CAREER: DISTRIBUTED COOPERATION IN BOUNDARY-SPANNING IS DESIGN

Project Summary

The IT component of information system development has been radically simplified in recent years. Many corporations are now attempting to jointly design business processes and IT systems, to integrate workflows and information flows across business processes. The majority of these efforts fail, because there is a fundamental contradiction in the way that we design this type of “boundary-spanning” information system (IS). Stakeholders need to establish common visions of design goals and information flows, but can only do this in situations where the context for doing these things is already well defined and stable -- so how can they do it in rapidly-changing or evolving development contexts? Understanding why something is done in a specific way is often possible only within the culture and local knowledge of a specific work-group. We lack ways to share this understanding across workgroups, or even to determine what knowledge is significant for an effective IS design.

Most boundary-spanning design projects employ the type of design process used for IT system development. Goals for change are defined, requirements for a solution are specified, then the solution is implemented. But this approach is not appropriate for the design of ill-defined, cross-functional information systems, where the boundaries and goals for change evolve as the design proceeds. The PI’s prior studies indicate that stakeholders from different areas of the organization perceive organizational processes and goals in very different ways and are often unaware that they understand the same concept differently. Stakeholders’ partial and different understandings of organizational processes is a major obstacle to developing a shared vision of design problems and solutions. Establishing a common language for people with different backgrounds and expertise is problematic. Consequently, there is too little input from IS users and organizational stakeholders to define an appropriate system.

There are three major challenges in designing that involves stakeholders from multiple disciplines and backgrounds, that are not resolved by current research:

- The need for a common language, that allows participants from a variety of organizational areas and backgrounds to understand and interpret the processes and concepts of design in the same way.
- The need for effective “boundary objects”, to mediate and integrate knowledge that is distributed among multiple stakeholders;
- The need to understand the process drivers that permit a design group to rapidly agree and constantly validate a common vision of their design.

The intellectual merit of the proposed work is that it aims to develop a new theory of knowledge integration for short-term, dynamic cross disciplinary teams designing information and communication technologies (ICTs). It aims to propagate this knowledge both to typical IS practitioners and to new groups of people who are key stakeholders but not typically first-class participants in critical IS design activities. The new theory of knowledge integration I propose to develop is essential. First, the knowledge integration issue has been shown to be at the heart of many ICT design/implementation failures, and second, this issue will only grow in importance, since the need for rapidly-developed ICTs is exploding.

The broader impacts of this research affect the design-related area of distributed problem-solving in new contexts, both organizational and educational. New ways of supporting collaborative, problem-centered learning are currently being developed: these will evolve with this CAREER plan. Women, students with disabilities and ethnic minority individuals are currently disadvantaged, as they do not share the mainstream cultural traditions or genres that drive the negotiation of outcomes in goal-driven processes. By developing collective problem-solving techniques and performance-measures that shift the focus from goal-achievement to inclusive problem-definition, they are provided with the opportunity to participate more fully in group work and to exert increased influence, both in business organizations and in the classroom. Current problem-based learning emphasizes complex, real-world problem investigation and this emphasis feeds back into the practical, strategic applications of this research. Results will be disseminated broadly, through the Drexel University education initiative, and through the PI’s current affiliations with Philadelphia Knowledge Management industry group, through industry seminars and workshops in the two collaborating organizations and through the AIS Cognitive Research Special Interest Group.

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CAREER: DISTRIBUTED COOPERATION IN BOUNDARY-SPANNING IS DESIGN

Project Description

RESULTS FROM PRIOR NSF SUPPORT

The PI has never been funded by NSF.

CAREER DEVELOPMENT PLAN

1. INTRODUCTION AND VISION

Companies are increasingly attempting to integrate information systems across functional boundaries, to provide effective support for enterprise-level business processes, such as Customer Resource Management or Supply Chain Management. The information systems function is now routinely involved in integrated business process innovation (BPI) [31], often combining this with the real-time sharing of business information in Enterprise Resource Planning (ERP) systems [32]. But even advocates of BPI and ERP estimate that the majority of these efforts fail [61]. Enterprise-level information systems are inappropriately designed, failing to integrate information-flows or to coordinate work across "silos" of local knowledge [61, 121]. This is a huge problem, that does not just relate to formal ERP systems, but to all systems that span the boundaries of organizational functions. Much of the economic growth of the 90s was accomplished through mergers and acquisitions, leaving companies with "islands" of information, surrounded by a sea of legacy systems and unusable data. Many companies, such as Dell and Wal-Mart, find formal ERP systems too inflexible to support their business and innovation processes. They use a "best of breed" approach, designing enterprise information systems that integrate IT from a variety of vendors around redesigned business processes. The ERP systems market is currently worth $15B annually and growing, yet over 50% of ERP systems are thought to incur a negative return on investment [89].

There is a fundamental contradiction in the way that we design this type of "boundary-spanning" information system (IS). Stakeholders need to establish common visions of design goals and information flows [104], but can only do this in situations where the context for doing these things is already well defined and stable [21] -- so how can they do it in rapidly-changing or evolving development contexts? Understanding why something is done in a specific way is often possible only within the culture and local knowledge of a specific work-group [28]. We lack ways to share this understanding across workgroups, or even to determine what knowledge is significant for an effective IS design.

The state of the art is that goal-directed processes and methods, that were developed to support well-defined technology design problems, are employed for ill-defined and emergent organizational IS design problems [26, 125]. These problems are highly subjective and difficult to articulate. We need to understand the processes required for this type of design, so that we can manage it effectively.

Research Goals. The goal of this work is to develop a new theory of knowledge integration for short-term, dynamic cross disciplinary teams designing information and communication technologies (ICTs). To achieve this, the proposed plan identifies a research agenda which has three major objectives:

1. To understand how stakeholders with different knowledge and expertise establish a common language for design in recently-established, cross-disciplinary teams.

Once we understand this, we may manage IS design more effectively than at present, where cross-disciplinary teams employ methods based on the assumption that they can quickly and easily establish consensus goals that will not change. This element builds on prior studies, to develop a coherent model of how such groups negotiate a shared system of language, conventions and values. This permits them to understand and interpret the design process in the same way. We will evaluate the achievement of this goal through experimental studies in years 2 and 3 and through action research studies in years 4 and 5 of this plan, where we will guide design processes according to lessons learned from our early studies. The speed and extent of convergence between team members' design frames (see Background and Related Work) will be assessed, to evaluate these processes.

