6-8-2014

Knowledge-Supported Design Thinking about Systems in Organizations: An Application of Work System Theory

Steven Alter
University of San Francisco, alter@usfca.edu

Recommended Citation
Steven Alter. "Knowledge-Supported Design Thinking about Systems in Organizations: An Application of Work System Theory" DTBIS 2014: Workshop on Design Thinking in Business Information Systems, June 8, 2014, Tel Aviv, Israel (2014): 1-20.

Knowledge-Supported Design Thinking about Systems in Organizations: An Application of Work System Theory

Steven Alter, Ph.D.
University of San Francisco
alter@usfca.edu

Abstract. This paper explains a type of knowledge-supported design thinking related to systems in organizations. It shows how work system theory (WST) provides the basis for the work system method (WSM), various versions of which have been used by many hundreds of MBA and Executive MBA students. Design thinking occurs throughout WSM and is especially prominent at the point where WST/WSM users apply their analysis and develop recommendations for improving an existing work system or creating a new work system. Knowledge support for that design thinking has been provided through the knowledge built into WSM, and can be provided in a more complete form through extensions of WST/WSM that include a series of design spaces based on knowledge about work systems and also a work system metamodel that expands on ideas in the core of WST. In contrast to systems analysis and design methods for IT professionals, this approach to design thinking for systems in organizations is equally applicable regardless of whether IT plays an important role.

Keywords: design thinking, systems in organizations, work system, work system theory, work system design space

Supporting Design Thinking through Knowledge about Systems in Organizations

There is a wide range of opinion about what design thinking is (Pourdehnad et al., 2011). Clearly, design thinking for creating the multibillion-dollar Largo Hadron Collider that enabled detection of the Higgs boson is quite different from design thinking for creating an innovative handle for a toothbrush or design thinking for creating a better process for transporting patients immobile patients within hospitals. Some design experts say that design thinking inherently involves collaboration with stakeholders. …. But what about genius designers who design something that most potential users never anticipated and might not even be able to imagine? Some design experts say that design thinking is a process performed by design professionals. …. Again, what about individuals who are not design professionals but in a moment of inspiration design something unique and valuable? The design thinking for the Large Hadron Collider required the highest level of technical knowledge and expertise. Other design thinking related to partially technical artifacts such as information systems can be performed by managers and executives who are not technical experts as long as their design thinking is augmented by the design thinking of technical experts who can complete and test the resulting specifications.

Design thinking for systems in organizations. This paper describes a form of design thinking that focuses specifically on systems in organizations and is inappropriate for building multibillion-dollar colliders or innovative toothbrushes. It provides guidelines about vocabulary and process, but does not insist that specific terms or processes must be used. The design thinking explained in this paper can be performed by an individual or by a group with or without direct cooperation of stakeholders. It is widely accepted that broader participation and greater stakeholder care and involvement usually increase the likelihood of successful system-related interventions.

Design thinking for business information systems or for systems in organizations addresses a more general problem than is addressed by systems analysis and design for software systems. Some system-related problems may be addressed by changing software or setting software parameters, but even those situations usually call for changing aspects of other things, such as business processes, information, work system participants, products/services being produced, and possibly even the customers. The design thinking described here starts from the premise that systems in organizations can be viewed as work systems rather than technical artifacts. To make that distinction clear, part of this paper will summarize work system theory (WST), which includes the definition of work system and frameworks that outline a basic understanding of what a work system is and how work systems evolve over time. In contrast with typical systems analysis and design prescriptions for IT professionals, this approach to systems in organizations is equally applicable regardless of whether IT plays an important role.

Design thinking for work systems involves the following steps, which are the basis of the work system method (WSM) for analyzing and designing systems in organizations:

- identifying the smallest work system that has the problem or opportunity that is being addressed
- describing and analyzing it in sufficient detail to understand design challenges, problems, issues, and opportunities,
- using the work system description and analysis as the basis for identifying appropriate improvements in the work system, which includes improvement in technologies and improvement in processes, information, knowledge, and other aspects of the work system
- describing the recommended improvements in the work system, which can be explained by specifying proposed changes in all aspects of the work system
- justifying the changes by explaining why it is likely that the work system will operate more effectively and efficiently than the current work system (or for a brand-new system, explaining why it is likely to perform effectively and efficiently).

Design thinking occurs throughout WSM and is especially prominent at the point where WST/WSM users apply their analysis to develop recommendations for improving an existing work system or creating a new work system.

Applying Knowledge about Systems in Organizations. A unique aspect of this paper's approach to design thinking is that it makes relevant knowledge visible and directly usable by managers, analysts, and technical experts who are engaged in design thinking related to systems in organizations. That knowledge is encapsulated as WST and a series of its extensions of WST. Knowledge support for that design thinking has been provided through the knowledge built into the various versions of WSM, and can be provided in a more complete form through extensions of WST that include a series of design spaces based on knowledge about work systems and a work system metamodel that expands on ideas in the core of WST.

