education*, 40 (2), 96-97.
- [26] Fraser, B., Roberts, J., Pianosi, G., Alencar, P., Cowan, D., German, D., & Nova, L. (1999). Dynamic views of SGML tagged documents. *SIGDOC'99: Proceedings of the 8th Annual International Conference on Systems Documentation*. NY, NY: ACM P, 93-98.
- [27] Frost, S. H., Jean, P. M., Teodorescu, D., & Brown, A. B. (2004). Research at the crossroads: How intellectual initiatives across disciplines evolve. *Review of Higher Education*, 27 (4), 461-479.
- [28] Grabinger, S. (2004). Design lessons for social education. In T. M. Duffy & J. R. Kirkley (Eds.), *Learner-centered theory and practice in distance education: Cases from higher education* (pp. 49-60). Mahwah, NJ: Lawrence Erlbaum.
- [29] Hallgren, C. (1990). The mythical task. *SIGDOC'90: Proceedings of the 8th Annual International Conference on Systems Documentation*. NY, NY: ACM P, 135-139.
- [30] Hambrusch, S., Hoffman, C., Korb, J. T., Haugan, M., & Hosking, A. L. (2009). A multidisciplinary approach towards computational thinking for science majors. *SIGCSE'09: Proceedings of the 40th Technical Symposium on Computer Science Education*. NY, NY: ACM P., 183-187
- [31] Hannafin, M. J., & Kim, M. C. (2003). In search of a future: A critical analysis of research on Web-based teaching and learning. *Instructional Science*, 31 (4/5), 347-351.
- [32] Hart-Davidson, W., Spinuzzi, C., & Zachry, M. (2007). Capturing and visualizing knowledge work: Results and implications of a pilot study of proposal writing activity. *SIGDOC'07: Proceedings of the 25th Annual International Conference on Design of Communication*. NY, NY: ACM P, p. 120-126.
- [33] Hirsh Hadorn, G., Biber-Klemm, S., Grossenbacher-Mansuy, W., Hoffmann-Riem, H., Joye, D., Pohl, C., Wiesmann, U., & Zemp, E. (2008). The emergence of transdisciplinarity as a form of research. In Hirsh Hadorn, G., Hoffmann-Riem, H., Biber-Klemm, S., Grossenbacher-Mansuy, W., Joye, D., Pohl, C., Wiesmann, U., & Zemp, E. (Eds.), *Handbook of Transdisciplinary Research* (pp. 19-39). London, UK: Springer.
- [34] Hoffman, M. E., Dansill, T., & Herscovici, D. S. (2006). Bridging writing to learn and writing in the discipline in computer science education. *SIGCSE'06: Proceedings of the 37th Technical Symposium on Computer Science Education*. NY, NY: ACM P., 117-121.
- [35] Kukla, C. D., Clemens, E. A., Morse, R. S., & Cash, D. (1992). Designing effective systems: A tool approach. In P. S. Adler & T. A. Winograd (Eds.), *Usability: Turning technologies into tools* (pp. 41-65). NY, NY: Oxford UP.
- [36] Landauer, T. K. (1997). *The trouble with computers: Usefulness, usability, and productivity*. Cambridge, MA: MIT P.
- [37] Levy, P. (2003). A methodological framework for practice-based research in networked learning. *Instructional Science*, 31, 87-109.
- [38] Manzini, E. (1995). Prometheus of the everyday: The ecology of the artificial and the designer's responsibility. In R. Buchanan & V. Margolin (Eds.), *Discovering design: Explorations in design studies* (pp. 219-243). Chicago, IL: U of Chicago P.
- [39] Mehlenbacher, B. (2007). Triangulating communication design: Emerging models for theory and practice. *SIGDOC'07: Proceedings of the 25th Annual International Conference on Design of Communication*. NY, NY: ACM P, 87-94.
- [40] Miller, C. R., Carter, M., & Gallagher, V. (2003). Integrated approaches to teaching rhetoric: Unifying a divided house. In J. Petraglia & D. Bahri (Eds.), *The realms of rhetoric: The prospects for rhetoric education* (pp. 209-228). NY, NY: SUNY P.
- [41] Nagourney, A., & Hulse, C. (2009). President urges public patience on economy. *The New York Times*, July 11. Available online: <http://www.nytimes.com/2009/07/12/us/politics/12obama.html?hp>
- [42] Navarrete, I. C. (1984). Documentation of a Fortran compiler study of a case. *SIGDOC'84: Proceedings of the 3rd Annual International Conference on Systems Documentation*. NY, NY: ACM P, 101-102.
- [43] Nikitina, S. (2005). Pathways of interdisciplinary cognition. *Cognition and Instruction*, 23 (3), 389-425.
- [44] Norman, D. A., & Spohrer, J. C. (1996). Learner-centered education. *Communication of the ACM*, 39 (4), 24-27.

- [45] Orrill, C. H., Hannafin, M. J., & Glazer, E. M. (2004). Disciplined inquiry and the study of emerging technology. In D. H. Jonassen (Ed.), *Handbook of research on educational communications and technology*, 2<sup>nd</sup> Edition (pp. 335-353). Mahwah, NJ: Lawrence Erlbaum.
- [46] Partnership for 21st Century Skills (2009). *Framework for 21st Century learning*. Tucson, AZ. Available online: [http://www.21stcenturyskills.org/documents/p21\\_framework\\_definitions\\_052909.pdf](http://www.21stcenturyskills.org/documents/p21_framework_definitions_052909.pdf)
- [47] Perkins, D. N. (1993). Person-plus: A distributed view of thinking and learning. In G. Salomon (Ed.), *Distributed cognition: Psychological and educational considerations* (pp. 88-110). Cambridge, UK: Cambridge UP.