2. To investigate how various types of boundary object may be used to establish a basis for shared knowledge construction and communication in recently-established, cross-disciplinary design and problem-solving groups.
As discussed below, under Background and Related Work, a "boundary object" is an artifact that mediates coordination between stakeholders with only partial knowledge of a collective work-task. Once we understand how various types of boundary object may be used in recently-established groups, we will be able to manage knowledge that is distributed between different design participants. This element also builds on prior studies and on prior experimentation in problem-based learning for graduate coursework. Findings from our prior studies will be integrated with observations from the ethnographic studies performed in years 1 and 2, to derive a set of directions for experimentation. We will then conduct short experiments in graduate student groups involved in problem-based, cooperative learning exercises. These exercises will be conducted in two contexts: in coursework, to develop the understanding required for the education goals discussed below, and in short research studies involving volunteer student groups. Outcomes will be evaluated through participant assessment, ongoing process evaluation and the assessment of group outcomes for the inclusion of multiple perspectives, as discussed in the Research and Education plans.

3. To investigate what process elements, such as collective breakdowns, primary generator concepts or other mechanisms, are required for knowledge integration in boundary-spanning design teams and how these elements vary in different contexts.

With this understanding, we will be able to develop a contextual model of how boundary-spanning design (and other forms of boundary-spanning problem-solving) proceeds. This will enable us to develop new management approaches and support tools for this type of initiative. We can then understand how to achieve knowledge integration across participants from cross-disciplinary education and work backgrounds. This objective will be achieved by developing observed process mechanisms from the ethnographic studies through a series of short experimental studies. These studies will produce an initial process model, which will be evaluated through action research studies in each of the two participating organizations. Outcomes will be assessed through management and participant feedback and through assessments of performance developed with the participating organizations.

Education Goals. This CAREER plan identifies three related goals for education, focusing on cooperative learning, an area that is closely related to cooperative design:

1. **Inclusion of disadvantaged groups.** The education plan focuses on the further development of educational methods and insights that support inclusive student cooperation and professional workers in organizations. This is already a core theme in the PI’s teaching, which emphasizes cross-functional and cross-cultural synthesis of IS problems and solutions. This work will influence the way in which previously excluded individuals are able to participate fully in group work and will produce more positive expectations of the contribution of minority group members and women, to cooperative work.

2. **Creation of a problem-based learning curriculum strength at Drexel University.** Student-centered learning is currently the least developed element of University education. However, the university has a strong interest in developing innovative instructional approaches. I will take advantage of this interest to develop a new approach to problem-based, cooperative work that fuses human, social and subject-related aspects of student-centered learning.

3. **Outreach to other educators and professionals.** The PI currently participates in the Philadelphia Knowledge Management Group and the AIS IS Cognitive Research special interest group. In addition, Drexel University has strong ties with local industry groups, through its undergraduate practical experience co-op program. This project will work with these groups, to develop presentation seminars and to share cooperative learning exemplars and methods.

2. **INTELLECTUAL MERIT AND EXPECTED SIGNIFICANCE**

The **intellectual merit** of the proposed work is that it aims to develop a new theory of knowledge integration for short-term, dynamic cross-disciplinary teams designing information and communication technologies (ICTs). It aims to propagate this knowledge both to typical IS practitioners and to new groups of people who are key stakeholders but not typically first-class participants in critical IS design activities. The new theory of knowledge integration I propose to develop is essential. First, the knowledge integration issue has been shown to be at the heart of many ICT design/implementation failures [8, 29,
41, 72], and second, this issue will only grow in importance, since the need for rapidly-developed ICTs is exploding [6, 7, 85]. Developing new channels of assimilation for this knowledge is also critical; the avenues that I propose --- the rapid development of a "common language" for design to bring about shared understanding of the process, the investigation of effective boundary-objects [120] for group collaboration, and the engineering of collective "breakdowns" to integrate stakeholders’ diverse knowledge --- are likely to be successful because they move collaborative design away from the assumptions of shared understanding that underlie traditional approaches, to support an explicit communication of distributed design perspectives [125] and the generation of deep, shared insights [10, 22, 26, 65, 92]. Prior studies conducted by the PI indicate that the development of shared meaning is driven by periodic, catalytic breakdowns in collective understanding that produces a new shared “vision” and indicates new areas of inquiry required to complete the design [52]. These findings indicate a very promising starting point for the research inquiry. This process will be further investigated by contrasting research findings from a large engineering company, a healthcare provider and problem-based learning groups in our graduate program. It is expected that this work will provide a fundamentally different view of how distributed knowledge may be shared effectively.

The concept of a "design theory" varies according to the various worldviews attached to both the process and product of design. In the information systems literature, design theories are alternately viewed as prescriptive, procedural and related to IS development "methodologies" [44, 87], as meta-models that provide a framework for action in the construction of specific organizational applications of information technology and so encompass both process and product characteristics [88, 133], or as theoretical frameworks that focus on the processes involved in the design of an information system [11, 80, 109, 116]. It is the last perspective that pertains to the research proposed here. This research examines the literature, not from the perspective of defining a prescriptive process model to guide the procedural stages of IS design, but to produce a framework and meta-models of the socially-situated processes of knowledge integration in design, so that we may better understand and manage them.

Theories of social cognition are used to provide the intellectual and theoretical basis for this work, as the concept of design "framing" emerges strongly from the few empirical studies that we have to explain the internal processes of design in boundary-spanning conditions. Social cognition is emerging as a key theme in the IS literature. Brooks [16] argues that software is "pure thoughtstuff, infinitely malleable ... invisible and unvisualizable". Thus, we need ways of enabling stakeholders to collectively make sense of organizational practices and goals [135] and to share their implicit interpretations and models of the organization [28, 84, 94]. While theories of social cognition have been adopted by other IS researchers as the basis for their work [e.g. 60, 92], much of this work focuses on the use of ICTs to support collaboration, rather than examining the nature of the collaboration to be supported. Coordination across different knowledge domains may be managed through the shared production of evolving design representations, shared workspaces, or other forms of "boundary objects" [120] that mediate and permit the negotiation of shared understanding [48, 64, 140]. But these studies have focused on established groups, that have derived a common language and mechanisms for coordination across their different areas of expertise, over time. Little work has been performed in how short-term and newly-established work-groups share and manage distributed knowledge in IS design and similar organizational problem-solving. This is therefore a long-term and potentially very exciting area of study.

This work has the potential to impact not only IS design approaches and methods, but many different processes of organizational innovation that link organizational learning with collective "sense-making" [126]. We will provide a fundamentally different view of how distributed knowledge may be shared effectively. Other than the boundary-spanning IS design projects investigated in this research plan, there are four main areas where this research can have a significant impact on both theory and practice:

- the management of collaborative learning, in both education and organizational contexts
- the generation of models for distributed knowledge management
- the development of management approaches and methods for cooperative, organizational innovation
- the design of appropriate technology systems for distributed, virtual collaboration.