Organization. This paper proceeds as follows. First it summarizes a work system perspective on systems in organizations, which was explained in detail in Alter (2013d) under the heading of work system theory (WST). It explains that WST is the basis of various versions of the work system method (WSM), which is designed to help business professionals understand work systems for their own purposes and to help them collaborate effectively with vendors, consultants, and IT staff members. As a way of explaining many relevant concepts and while also illustrating a WSM approach in a common and often problematic situation, it summarizes how WSM can be used in the context of an ERP implementation. Next it summarizes how a number of extensions of WST might be used in design thinking related to systems in organizations. The extensions include a set of work system principles, a set of work system design spaces, a metamodel that outlines a work system's components and operation in more detail, a theory of workarounds, and a taxonomy of system interactions. This paper will provide specific examples of some of the design spaces and will mention the design value of the other extensions more briefly. In order to devote the available space to this paper's ideas about a knowledge-based approach to design thinking about systems in organizations, past discussions of the nature, process, and culture of design thinking (e.g., Brown, 2008; Cross, 2006; Kimbell, 2011; Lee 2008, Owen, 2007) are not reviewed here.

Work System Theory

WST encapsulates a perspective for understanding systems in organizations by viewing them as work systems. WST defines the term *work system* and describes work systems using two central frameworks. The work system framework provides a static view of a work system during a period when it is relatively stable. The work system life cycle model (WSLC) provides a dynamic view of how a work system evolves over time through a combination of planned and unplanned change. WST is the basis of a flexible systems analysis method called the work system method (WSM) that has been used in many versions over more than a decade. A number of extensions of WST that were mentioned above are also directly relevant to design thinking. WST and its extensions are explained in much greater depth in Alter (2013d) and other articles mentioned in that article's references.

Definition of Work System. A work system is a system in which human participants and/or machines perform processes and activities using information, technology, and other resources to produce products/services for internal or external customers. Enterprises that grow beyond a largely improvised start-up phase can be viewed as consisting of multiple work systems. Typical business enterprises contain work systems that procure materials from suppliers, produce products, deliver products, find customers, create financial reports, hire employees, coordinate work across departments, and perform many other functions.

Work system is a general case for which there are many special cases. Work systems are generally considered sociotechnical by default, but can also be totally automated systems. Sociotechnical work systems have human participants. Totally automated work systems operate autonomously and automatically after being launched. Information systems are work systems whose activities are all devoted to processing information. Projects are work systems designed to produce specific products/ services and then go out of existence. Supply chains are inter-organizational work systems that provide supplies and other resources required for the operation of customer organizations.

Work System Framework. Shown in Figure 1, the work system framework is a pictorial representation of a work system in terms of nine elements of a basic understanding of the work system's form, function, and environment during a period when it is relatively stable, even though incremental changes may occur during that period. Processes and activities, participants, information, and technologies are viewed as completely within the work system; customers and products/services may be partially inside and partially outside because customers often participate in the processes and activities within the work system (e.g., the patient during a medical exam, the customer during design meetings for custom-built software) and because products/services take shape within the work system; environment, infrastructure, and strategies are viewed as largely outside the work system even though they have direct effects within the work system.

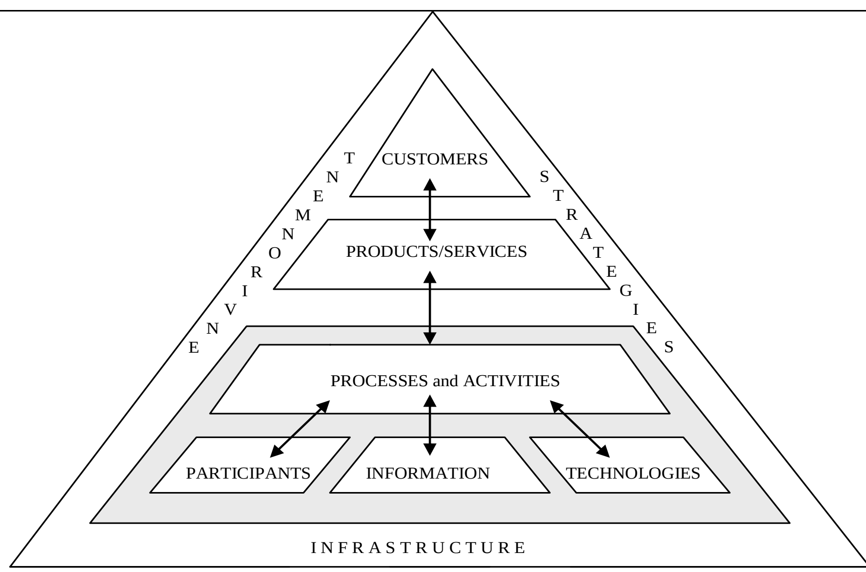

Figure 1. The Work System Framework (Alter, 2013d)