- [48] Perkins, D. N. (2008). Beyond understanding. In R. Land, J. H. F. Meyer, & J. Smith (Eds.), *Threshold concepts within the disciplines* (pp. 3-19). Rotterdam, Netherlands: Sense Publishers.
- [49] Petraglia, J. (2003). Identity crisis: Rhetoric as a pedagogic and an epistemic discipline. In J. Petraglia & D. Bahri (Eds.), *The realms of rhetoric: The prospects for rhetoric education* (pp. 151-170). NY, NY: SUNY P.
- [50] Pierce, R., Mehlenbacher, B., Costa, C. J., Albers, M. J., & Protopsaltis, A. (2008). Panel design of communication: New steps. *SIGDOC'08: Proceedings of the 26th Annual International Conference on Design of Communication*. NY, NY: ACM P, 183-184.
- [51] Pierce, R., Protopsaltis, A., Mehlenbacher, B., & Zachry, M. (2007). What is design of communication? *SIGDOC'07: Proceedings of the 25th Annual International Conference on Design of Communication*. NY, NY: ACM P, 181.
- [52] Pohl, C., & Hirsh Hadorn, G. (2008). Core terms in transdisciplinary research. In Hirsh Hadorn, G., Hoffmann-Riem, H., Biber-Klemm, S., Grossenbacher-Mansuy, W., Joye, D., Pohl, C., Wiesmann, U., & Zemp, E. (Eds.), *Handbook of Transdisciplinary Research* (pp. 427-432). London, UK: Springer.
- [53] Quinn, C. N., & Wild, M. (1998). Supporting cognitive design: Lessons from human-computer interaction and computer-mediated learning. *Education and Information Technologies*, 3, 175-185.
- [54] Quintana, C., Shin, N., Norris, C., & Soloway, E. (2006). Learner-centered design. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 119-134). Cambridge, UK: Cambridge UP.
- [55] Rittel, H. (1972). On the planning crisis: Systems analysis of the "first and second generations". *Bedrifts Ojonomen*, 8, 390-396.
- [56] Rowe, A. L., & Cooke, N. J. (1995). Measuring mental models: Choosing the right tools for the job. *Human Resource Development Quarterly*, 6 (3), 243-255.
- [57] Rymer, J. (1988). Scientific composing processes: How eminent scientists write journal articles. In D. A. Jolliffe (Ed.), *Writing in academic disciplines: Advances in writing research*, Vol. 2 (pp. 211-250). Norwood, NJ: Ablex.
- [58] Scenters-Zapico, J. T., & Cos, G. C. (2003). A new canon for a new rhetoric education. In J. Petraglia & D. Bahri (Eds.), *The realms of rhetoric: The prospects for rhetoric education* (pp. 61-71). NY, NY: SUNY P.
- [59] Schön, D. A. (1983). *The reflective practitioner: How professionals think in action*. NY, NY: Basic.
- [60] Schriver, K. A. (1997). *Dynamics in document design: Creating texts for readers*. NY, NY: John Wiley & Sons.
- [61] Simon, H. A. (1969, 1981). *The sciences of the artificial*. Cambridge, MA: MIT P.
- [62] Spinuzzi, C. (2006). What do we need to teach about knowledge work? *Computer Writing and Research Lab White Paper Series: #060925-1*. Austin, TX: U of Texas at Austin. Available online: <http://www.cwrl.utexas.edu/node/962>
- [63] Spinuzzi, C. (2007). Introduction to TCQ Special Issue: Technical communication in the age of distributed work. *Technical Communication Quarterly*, 16 (3), 265-277.
- [64] Stinson, J. (2004). A continuing learning community for graduates of an MBA program: The experiment at Ohio University. In T. M. Duffy & J. R. Kirkley (Eds.), *Learner-centered theory and practice in distance education: Cases from higher education* (pp. 167-182). Mahwah, NJ: Lawrence Erlbaum.
- [65] Thelwall, M. (2004). Digital libraries and multi-disciplinary research skills. *LIBRES: Library and Information Science Research Electronic Journal*, 14 (2). Available online: <http://libres.curtin.edu.au/libres14n2/index.htm>
- [66] Thomas, S., & McShane, B. J. (2007). Skills and literacies for the 21st Century: Assessing an undergraduate professional and technical writing program. *Technical Communication*, 54 (4), 412-423.
- [67] Tomlinson-Keasey, C. (2002). Becoming digital: The challenge of weaving technology throughout higher education. In S. Brint (Ed.), *The future of the city of intellect: The changing American university* (pp. 133-158). Stanford, CA: Stanford UP.
- [68] Unsworth, J. (2000). Scholarly primitives: What methods do humanities researchers have in common, and how might our tools reflect this? *Humanities computing symposium: Formal methods, experimental practice*. London, UK: King's College. Available online: <http://www.iath.virginia.edu/~jmu2m/Kings.5-00/primitives.html>
- [69] Vaezi-Nejad, S. M., & Olabiran, Y. (2005). Telematics education II: Teaching, learning and assessment at foundation level. *International Journal of Electrical Engineering Education*, 42 (2), 147-163.
- [70] Younglove-Webb, J., Gray, B., Abdalla, C. W., & Thurow, A. P. (1999). The dynamics of multidisciplinary research teams in academia. *Review of Higher Education*, 22 (4), 425-440.
- [71] Zachry, M. (1999). Constructing usable documentation: A study of communicative practices and early uses of mainframe computing in industry. *SIGDOC'99: Proceedings of the 17th Annual International Conference on Computer Documentation*. NY, NY: ACM P, 22-25.