The broader impacts of this research are discussed further in section 8, below.
3. INTERRELATEDNESS OF LONGER-TERM RESEARCH AND EDUCATIONAL GOALS

The long-term goal of this research is to provide a new theory of knowledge integration in problem-centered collaboration, applied to both educational and organizational innovation. Design is strongly associated with other forms of innovative group collaboration, such as strategic planning or organizational problem-solving. Underpinning these activities is the need to educate people, both in an organizational and an educational context, to provide them with the transferable skills and process exemplars that enable them to share knowledge across diverse organizational and professional groups. Communicating and understanding the multiple perspectives and contextually-situated knowledge required to agree action for complex organizational problems and IS solutions is problematic. We do students a disservice if we do not prepare them to deal with the challenges of diverse perspectives and the need to merge multiple perspectives in collaborative work. Incorporating this type of preparation for real-world work into IS curricula and practice is a major, long-term career goal that I have already started and intend to continue. Both the research and educational components of this CAREER plan feed into each other, providing new insights into how distributed knowledge may be managed in cooperative problem-solving and design, and enabling the development of specific techniques that support goal-emergence and collaborative learning.

4. BACKGROUND AND RELATED WORK

In this section, we first examine the role of existing design theory in guiding these processes and then we address three behavioral, process-oriented views of social cognition from the IS and organizational management literatures: (i) socially-situated cognition, involving design “framing” processes; (ii) socially-shared cognition, required to achieve joint models of an information system; and (iii) distributed cognition, where diverse groups coordinate collective action across knowledge boundaries.

4.1 Design Theory Relating To Organizational Information Systems

Current approaches to boundary-spanning cooperative activity are stressful for those involved because of the dissonance between an espoused theory [3] that emphasizes a process driven by well-defined, consensus goals for change and a theory-in-use [3] that understands such activity as driven by organizational contingencies and emergent knowledge discovery. Alexander’s model of design as hierarchical problem decomposition underlies the traditional, waterfall model [109] employed for IT system development. But this model has three main limitations as a guide to the design of organizational information systems. Firstly, it is based on Simon's [114, 115] argument that ill-structured problems such as IS design are associated with a consensual and objectively-defined set of initial goals. Secondly, it is based on an individual model of problem-decomposition [2], whereas organizational IS design tends to involve group processes, affected by a social and cultural context [13, 103]. Thirdly, it assumes that objective goals and solution requirements may be defined early in the design process whereas empirical research tells us that IS goals emerge through the processes of design [57, 106]. These goals are political, subjective and negotiated [13, 99].

Surveys by the PI [51] and others [6, 45, 141] have discovered that the traditional waterfall approach dominates IS design, even when it is patently inappropriate to the type of IS or the degree of organizational uncertainty. This may be because we have no compelling alternative model with which to replace it. We have "spiral" process models [11], that reflect an evolutionary approach to solution-definition. But the detailed activities required for emergent design are ill-understood and these models are still goal-directed, focusing on problem closure through a “try it and see” approach, rather than problem inquiry and synthesis. A new generation of interaction design and agile design methods [e.g. 63, 102] has recently emerged, based on a recognition that interactive mechanisms are required for user involvement, for design requirements to emerge. But these methods lack theoretical underpinnings and also adopt the goal-directed, consensus assumptions of traditional methods.

Simon's [115] assumptions of a goal-driven process have received remarkably little attention in the IS literature [26], yet empirical research into software design reflects a much more subjective approach. In the “psychology of programming” literature, the behavior of experienced designers is categorized as “opportunistic” [4, 57, 68], because it diverges from a breadth-first or depth-first decompositional strategy. Expert designers reuse known solutions, by identifying partial sets of requirements that fit with these solutions, incorporating implicit knowledge and implied requirements into the “framing” of new
solutions [58, 84]. If requirements do not fit with available solutions, it is the requirements that are
redefined, not the solutions. As designers interact with users and other stakeholders, new information
emerges that makes existing goals a poor fit with emerging requirements [84]. Goals are not only
redefined, but they are gradually and partially reframed — often implicitly and subjectively [111, 123]. Far
than being planned or guided, definitions of a design problem and solution converge in tandem [30, 128].
So design perspectives, or "frames" are not constant: they change and adapt, often on the basis of
implicitly-formulated local contingencies, rather than rational analysis. Turner argues that "the issue
becomes identifying what guides the discrimination between significant and insignificant" [128, page
105]. The communication and coordination of relevant knowledge are key elements in this process [29].
In boundary-spanning design, knowledge of goals and solution requirements is negotiated between
stakeholders who possess different knowledge and expertise and so need explicit mechanisms for
knowledge “framing” in terms that they can understand [72].

Relation to Proposed Work. Traditional models fail to support the problem exploration and inquiry
elements of design, leading to hidden, "opportunistic" activities, that are unplanned for, yet nonetheless
are required for effective design to take place. The current theoretical literature does not challenge the
goal-directed assumptions of existing methods, to suggest alternative models. New models are required
that focus on how stakeholders collectively make sense of and resolve complex, subjective and emergent
knowledge about IS problems and their solutions. We therefore base this work on an alternate theoretical
domain, of social cognition in design.

4.2 Three Views of Social Cognition Processes In Boundary-Spanning Design

4.2.1 Boundary-Spanning Design As Socially-Situated Cognition
The understanding that individuals inhabit a socially constructed world and through their actions,
reproduce and give meaning to that world [9, 24, 67, 90, 134] is central to this research plan. We employ
the concept of framing to interpret the process of sensemaking [136] that underlies design-as-
improvisation. Giddens [56] defines framing as “providing the ordering of activities and meanings”,
through an interactive interpretation of organizational rules. Orlikowski and Gash [96] originally employed
the concept of “technological frames”, building on literature in the field of social psychology, to explain
the impact of differences in stakeholder perspectives of technology on IS outcomes. More recent work in
IS has demonstrated that individuals frame organizational problems and solutions according to norms and
values that pertain in their organizational unit or that are derived from their area of expertise [34, 88].
But the concept of framing is used inconsistently and has been treated largely as a convenient
explanation of differences in perspective, rather than operationalized in terms of a process, or set of
activities required in various contexts.

The process of framing is embedded within a local system of shared values that make sense of “how we
do things here” [79]. But with recently established workgroups, definitions of legitimate and appropriate
knowledge and goals change, as views from competing experts, interest groups and influential
stakeholders become part of routine group practice over time [76, 79, 103]. We know that emerging
norms and values may be reflected and promoted through the use of specific representational
conventions or genres of communication, such as the use of memos, or of highly formalized reports by
different groups [19, 97]. But we do not understand how to represent or elicit the implicit knowledge of
organizational processes that underlies these accommodations. This type of knowledge resides in people's
heads, rather than in external procedures or documents [94]. It is embedded in unreflective practice,
rather than being capable of articulation [111].