Work System Life Cycle Model. Shown in Figure 2, the other central framework in WST is the work system life cycle model (WSLC), which expresses a dynamic view of how work systems change over time through iterations involving planned and unplanned change. (Alter, 2013d). The WSLC represents planned change as projects that include initiation, development, and implementation phases. Development involves creation or acquisition of resources required for implementation of desired changes in the organization. Unplanned changes, represented by inward-facing arrows, are ongoing adaptations and experimentation that change aspects of work systems or work system projects without separate allocation of significant project resources. For example, the inward facing arrow attached to the operation and maintenance phase is typically about small work system changes that do not require formal projects or allocation of significant resources. The inward-facing arrow for that phase can also represent emergent changes in practices or goals that occur over longer periods without conscious planning. Inward-facing arrows for development and implementation phases of formal projects represent emergent changes in intentions, designs, and plans based on new insights and knowledge after the initiation phase.

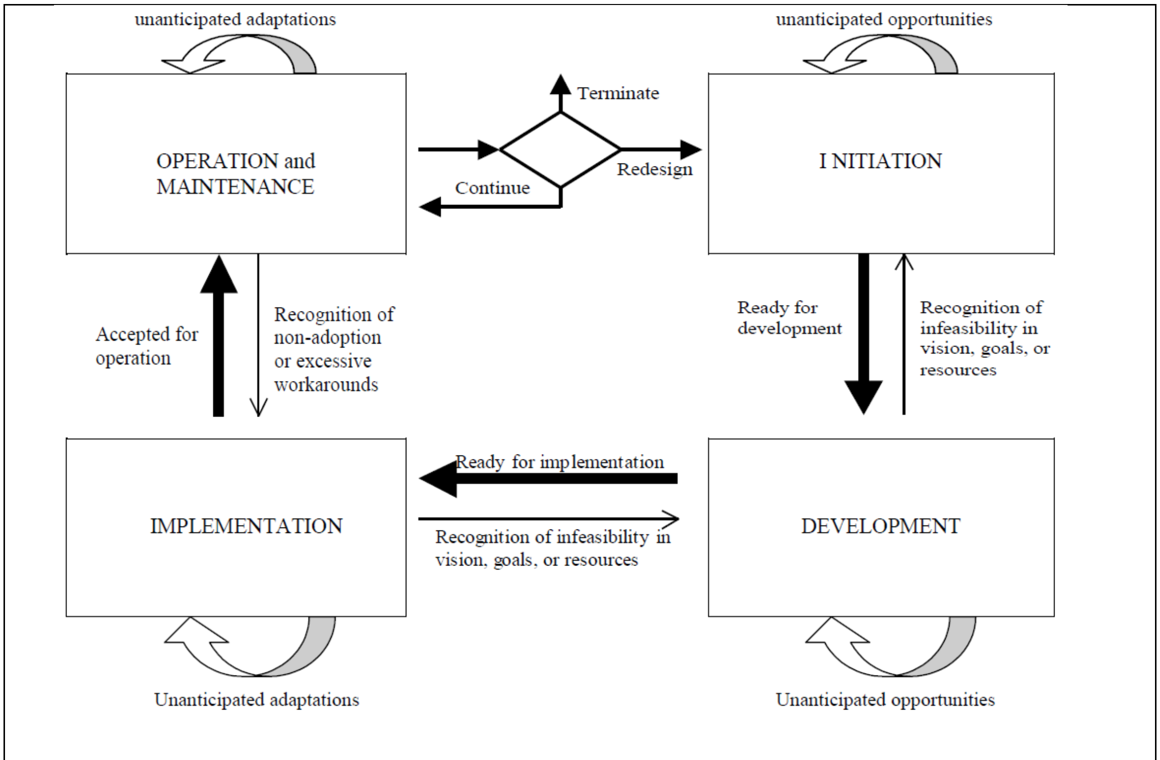

Figure 2. Work System Life Cycle Model (Alter, 2013d)

The WSLC differs fundamentally from the "system development life cycle" (SDLC), which is basically a project model rather than a system life cycle. Some current versions of the SDLC contain iterations, but even those are basically iterations within a project. "The system" in the SDLC is a basically a technical artifact that is being programmed. In contrast, the system in the WSLC is a work system that evolves over time through multiple iterations that combine defined projects and incremental changes resulting from small adaptations and experimentation. In contrast with control-oriented versions of the SDLC, the WSLC treats unplanned changes as part of a work system's natural evolution.