Relation to Proposed Work. The framing concept has so far been employed only as an explanatory
concept to explain outcomes in the IS literature. We do not understand the socially-situated processes of
design framing. However, we do understand that many of these processes take place at an implicit level
and that they are driven by local contingencies and the unreflective use of certain ways of communicating
knowledge. The framing concept is operationalized as the basis for this work, in the Research Plan, below.

4.2.2 Boundary-Spanning Design As Socially-Shared Cognition
Groups of people who regularly work together on shared tasks have been observed to develop a
repertoire of shared frames. Shared frames provide cognitive shortcuts, such as ways of representing
problems or using language that permit a group to share common interpretations of the organization without the need for complex explanations [13, 17, 42, 79]. For example, IT developers share a vocabulary that is often unintelligible to other workers, but which allows them to communicate effectively, using shorthand terms such as “this is a blue screen error”. This may be done through developing a common language, to reconcile competing or complementary perspectives [125] and through the generation of deep, shared insights [10, 22, 26, 65, 92]. Individuals’ design frames (or their equivalent concept, in work that does not use this term specifically) may be shared and modified through the use of metaphor [35], by specific language which reinforces the extent of shared understanding within a work-group [74, 82, 125], and through design models and representations [48, 101]. Operationalization of these concepts is discussed in the Research Plan, below.

Established workgroups develop this type of common language over time. But members of recently-established workgroups have great difficulty in communicating and sharing these perspectives, as they lack the basis for a common language [52, 53]. For example, in IS development projects, shared understanding is achieved through a “argumentation” around a graphical model of the problem and potential solutions [29, 48]. This process works because those involved in this process of argumentation share a common background, with common language and conventions that allow them to interpret both the model and others’ behavior in the same way [79].

Relation to Proposed Work. If we can manage design so that a common language and conventions are rapidly established, we can provide boundary-spanning groups with the basis for a shared understanding of design goals and problems. Current studies focus on established workgroups and the IS literature tells us little about how this may be achieved.

Research Question 1: How do stakeholders with different knowledge and expertise establish a common language for design in recently-established, cross-disciplinary teams?

By answering this question, we will provide teams with the basis to work coherently. Individuals from diverse backgrounds interpret the design process and the information that they encounter in very different ways. If the team shares a common language, they can communicate concepts much more quickly and interpret events in the same way, leading to a smoother and faster design.

4.2.3 Boundary-Spanning Design As Distributed Cognition

A diversity of perspectives is necessary for a sufficiently wide number of design alternatives to be considered in boundary-spanning design, but this conflicts with the need for intersubjective (cognitively-shared) understandings of potential outcomes [48] [106]. A wide spread of experience must be expected to cause problems of group cohesion and productivity [72]. Theories of distributed cognition [64, 95, 120] address an interdependency between actors’ individual design frames, but also reflect a lack of congruence. Understanding is not so much shared between, as "stretched over" members of a cooperative group [120].

“Distributed cognition is the process whereby individuals who act autonomously within a decision domain make interpretations of their situation and exchange them with others with whom they have interdependencies so that each may act with an understanding of their own situation and that of others.” (Boland et al., 1994, page 457).

Studies of distributed cognition in cooperative workgroups have examined how coordination across different knowledge domains is managed through the shared production of evolving design representations, shared workspaces, or other forms of "boundary objects" [48, 64, 120, 140]. But these studies have focused on established groups, that have derived mechanisms for coordination across their different areas of expertise, over time. We understand that common representations and other types of boundary objects can aid or constrain collaboration across organizational units [15, 23]. But boundary objects only mediate distributed understanding where those involved can establish a common understanding of what the objects represent, which is not easy to accomplish [23, 54]. Some work has experimented with information and communication technologies in supporting the distributed knowledge required for collaborative work-tasks [92]. But we do not understand how distributed knowledge is mediated by recently-established workgroups, so such work is not based in empirical observation.

Cooperative design involves the surfacing and merging of various partial understandings of organizational processes, problems and goals, to produce a shared group understanding [48, 79]. It is this “knowledge
externalization” process that allows group members to understand what they know and to share it with others [78, 94]. Often this process is complicated by the competing claims to knowledge of different organizational groups [27, 75]. Our own prior studies would indicate that a boundary-spanning design group may not realize that they hold distributed knowledge about the design [52].

A possible way of making distributed knowledge apparent is provided by the suggestion that collective design framing may be driven by the early definition of a particular type of boundary object. Darke [30], in a study of architectural design groups, observed that they mobilized their understanding around a "primary generator" concept. This concept provided an example of the form that the design would take, permitting designers to visualize how the design would work. For example, an architect in described how his team was inspired to produce a design: "Once we'd flipped from a stack dwelling to a house on the ground, we assumed a terrace would be the best way of doing it" [30, page 185]. Urquhart [129] employs a similar concept when she argues that the use of conscious problem reframing is a tactic that may be useful to both IS design analysts and their clients. In our prior studies, we observed that the development of shared meaning in boundary-spanning design was driven by periodic, catalytic breakdowns [62, 138] in collective understanding. A breakdown occurs when someone's internalized model of the world is challenged by external evidence to the contrary, forcing them to reexamine their knowledge of how the world works. These occurred while discussing the current primary generator concept and produced a new, shared vision. This resulted in a new primary generator concept [52-54]. The breakdown concept has so far been used to understand individual design behavior [10], but has not been applied to cooperative design in boundary-spanning groups.

**Relation to Proposed Work (a).** Traditional ways of representing a design capture information only at the current decompositional focus, meaning that these models are over-simplified and provide a poor way of communicating the group knowledge about the design (as distinct from explicit information). We need to understand the role that various types of boundary object play in mediating distributed understanding and knowledge. Once we have this understanding, we may be able to use boundary objects to "surface" implicit knowledge and to integrate the knowledge of multiple various stakeholders in design. The PI has already used Soft Systems Methodology [24-26] for this purpose in a prior study; it is intended to pursue this approach, among others, here.

**Research Question 2:** How may various types of boundary object be used to establish a basis for shared knowledge construction and communication, when this knowledge is distributed between different stakeholders in a boundary-spanning design?

By answering this question, we will be able to develop more effective representational and coordination techniques, that provide the means to mediate and integrate knowledge that is distributed among multiple stakeholders, into a coherent design model.

**Relation to Proposed Work (b).** Our analysis of the literature and our own prior studies indicate that a boundary-spanning design process may be driven by a series of collective breakdowns in shared understanding, leading to the replacement of one mobilizing design concept, or "primary generator" [30] with another. But this requires further investigation in different organizational contexts.

**Research Question 3:** What process elements, such as collective breakdowns, primary generator concepts or other mechanisms are required for knowledge integration in boundary-spanning design teams? How do these process elements vary in different organizational contexts?

By answering this question, we understand how to manage design in such a way that the design group can rapidly agree and constantly validate a common vision of their design. This will lead to a new theory of knowledge integration for short-term, dynamic cross-disciplinary teams designing information and communication technologies.

### 4.2.4 An Integrated View Of Boundary-Spanning Design As Social Cognition

From the above discussion, we conclude that there are three major challenges in designing that involves stakeholders from multiple disciplines and backgrounds, that are not resolved by current research:

- The need for a common language, that allows participants from a variety of organizational areas and backgrounds to understand and interpret the processes and concepts of design in the same way.
• The need for effective “boundary objects”, to mediate and integrate knowledge that is distributed among multiple stakeholders;
• The need to understand the process drivers that permit a design group to rapidly agree and constantly validate a common vision of their design.

We have seen that IS design can be viewed as involving three "layers" of analysis, that relate to theories of social cognition in design. The processes of interest to this work are summarized in Table 1.

Table 1: An Integrated Research Framework For Social Cognition In Boundary-Spanning Design.

<table>
<thead>
<tr>
<th>Level of Analysis</th>
<th>Theoretical Concept</th>
<th>Processes of Interest in Boundary-Spanning Design</th>
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<tbody>
<tr>
<td>Individual</td>
<td>Socially-situated cognition</td>
<td>How various team members frame goals for change, organizational problems and IS solutions.</td>
</tr>
</tbody>
</table>
| Group             | Socially-shared cognition Distributed cognition | (i) How a common language for boundary-spanning design is achieved in recently-established groups.  
                      |                                      | (ii) How different types of boundary object mediate shared understanding, to support the merging of individual design frames. |
| Organization      | Socially-situated cognition          | How organizational culture and context affects elements of social cognition at the individual and group layers (reflecting socially-situated cognition). |

4.3 Preliminary Studies and Prior Educational Accomplishments

As significant findings from prior studies are discussed in the Background sections above, this section will summarize these studies in terms of the research approach.

The PI performed a survey of approaches to IS design and development in UK companies, to understand how companies use development methods and processes in IS design [51]. A case study of human-centered design in a University research group investigated the cultural and process issues that led to the project’s failure [54]. A participant observation study of a boundary-spanning design team in a midsize engineering company was conducted over a period of eighteen months [52, 53]. This study combined ethnographic data collection with multiple methods of data analysis, focused on analyzing social-cognitive design “frames”. These methods are discussed in the Research Plan, below.

Experience Of A Student-Centered Teaching and Learning Focus.

I was selected for a competitive Management Teaching Fellowship at Warwick Business School in the UK, sponsored by the Economic and Social Research Council. This program stressed the joint importance of both research and teaching in academic development and in particular emphasized student-centered learning approaches to education. As part of the Fellowship scheme, I attended an incremental academic development and training program that highlighted the importance of experiential learning. I have practiced approaches that encourage this type of deep learning since then. I encourage cooperative group work in my courses and I work hard to provide an environment in which inclusive learning may take place. I have had many successes and also some failures, where cooperative learning was subverted by students’ division of labor [127]. I intend to continue to develop approaches to cooperative, problem-based learning, as part of an integrated research and teaching plan. Drexel University jointly emphasizes teaching and research excellence and so my plans are a very close fit with the goals of my department and with University goals.

5. RELATION TO OTHER WORK IN PROGRESS

5.1 By the principal investigator under auspices of other support

Previous studies by The PI were funded by the Economic and Social Research Council of the United Kingdom, through a competitive Management Teaching Development Fellowship award, and by Warwick University in the UK.

5.2 Elsewhere

There are two main areas of current research that are related to this CAREER plan. The first stream of research focuses on computational models of IT systems to mediate group processes, rather than inquiring into the nature of the human processes underlying these mediated transactions. The design of virtual, cooperative work-spaces [43, 46, 110, 119] is a strong thread in this work, but does not examine
the processes of design cooperation. The study of distributed cognition in IS design [14, 65, 92, 100, 125] is a more closely related thread, but again has a significant focus on experimentation with technology support for the cooperative process, rather than investigating the processes themselves.

The second stream of research focuses on the organizational management of IS definition and design. Research on the impact of “technological frames” [96, 98] [33-35] is closely related to the core concept underlying this research plan and provides some insights on how to operationalize the framing concept. But this work largely focuses on the impact of diverse perspectives on IT systems outcomes, rather than on the processes of IS design and definition. Work in Soft Systems Methodology [24-26, 139] has promoted the interest in design inquiry and informs the methods used to operationalize the processes of framing, for this proposal, as does work in cognitive mapping [40]. Research on stakeholder learning and negotiation during systems definition and technology adaptation [83, 85, 88, 129, 131] also informs this work, but focuses on organizational groups or individual processes, rather than the design group focus of this proposal. Work in group negotiation processes in IS definition [66, 137] and social cognition [105, 107] are also closely related to the work proposed in this CAREER plan, although these studies do not focus on cooperative IS design and definition processes. Other related work informs the understanding of distributed knowledge management in organizational change processes [18, 21, 28, 50, 78, 120], social informatics [1, 37, 38, 69-71, 124].

While social cognition has begun to be of interest to these research streams, distributed cognition has made little impact, in terms of surfacing and managing distributed knowledge in the contextually-situated, group processes of IS definition and design. The first group of studies focus on technology-mediated, virtual group processes, rather than the human processes that are the subject this research plan. These areas of work may well move forward dramatically as new models of group cooperation and cognition emerge from the findings. The area of greatest impact is that this work will extend organizational management theories of cooperative design and technology-related change, to relate them much more closely to the management of distributed, organizational knowledge. This will have a "trickle-down" effect, to inform both technology-mediated and face-to-face cooperative process research.

6. RESEARCH PLAN

An integrated view of social cognition enables us to understand how the individual and group design framing shapes a design, how fragmented knowledge of different organizational groups is assembled into a coherent whole and how the different "layers" of social cognition interact. This provides us with a contextualist view of design that guides our appreciation of how to compare and contrast process findings from different organizations and studies.

The research will be grounded in a set of real-world domains, with collaborators in industry (a large aerospace company and a health sector organization) and in education (the integration of the research and educational components of this plan, through experiments in problem-based learning). It is not appropriate to use quantitative techniques for this type of investigation. As argued in the Background and Related Work section above, we have little extant theory on which to base hypotheses and the research problem is situated in a specific organizational context that forms part of the data to be collected. We will therefore use qualitative data collection and analysis methods, with much of the data collection taking place in an organizational context.