Work System Method

The work system method (WSM) is a flexible system analysis and design method that is based on WST. It treats the system of interest as a work system and builds on the two central frameworks in WST. WSM was created for use by business professionals, and can be used jointly by business and IT professionals as part of the initial analysis for designing work system improvements that may or may not involve producing software. It can be used for high-level guidance in thinking about a work system or can organize a relatively detailed analysis through use of a work system analysis template. WSM was originally developed as a straightforward application of general problem solving that started from whatever work system problems, opportunities, or issues launched the analysis. The most notable aspect of WSM in relation to other analysis and design methods is that the "as is" and "to be" systems are work systems rather than configurations of hardware and software that are used by users (Alter, 2013d).

WSM starts by identifying the smallest work system that has the problem or opportunity that launched the analysis and design effort. The analysis phase creates an overview of the work system using a tabular form: work system snapshot. It also compiles performance gaps related to important metrics for the work system and its elements. Depending on the user's goals and capabilities, the analysis may also include flowcharts, scatter plots, rate of diagrams, control charts, discussions of key incidents, discussions of customer concerns, and other factors that should be understood before making a recommendation. The design phase is the creation of the recommendation. Since the recommendation is about a proposed work system, the summary of the recommendation includes post changes and work system snapshot of the “to be” work system. The justification of the recommendation explains why proposed changes should result in better work system performance and why the benefits of the changes outweigh the effort of making those changes.

WSM was designed to be usable for different purposes and at different levels of detail because the specifics of a situation determine the nature of the understanding and analysis that is required. An executive can use WSM at a highly summarized level in the initiation phase of the WSLC to think about whether a system-related investment proposal is actually about improving a work system (rather than just acquiring software), and whether the comparison of the "as is" and "to be" work systems convincingly implies that business performance will improve. A manager may simply want to ask questions to make sure someone else has done a thoughtful analysis. Implementers, change agents, and work system participants can use various aspects of WSM to think about how the "as is" work system operates, how well it operates, and how and why possible changes might generate better results for the organization and for specific stakeholders. IT professionals can use the ideas in WSM for understanding system-related situations from a business viewpoint and for communicating more effectively with business professionals who are the customers for their work.

To date, over 700 student papers using various versions of work system analysis templates have been collected from courses in the United States, China, Vietnam, and

Australia. The vast majority of those papers were produced by employed MBA or Executive MBA students doing a preliminary analysis and then designing and explaining an improvement recommendation related to a work system in an organization that they or a team member worked. The best published evidence for the practical value of WST/WSM is from Truex et al. (2010, 2011), which summarized results from 75 and later 300 management briefings produced by employed MBA students based on a work system analysis template. These briefings contained the kind of analysis that would be discussed in the initiation phase of the WSLC, as decisions were being made about which projects to pursue and how to proceed. Most of the individuals who produced those briefings had substantial business experience (an average of six years) and therefore were meaningful representatives of business professionals to whom WSM is directed. The evaluations found that most students produced understandable and at least reasonably well argued reports. The general quality of the results suggests that a work system approach can help business professionals think about IT-reliant systems analytically.

Applying WST/WSM when Commercial Software Plays a Major Role

This section summarizes elements of the two frameworks while illustrating how WST/WSM can be applied in design thinking related to a common business issue, i.e., attaining maximum business benefits from an ERP implementation, an important representative example of the challenge of maximizing benefit from commercial application software. This section views ERP software as part of the technical infrastructure that is used in multiple work systems.

Elements of the Work System Framework in an ERP Context

The nine elements of the work system framework will be defined briefly along with a brief comment about how that work system element is relevant to design thinking in the context of an ERP implementation. That type of example is appropriate because much of the design thinking related to systems in organizations occurs in the context of implementing large commercial software packages. In those situations, the design is about how to maximize the performance of the work system, partially by configuring the software properly and partially by changing many other aspects of the situation that are not fundamentally about the software.

Customers. A work system's customers are recipients of a work system's products/services for purposes other than performing work activities within the work system. Customers of a work system may also be participants in the work system (e.g., patients in a medical exam, students in an educational setting, and clients in a consulting engagement). Since work systems exist to produce products/ services for their customers, both ERP configuration choices and other design decisions related to a work system should consider a work system's customers, what they want, and how they use whatever the work system produces.

Products/services. Work systems exist in order to produce things for their customers. A design process that ignores what a work system produces also ignores the work system's effectiveness. Products/services consist of information, physical things, and/or actions produced by a work system for the benefit and use of its customers. The term "products/services" is used because the controversial distinction between products and services in marketing and service science (Chesbrough and Spohrer, 2006) is not important for WST/ WSM even though product-like vs. service-like is the basis of a series of valuable design dimensions for characterizing products/services.