6.1 Operationalization of concepts for data gathering, 'measurement,' and analysis.

The main focus of this research is at the group level, although it is necessary to understand individual design framing to discern how this affects shared design frames and outcomes. It is also necessary to understand the impact of the organizational context, to understand which elements of the process are transferable and which are context-specific. Concepts from Table 1 in the Background and Related Work section, above, will be operationalized as follows:

At the individual level. We focus on how various team members frame goals for change, organizational problems and IS solutions. The concept of a design frame can be operationalized by analyzing how team members understand various aspects of the design. Tenkasi and Boland [125] employed cognitive maps [39] for this purpose, exploring chains of cause and effect. In our prior studies, Soft Systems Methodology (SSM) [24-26] was used to elicit implicit design frames, in interactional interviews and modeling sessions
with design team members. Perspectives were elicited in respect of how participants understood the process of design, the design problem(s) and the designed solution. This permitted different views of the process to be obtained, by analyzing convergence and differences in these frames over time. Using SSM permitted the analysis of similarities and differences in individual design frames of which the individuals themselves were unaware. It also highlighted areas where individuals had partial or conflicting perspectives of the design, as SSM permits the elicitation of multiple perspectives of a problem. A simple cause-effect model was used successfully in participant workshops, to combine different stakeholder problem frames and to highlight conflicts.

**At the group level.** We focus on how a common language for boundary-spanning design is achieved in recently-established groups. This concept can be operationalized through a discourse analysis. Davidson [35] and Urquhart [129, 130] employed discourse analysis to understand issues that affected the course of a design, organizing their data into themes that explained a progression of understanding. In our longitudinal study, we employed discourse analysis [91], to understand shared and divergent themes in design debates and to track the process of design convergence. This approach will be used in the following ways:

We will use discourse analysis to track the emergence of a “common language” for design and the processes that support this. We will compare the use of language-terms and metaphors, over time, to determine differences and similarities in explicit knowledge conceptualization by the design group and to understand how design frames converge.

We will analyze boundary objects employed by various groups, to determine processes and attributes that lead to these being more or less effective, using a qualitative coding scheme. We will use discourse analysis to understand how different types of boundary object mediate shared understanding over time.

We will use discourse analysis to understand when breakdowns in collective understanding occur, linking these to the use of boundary objects, or other events. We will identify changes in the dominant attributes of the current design model and analyze the interactions that caused these to occur.

**At the organizational (context) level.** We focus on how organizational culture and context affects elements of social cognition at the individual and group layers (reflecting socially-situated cognition). This concept will be operationalized by comparing the findings from three phases of study.

*In the first phase*, we will perform participant observation studies of a boundary-spanning design group, over a period of approximately six months, in each of the two collaborating organizations.

*In the second phase*, we will perform experimental studies, involving graduate students at Drexel University (who tend to have substantial work-experience and would therefore constitute appropriate proxy subjects for organizational design stakeholders). We will experiment with different process mechanisms and forms of boundary object, to investigate our three research questions. The specific mechanisms and objects that form the basis of these experiments will be informed by the findings of the initial studies in phase one. **This phase also includes activities specified in the Education Plan.**

*In the third phase*, we will perform action research studies, involving a boundary-spanning design group from each of the two collaborating organizations, to refine the findings from the experimental studies. This phase will provide the basis for a contextual understanding of design process mechanisms and boundary objects, leading to the formulation of a new theory of knowledge integration for short-term, dynamic cross disciplinary teams designing information and communication technologies (ICTs). These phases are reflected in the management schedule shown in Figure 2, below.

### 6.2 Management Schedule and Support Plan

Figure 1 provides an overview of the management schedule for this work. Each phase of the plan reflects a major research objective. Bars represent a research-phase timeline, arrows represent detailed activity durations. As data analysis and synthesis guide and are interrelated with data collection activities, dependencies are flexible. This schedule has been planned for activities to be interchanged and for start/end points to be movable, within the overall timeframe, to allow for investigation contingencies.
Figure 1: Timetable Of Research and Education Program, Showing Major Stages Of Investigation

<table>
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<tr>
<th>AIMS/TASKS</th>
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<th>YEAR 02</th>
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<td>1. Investigate design groups in context.</td>
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<td>1.1 Investigatory interview &amp; case studies</td>
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<td>1.2 Ethnographic studies</td>
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<td>1.3 Data analysis and synthesis</td>
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<td>1.4 Report on findings</td>
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<td>2. Experimental and educational group studies</td>
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<td>2.1 Group problem-based learning exercises</td>
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<td>2.2 Participatory workshops</td>
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<td>2.3 Report on findings</td>
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<td>3. Operationalize and test process concepts/methods.</td>
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<td>3.1 Concept/method development</td>
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<td>3.2 Action research studies</td>
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<td>3.3 Data analysis and synthesis</td>
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In the first year of the project, I will hire a research assistant, and together we will initiate participant observation studies with the collaborating organizations. We will start one of the two observation studies in progress, while performing initial, case-based interviews in the other organization, then follow with the second observation study continuing into year two. In years two and three, we will integrate problem-based learning exercises into the two existing graduate courses, discussed below in the Education Plan and assess the outcomes from these exercises. We will also initiate facilitated workshops and short studies in the collaborating organizations, to experiment with process management approaches and design techniques arising from initial and prior studies. In the fourth and fifth years, we will test and operationalize the methodology framework that results from the initial studies (both educational and organizationally-situated), performing action-based research studies, to develop practical approaches to emergent, boundary-spanning cooperation in organizational IS design and problem-solving. We will also continue with the problem-based learning exercises, reporting again on the learning points at the end of this program of work. The following sections address each phase of the research in turn, discussing how this achieves the three research goals.

6.3 Detailed Research Plan

6.3.1 Phase 1: Participant Observation Studies of Boundary-Spanning IS Design

**Research Design.** Two collaborating organizations have agreed to participate in this research (please see the included letters of support): the Management and Data Systems division of an aerospace corporation and the Drexel University Institute For Healthcare Informatics (who will provide access to enterprise IS design groups in Drexel healthcare organizations). We will perform participant observation studies of a boundary-spanning design group in each of the two collaborating organizations, over a period of approximately six months. Each of these studies will involve an enterprise-level IS design team comprising stakeholders from multiple organizational areas and disciplines. Data will be collected using ethnographic methods [132]. We will attend team design meetings and other relevant meetings and discussions, conduct regular formal and ad hoc interviews, and collect all project documentation. We will tape-record all meetings and interviews and also video-record design meetings, where this is possible. We will keep observation notes, recording or copying informal design models and other forms of boundary object used by the design team. Data will be analyzed as discussed above.
Expected Outcomes.

Objective 1. By the end of this phase, we will have analyzed elements that lead to a common language for shared understanding in two separate contexts. A constant comparison [122] of findings from the two organizations will provide us with a set of transferable process mechanisms for boundary-spanning groups.