Processes and activities. Although the work performed by a work system is usually described as its processes and activities, a work system is much more than just the business processes and activities that it contains or is supposed to perform. Explicit identification of the other eight elements in the work system framework is a reminder that the same steps might be performed with different participants, different information, and/or different technology. The design of a work system should recognize the difference between documented or ideal work flows and the steps that are performed in reality when work system participants need to deal with special cases, exception conditions, and workarounds. In the context of ERP, the design should recognize that some important activities that are essential for work system success may not be reflected at all in the ERP software or database.

Participants. Participants are people who perform work within the work system, including both users and non-users of IT. Work system participants may be customers of the work system, as happens in self-service work systems and in many service systems such as medical treatment. Designers of a work system consider capabilities, incentives, interests of work system participants because those factors are determinants of how well the work system will operate. Even when a work system is supported by ERP, some of the important work system participants may not be users of ERP. Notice also that people who configure, install, and maintain the ERP software are not considered participants of a work system that uses the ERP software. Instead, they are participants in work systems that configure, install, and maintain ERP software.

Information. In the context of work system design, information is informational entities that are used, created, captured, transmitted, stored, retrieved, manipulated, updated, displayed, and/or deleted by processes and activities. Typical informational entities include orders, invoices, warranties, schedules, income statements, reservations, medical histories, resumes, job descriptions, and job offers. A work system analysis views information as all information that is worth mentioning, regardless of whether it is stored in an ERP database. Non-computerized information that is used or generated in the work system is also relevant for design because ignoring it will hide important factors related to work system performance.

Technologies. Work system designers should consider the full range of a work system's technologies, which include hardware and software that are used directly by human participants, other relevant hardware and software that operates automatically after being launched by other work systems, and other technical resources. In the context of ERP, individual work systems use only a small subset of an ERP suite, which serves as infrastructure for multiple work systems. Conversely, ERP software modules used by a specific work system may be only part of the technology that it uses. Realistic design needs to consider interactions between needs of work system participants and limitations of the ERP software. Ignatiadis and Nandhakumar (2009) called such efforts “workarounds by using external systems” (outside of the ERP software). Others describe linking supply chain modules to ERP packages or adding bolt-on internal control systems to ERP systems that may bypass internal controls such as segregation of duties and supervisory review (Brazel and Dang, 2008). Shadow systems built on spreadsheets outside the purview of corporate IS managed by IT professionals often contain logic and data that are inconsistent with corporate data and frequently bring information security problems. Shadow systems also have been viewed as a type of "feral system" (Thatte and Grainger, 2010); Kerr and Houghton, 2010), implying that despite certain benefits, they grow wild and should not be trusted, e.g., "once created, these systems spread throughout an organization like pernicious vines, strangling any chance for information consistency and reliability" (Eckerson and Sherman, 2008, p. 4).

Environment. Work system designers should consider the relevant organizational, cultural, political, competitive, technical, regulatory, and demographic environment within which the work system operates, and that affects the work system’s effectiveness and efficiency. Factors in a work system's environment may have direct or indirect impacts on its performance results, aspiration levels, goals, and requirements for change. Ignoring important factors in the environment may result in overlooking issues that degrade work system performance or even cause system failure. Consideration of the surrounding environment is equally important in work systems that use ERP software as in any other work system.

Infrastructure. Work system designers should consider the relevant human, informational, and technical resources that are used by the work system but are managed outside of it and are shared with other work systems. The ERP software modules that are used directly in a work system can be viewed as technology within that work system. The entire suite of ERP software can be viewed as a work system's technology infrastructure, which is shared with other work systems. The ERP database is part of the work system's informational infrastructure.

Strategies. The success of a work system depends in part on the enterprise strategy, organization strategy, and work system strategy. Work system designers should consider whether strategies exist at all three levels, and if so, whether they are in alignment. Unfortunately, strategies at any of the three levels may not be articulated or may be inconsistent with reality or with beliefs and understandings of important stakeholders. Use of ERP can be part of a strategy at any of the three levels.

Work System Life Cycle in an ERP Context

ERP is a cross functional intervention that affects multiple work systems. Since the work system life cycle model (WSLC) focuses on a particular work system, the WSLC is not a model of an entire ERP project.