Objective 2. By the end of this phase, we will understand the role of some boundary objects in facilitating productive, collective breakdowns in design. A comparison of findings between the two organizations will provide context-specific elements that add to this model and suggest the most effective forms of boundary object.

Objective 3. By the end of this phase, we will have tracked process mechanisms over two separate projects, to understand the drivers for knowledge integration across disciplinary areas of expertise, in collaborative design. This will provide us with a set of methods for the experimental studies of phase 2.

Evaluation and reporting of findings. Initially, outcomes will be evaluated through validation interviews and workshops, involving study participants and managers from the two organizations. Further evaluation will be performed through experimental and action research studies in phases 2 and 3.

At the end of year 1, we will report on findings to these questions from the first study. At the end of year two, we will report on findings from the second study and produce an initial comparison of findings from the two studies. A further comparison will follow insights he concept/method development phase in year 3. This is discussed under phase 3. The findings will be presented annually at a major conference, such as AMCIS or ICIS, to elicit insights from the IS research community.

Anticipated problems and alternative strategies. This element builds on the experience of prior studies, so data analysis is relatively low-risk. It may be that the findings yield little in the way of transferable elements, given the disparity in contexts. However, this in itself will yield findings on contextual influences on the design process. From initial discussions of findings from prior studies with IS managers from other companies, a lack of transferable findings is also expected to be low risk.

6.3.2 Phase 2: Development of Problem-Based Learning Approach

Research Design. Short, experimental studies will involve volunteer student groups and also use findings from student group exercises discussed in the Education Plan. Different combinations of problem-analysis methods and techniques, suggested by the findings from Phase 1 and by the PI’s previous experimentation with Soft Systems Methodology [24], Boehm’s value-based realization modeling [12], and cognitive mapping [40] will form the basis for these experiments. The findings from these exercises will feed into an initial operationalization of the working models, which will feed into a second set of studies.

This stage includes and aligns with the education plan: more detail is provided in the discussion below.

Expected Outcomes.

Objective 1. These studies will involve graduate students with a diverse range of educational backgrounds and work-experiences. This will add a great deal of insight to the findings from stage 1, which are based on group members from the same organization. By the end of this phase, we will have a strong understanding of how differences in culture and expertise can be transcended and what elements combine to produce a common language for cooperative problem-solving.

Objective 2. The findings from phase 1 of this research will provide a set of problem representations that supplement our existing set. Students will be asked to use a variety of techniques, providing rich feedback on each. By the end of this phase, we will understand what types of representation best capture different types of knowledge that participants consider significant in cooperative problem-solving.

Objective 3. The extent of similarity and diversity of perspectives included in group outputs will be analyzed for each study. By the end of this phase, we will understand what types of method best produce collective breakdowns or other mechanisms conducive to knowledge integration.

Evaluation and reporting of findings. Outcomes will be compared over time and between groups, to understand how these methods permit effective design emergence. Participant feedback and appraisal of the methods will be an ongoing part of this experimentation. Participants will be encouraged to keep journals in which design/problem-solving issues and reflections on the group process are recorded and
these will be analyzed at the end of each experiment. We will present intermediate findings at the annual IFIP WG8.2 research workshops (this working group focuses on organizational issues of IS), to elicit insights and suggestions from a highly constructive community of peer researchers.

**Anticipated problems and alternative strategies.** It may be that findings of the observational studies are not transferable to an experimental context: transferring “best practice” elements of the observational studies to experimental or action research may prove difficult. However, it is expected that new insights will emerge from ongoing interaction between the researcher and the groups, particularly in the student experiments, which will take the form of problem-based learning exercises, as described below, in the Education Plan. The researcher adopts a new role, *instructor-as-researcher*, to extend the previous role of *researcher-as-instructor*. The opportunities for learning about how social cognition proceeds in temporary, boundary-spanning cooperative groups, are greatly increased, with this strategy.

### 6.3.3 Phase 3: Action Research Studies of Boundary-Spanning IS Design

**Research Design.** We will experiment with management approaches, design methods and techniques that are suggested by phases 1 and 2. Action research studies will be performed in each of the two participating organizations, with short workshops followed by a full-scale, boundary-spanning cooperative IS design project that is facilitated by the PI and the RA.

**Expected Outcomes.**

*Objective 1.* By the end of this phase, we will have essayed methods that rapidly establish a common language for design in a boundary-spanning group and – perhaps more importantly – developed ways of assessing that we have done so.

*Objective 2.* By the end of this phase, we will have a set of representational techniques and formats, that support design in various ways. We will also have developed a contingency framework for their use.

*Objective 3.* By the end of this phase, we will understand the main drivers of boundary-spanning design. We will also have an initial theoretical process model for knowledge integration in boundary-spanning design and problem-solving.

**Evaluation and reporting of findings.** The use of an action research strategy allows us to evaluate the outcomes through the success and outputs of the studies in this phase. Outcomes will be assessed through management and participant feedback and through jointly-developed assessments of performance. Performance measures will rely heavily on local conventions in the two participating organizations and will form part of the contingency model element of this framework. Stakeholder learning in participating organizations will be evaluated from participant feedback interviews.

**Anticipated problems and alternative strategies.** If the findings from stage 2 are not wholly transferable, or if they are contradictory, indicating that further research is called for, the action research studies will employ only those findings that are directly derived from, or transferable to, the local context.

### 6.5 Future Directions

The long-term goal of this research is to provide a new theory of knowledge integration in problem-centered collaboration, applied to both educational and organizational innovation. By the end of this plan, the initial theory will have been developed in two contrasting organizational cultures and settings. Future directions of this work include further studies in different organizational contexts and the development of Information and Communication Technologies to support the processes suggested by the theory. This program of research will be ongoing, to develop theories and methods for emergent, boundary-spanning cooperation and knowledge-integration that are transferable across multiple contexts.

### 7. EDUCATION PLAN

This CAREER plan includes a related education plan focusing on the development of new approaches to problem-based learning. The plan has three objectives, each of which is dealt with in the sections below.

### 7.1 Objective 1: Inclusion Of Disadvantaged Groups Through Cooperative Learning

Educational research confirms the academic and social benefits of cooperative learning approaches to instruction for students of diverse abilities, backgrounds, gender and race [59, 113, 117]. There are academic and social benefits of working in diverse groups for more advantaged students as well as for
students who are low-achieving, disadvantaged, or from a minority group [117, 118]. This may be because of the opportunities that cooperative learning provides for interactions among students. When reciprocity dominates group learning, as it does in communities of practice, groups quickly develop sufficient coherence to support shared sensemaking [13, 20]. But the ability to participate fully and on an equal basis in group problem-solving is often determined by locally-defined perceptions of legitimate knowledge and expertise. What is valued in one context may not be deemed so in another [77-79]. Our understanding of what constitutes legitimate knowledge is largely formed by normative practice in local workgroups, through which we acquire our understanding of how to be competent in a particular profession [79, 108].