An entire, corporate-level ERP project provides or affects the technical infrastructure for multiple work systems in an attempt to achieve corporate-level goals such as efficient transaction processing, greater consistency, seamless availability of information, and smoother coordination. Various shortcomings related to the performance of multiple work systems contributed to the initial need for the corporate ERP project. The corporate project includes many subprojects at the work system level. A likely reason for failing to maximize business value from ERP in many cases is that those work system projects are never fully realized. Instead, the huge effort of simply getting the ERP running in a reasonable way absorbs most of the available budget, time, and energy. The various work systems use ERP software, but many of the affected work systems themselves are not redesigned to fully benefit from ERP and other software that is available. Even if the ERP project seems like a success in terms of conversion to using ERP software and in terms of expected benefits of consistency and data availability, many of the localized improvements that could have occurred might never be analyzed or even considered

In relation to individual work systems, the WSLC is pertinent to each of the work system improvement projects that might be included in a larger corporate ERP project, or that might be performed after the initial implementation of ERP. Here is how each phase of the WSLC looks in an ERP context:

Operation and maintenance is the ongoing operation of the work system after it has been implemented, plus small adaptations, adjustments, and corrections of flaws. In an ERP context, the design of some of those changes would be related to ERP details such as modifying ERP parameters. Other changes would be related to any of the other elements of the work system, including training, incentives, process details, and so on.

Initiation is the process of defining the need for significant change in a work system and describing in general terms how work system changes will meet the need. In other words, it produces a high-level, preliminary design. In an ERP context, the work system improvement project could be part of the initial ERP project. Alternatively, it could be a separate post-implementation project that attempts to improve the performance of one or more work systems through additional changes that actually require a project.

Development is the process of defining and creating or obtaining software, documentation, procedures, facilities, and any other physical and informational resources needed before the desired changes can be implemented successfully in the organization. All of those resources require a design effort. In an ERP context, the software was designed and developed by the vendor and the ERP project involves other design topics related creating or updating training materials and documentation, configuring ERP parameters, and creating customized add-ons to ERP. Those add-ons might include business intelligence or spreadsheet software to create capabilities that are not linked directly to ERP software and that may or may not use ERP data and other data that is not in the ERP database.

Implementation is the process of making a new or modified work system operational in the organization, including planning for the rollout, training work system participants, and converting from the old way of doing things to the new way. In an ERP context, this might involve the design of secondary rounds of training and process changes that were not fully addressed in the initial implementation.

Applying Extensions of Work System Theory

The previous section discussed how the definition the core of WST (the definition of work system and the frameworks in Figures 1 and 2) can be used in designing work systems or work system improvements. This section continues by showing how extensions of WST address additional design issues that go beyond the WST core. These extensions include a set of work system principles, work system design spaces, various versions of a work system metamodel, a theory of workarounds, and a taxonomy of work system interactions. Since work system principles and the taxonomy of work system interactions can be treated as the basis of specific design spaces, this paper will cover them as part of the coverage of work system design spaces. It will also say a bit about the additional contribution of the metamodel and a theory of workarounds.

Work System Design Spaces

Initial versions of WSM proved more useful for providing analysis and documentation techniques and less useful for supporting design efforts by guiding the identification of potential improvements to an existing work system. This led to specification of a set of "design spaces" identifying generic types of changes or directions for change, thereby helping designers identify and evaluate improvement paths that they might not otherwise imagine or recognize as relevant. (Alter, 2010b, 2013d).

A work system design space is a category of things that might change or whose problematic nature might impel change in relation to any work system element, any subsystem of a work system, or the work system as a whole. To date, eight such design spaces have been described. Some have been used informally as a reference by MBA and Executive MBA students analyzing systems in organizations. No data was collected about whether those design spaces influenced their thinking. Tables 1, 2, and 3 will show the first three design spaces. The others will be mentioned but not shown. Each of the design spaces can be presented to designers in the form of checklists, sliding scales, or other representations that are convenient to use.

Design Space #1: Work System Principles

The idea of defining work system principles and incorporating them within WSM was motivated by difficulties encountered by MBA and Executive MBA teams in accomplishing more than describing a work system and identifying several readily apparent weaknesses. The teams seemed to need guidelines for thinking about the various types of improvements that might be considered. Introducing a set of general principles for work systems seemed a plausible way to make sure that the teams would think about each work system element and would have a basis for comparing the current status and possible modifications not only to a current problem or issue, but also to a set of ideals. One of the simplest forms for using the principles in design is to include them in a checklist that asks how well the current or proposed work system conforms to each principle. Major discrepancies call for designing improvements.

An initial set of work system principles eventually expanded to 24 work system principles in Table 1 (Alter, 2006) that seemed to strike a reasonable compromise between completeness and complexity. As reported by Alter and Wright (2010), individual students in six small cohorts of EMBA students rated each principle from 1 to 7 for "correctness," the extent to which most work systems in their organizations should conform to the principle, and for "conformance," the extent to which they believed most work systems in their organizations actually conformed to the principle. The average correctness and conformance scores were 5.95 and 4.25, a difference of 1.7 out of 7. This implied that most respondents found the principles highly plausible but also believe that their own organizations did not enact those principles well in many existing work systems.