Students from minority groups and women may not participate fully in shared sensemaking because their contribution is not valued — often because of language difficulties, gender perceptions or other dissimilarities from the “majority” perspective. I have observed that our women students prefer to work together, as do our international students, because their perspectives are more likely to be accepted by their collaborators and because they share the same genres and conventions of communication. It is intended that these courses will change students’ preconceptions concerning relative contributions, by designing problem-based learning exercises that force them to cooperate, to incorporate diverse perspectives and devise shared genres, in order to produce a successful outcome. An improved understanding of how to achieve this will be a major outcome of this education plan.

For deep learning to take place, cooperative learning must encourage frequent interactions between group members [117, 127]. But active engagement in learning cannot be assumed, even with collaborative work: much apparently reflective action is automatic [5, 113]. So we need to encourage students to engage in group investigation of problems to set tasks which cannot easily be completed by a stratified approach. People engage in mindful, or reflective, action when they encounter a situation for which they have no script or when the environment demands more than their current scripts provide [73, 86]. Thus, we need to place students in situations that are discrepant with their past experience. The role of “breakdowns” [62, 138] may be significant in driving such discrepancies. This approach has formed the basis of prior coursework experiments which will be developed and disseminated further through integration with cooperative, problem-based learning exercises. Problem-based learning derives from experiential learning theory [36, 81, 111]. Learning is self-directed, so when it is employed in student groups, it needs to be managed carefully to preclude the effort-reduction strategies discussed above. This plan will develop approaches that combine problem-based learning with occasions for cognitive breakdown that require social cooperation. Students will be formed into groups that reflect the diversity of the student population and that mix genders as equally as is feasible.

**Evaluation of Outcomes.** Outcomes will be assessed using two operationalized concepts: the extent of student learning and the degree to which a diversity of perspective is included in the outcome. Assessment mechanisms will include student self-reporting, formal student assessment of courses and critical incident analysis [47]. Student peer and self-review will be an active and ongoing part of this process, to assess and encourage the participation and inclusion of all group members.

7.2 Objective 2: Creation Of A Problem-Based Learning Curriculum Strength

Student-centered learning is currently the least developed element of education at Drexel University, but the University values educational innovation highly. This offers the opportunity for curriculum development, to provide problem-based learning exemplars at Drexel University and for general use. The PI is currently the faculty member responsible for two core graduate courses:

- **Information Systems Management**: prepares students to manage and to plan for the acquisition, development and support of information systems in business organizations.
- **Information Systems Requirements Engineering And Management**: prepares students to analyze and define information systems requirements.

Each of these courses already includes a group project. Project assignments will be developed to provide a progressive program of self-directed learning for each of the two courses. As discussed in the previous section, this approach will design "breakdowns" into cooperative exercises, to achieve deep learning. In addition, I plan to supplement this curriculum with at least one new course:

- **Systemic Problem Exploration**: will explore the use of a variety of systemic methods to define
real-life problems from various perspectives, emphasizing systemic methods of problem analysis, such as soft systems analysis [24], systems dynamics [49] and cause-effect modeling [39]. The new course will be developed as a totally problem-based learning course, emphasizing distributed collaboration. Students will be formed into diverse, self-directing groups and will work autonomously, with weekly consultation with the instructor. Students will investigate a “real-world” problem, such as the extent to which University Library information systems support distributed collaboration. Each group will be rewarded for inclusive activity and perspectives that develop from combining their various insights.

**Evaluation of Outcomes.** Outcomes will also be assessed using the measures discussed in section 7.2.

7.3 **Outreach To Other Educators And Professionals.**

This project will work with established local and national organizations (Philadelphia Knowledge Management Group, AIS SIG-COPE and ISWORLD) to develop presentation seminars and discussion groups and to provide a much-needed resource for educators and industry human resource professionals to disseminate and discuss inclusive, cooperative learning exemplars. I have published a teaching case study [55] as part of a focus on educational development. Findings from the education component of this program will be published in leading journals, such as the *Journal of the Learning Sciences,* or *Educational Researcher.* Findings will also be presented annually at a major IS research conference, such as AMCIS, which has a track for educational research.

7.4 **How The Planned Activities Relate To Effective Teaching and Learning**

The relationship between design and problem-solving activity has been established by Simon [93, 116] and Schön [111, 112], among others. A highly effective IS analyst develops meta-models and transferable skills, that guide the application of these techniques and permits ongoing learning-by-doing across a variety of contexts [111]. To provide the basis for this ongoing, personal development in their career, IS education aims to provide students with a set of transferable skills. These include intellectual, organizational, inter-personal and communication skills, as well as domain-specific skills such as numeracy, problem analysis and the ability to understand how information technologies support organizational work in different ways. My current approach to education emphasizes learning in real-world organizational projects, to develop transferable skills. This CAREER plan further emphasizes the development of transferable skills, both in the explicit delivery of problem-based learning approaches to education and in the program of organizational learning conducted via the research plan.

8. **BROADER IMPACTS OF THE PROPOSED CAREER PLAN**

**Integration Of Research And Education.** The integration of research and teaching are a fundamental element of this CAREER plan. Research informs my work in educational teaching and learning, which in turn informs research, the findings of which are used in education, and so on. This aligns closely with the expectations of my department at Drexel University, which emphasizes excellence in both area. **Participation of underrepresented groups.** As discussed above, under the *Education Plan,* developing cooperative education methods that ensure inclusion of ethnic minorities, disadvantaged students and women is an explicit and central component of this CAREER plan. The objective of this work is to develop ways of achieving inclusiveness and diverse perspectives in cooperative work outcomes.

**Effect of the activity on the infrastructure for science, engineering and education.** This CAREER plan develops new approaches to cooperative, problem-based learning that will form the basis for a problem-based learning curriculum strength at Drexel University. It will also provide a process framework for boundary-spanning innovation that will fundamentally change education and practice. **How results will be disseminated broadly.** This CAREER plan proposes a program of work where the PI and her research team will continue her work with established local and regional organizations (Philadelphia Knowledge Management Group, AIS SIG-COPE) to develop presentation seminars, workshops, and discussion groups. This will provide a much-needed forum for students, educators, and industry developers to disseminate and discuss inclusive, boundary-spanning design and problem-solving. **Benefits to society at large.** In addition to the benefits discussed above, this CAREER plan will assess the benefits of more inclusive and more effective boundary-spanning cooperative work in both problem-based learning and the co-design of business and IT systems. These findings will provide specific examples and explanations, to promote more inclusive processes in organizational work and in education.
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