Table 1. 24 work system principles

Customers	Products/Services
• #1: Please the customers. • #2: Balance priorities of different customers.	

Processes and Activities
• #3: Match process flexibility with product variability • #4: Perform the work efficiently. • #5: Encourage appropriate use of judgment. • #6: Control problems at their source. • #7: Monitor the quality and timing of both inputs and outputs. • #8: Boundaries between steps should facilitate control. • #9: Match the work practices with the participants.

Participants	Information	Technologies
• #10: Serve the participants. • #11: Align participant incentives with system goals. • #12: Operate with clear roles and responsibilities.	• #13: Provide information where it will affect action. • #14: Protect information from inappropriate use.	• #15. Use cost/effective technology. • #16: Minimize effort consumed by technology.

Infrastructure	• #17: Take full advantage of infrastructure.
Environment	• #18: Minimize unnecessary conflict with the external environment
Strategies	• #19: Support the firm's strategy
Work System as a Whole	• #20: Maintain compatibility and coordination with other work systems. • #21: Incorporate goals, measurement, evaluation, and feedback. • #22: Minimize unnecessary risks. • #23: Maintain balance between work system elements. • #24: Maintain the ability to adapt, change, and grow.

Design Space #2: Possibilities for Change in a Work System

Systems analysis and design typically focuses on identifying and improving specific components, subsystems, or interactions of systems, both at aggregated and detailed levels. Table 2 (Alter, 2006, 2010b) lists many types of changes that an analysis and design effort might consider. This table or some other way of expressing typical possibilities for changes in work system elements or the work system as a whole could support design efforts through general knowledge, checklists, or even design tools.

Table 2. Design space identifying possibilities for changing components, subsystems, and interactions

Customers	Products/ Services
Add or eliminate customer groups. Change customer expectations. Change the nature of the customer relationship. Change the customer experience.	Change information content. Change physical content. Change service content. Increase or decrease customization. Change controllability or adaptability by the customer. Change customer/ participant relationships Provide different intangibles. Change by-products.

Processes and Activities	
Change roles and division of labor. Improve processes and activities by adding, combining, or eliminating steps, changing sequences, or changing methods used within steps. Change business rules and policies Eliminate built-in obstacles and delays. Add new functions not currently performed.	Improve coordination between steps. Improve decision making practices. Improve communication practices. Improve the processing of information (capture, transmission, retrieval, storage, manipulation, display) Change practices related to physical things (creation, movement, storage, modification, usage, protection)

Participants	Information	Technologies
Change the participants. Provide training. Provide resources needed for doing work. Change incentives. Change organizational structure. Change the social relations within the work system. Change the degree of interdependence in doing work. Change the amount of pressure felt by participants. Assure understanding of details of tasks and use of appropriate information and knowledge. Assure that participants understand the meaning and significance of their work.	Provide different information or codified knowledge. Use different rules for coding information. Codify currently uncodified information. Eliminate some information. Organize information so it can be used more effectively. Improve information quality Make it easier to manipulate information. Make it easier to display information effectively. Protect information more effectively. Provide access to knowledgeable people.	Upgrade software and/or hardware to a newer version. Incorporate a new type of technology. Reconfigure existing software and/or hardware. Make technology easier to use. Improve maintenance of software and/or hardware. Improve uptime of software and/or hardware. Reduce the cost of ownership of technology.

Infrastructure	Make better use of human infrastructure. Make better use of information infrastructure. Make better use of technical infrastructure.
Environment	Improve fit with organizational policies and procedures (related to confidentiality, privacy, working conditions, worker's rights, use of company resources, etc.). Improve fit with organizational culture. Respond to expectations and support from external stakeholders. Improve fit with organizational politics. Respond to competitive pressures. Improve conformance to regulatory requirements and industry standards.
Strategies	Improve alignment with the organization's strategy. Change the work system's overall strategy. Improve characteristics related to specific work system elements
Work System as a Whole	Reduce imbalances between elements. Improve problematic relationships with other work systems. Conform to work system principles.

Design Space #3: Intentions Related to Work System Characteristics

Table 3 summarizes another design space by using work system elements (plus "work system as a whole") to organize design characteristics that are relevant to many work systems. Each characteristic in Table 3 (Alter, 2006, 2010b) is a design variable that represents a big picture choice that might be considered before determining work system details, and that might be assessed on a numerical scale such as 1 to 5 to make a discussion a bit more concrete. Typical systems analysis and design texts for IS students say little about these design characteristics, and move quickly to technical documentation of processes and information. Design characteristics that are relevant to a specific work system might be used in searching for gaps between a work system's current and desired status in relation to important characteristics (e.g., Are decisions too structured or too unstructured? Are the activities too complex or too simple? Is the work too manual or too automated?) Important gaps would provide directions for changes that could be accomplished through many combinations of possible changes in the design space in Table 2.

Table 3: Design space identifying characteristics for elements of a work system

Customers	Customer segmentation Treatment of customer priority Nature of the customer experience Style of interaction with the customer	
Products/ Services	Mix of product and service Product/service variability Mix of information and physical things Mix of commodity and customization Controllability and adaptability by customer Treatment of by-products	
Processes and Activities	Degree of structure Range of involvement Level of integration Complexity Variety of work Degree of automation	Rhythm Time pressure Amount of interruption Form of feedback and control Error-proneness Formality of exception handling
Participants	Reliance on personal knowledge and skills Personal autonomy Personal challenge Personal growth	
Information	Quality assurance Quality awareness Ease of use Security	
Technologies	Range of functionality Ease of use Ease of technical support Ease of maintenance	
Infrastructure	Reliance on human infrastructure Reliance on information infrastructure Reliance on technical infrastructure	
Environment	Alignment with culture Alignment with policies and procedures	
Strategies	Fit with the organization's strategy Fit with the strategy of related work systems	
Work System as a Whole	Centralization/ decentralization Capacity Leanness Scalability	Resilience Agility Transparency

Design Space #4: Concepts Related to Generic Subsystem Types within a Work System

The principles, tactics, and design characteristics in Tables 1, 2, and 3 are far from exhaustive, as becomes apparent when thinking about common types of subsystems of work systems. Examples of common subsystem types include representation subsystems, information processing subsystems, informing subsystems, decision subsystems, communication subsystems, social subsystems, and sensemaking subsystems. As explained in Alter (2013b), identifying the various types of subsystems is potentially valuable for design because each type brings a set of metaphors, analytical concepts, design criteria, theories, and performance metrics that might be overlooked if the design of a work system focused primarily on process steps and details of information.

Design Space #5: Minimizing Risks and Removing Obstacles

Lists of common risks and obstacles can be organized using the format that is used in Tables 1, 2, and 3. A sample table of this type appeared in Alter (2006, p. 66). Using that type of information to minimize risks and bypass obstacles might support design by helping designers recognize vulnerabilities and obstacles.

Design Space #6: Minimizing Counterproductive Interactions between Work Systems

Regardless of how well a work system is constructed internally, direct and indirect interactions with other work systems may be essential for a work system's successful operation or may cause that system's performance to degrade or even fail catastrophically. Alter (2010c) presents concepts and taxonomies for understanding, analyzing, and designing interactions between IT-reliant work systems. Types of interactions include direct control, joint control, precedence-based control, management oversight, auditing control, accidental interactions, and implicit interactions. Various types of persistent and transient misalignment and non-congruence between corresponding elements of interacting work systems are another source of potential difficulties, and therefore another path toward increasing business value by eliminating problems. Once again, these tables are available but cannot be shown here.

Design Space #7: Alternative Locations of Information and Knowledge

Another design space in the format of Tables 1, 2, and 3 involves the location of information and knowledge, which can reside within any of the work system elements. Where knowledge should reside, and in what form, can be viewed as a design choice. For example, knowledge about aspects of a particular work system might be tacit knowledge in the heads of work system participants, might be built into the overall logic of processes and activities and into business rules for specific activities, might be codified in expert systems, or might be built into hardware or software technologies to support skilled workers or guide less skilled workers. (Alter, 2010b)

Design Space #8: Design Dimensions for Products and Services

Research on service and service systems led to a final design space in a different format. Longstanding debates about the definition of service, sometimes as acts for the benefit of customers and sometimes as outcomes or affordances for the benefit of customers, led to a series of design dimensions totally devoted to characteristics of products/services produced by a work system (Alter 2012a, p. 28). Each dimension uses *product-like* and *service-like* in a metaphorical sense and is fundamentally about finding the right combination of characteristics for a work system's offering to customers. The first step is to position a particular product/service somewhere between the extreme of product-like versus extreme of service-like along each of a series of dimensions such as the following:

- production by provider vs. co-production with customer
- standardized and scripted vs. customized and non-scripted,
- value from things received vs. value from perceptible actions performed
- transfer of ownership vs. non-transfer of ownership, and so on.

The specifics of any particular product/service might call for movement in the direction of more product-like or more service-like along any of the dimensions. Making the dimensions visible provides an easy reminder that product/services can be re-positioned along multiple dimensions and that related changes in the work system might be required.

Work System Metamodel

Figure 3 is the latest version of a work system metamodel that outlines a more detailed operational view of a work system than is provided by the work system framework. The work system framework is useful for summarizing a work system and achieving mutual understanding of the scope and nature of a work system, but is less effective as a tool for detailed analysis. The more complete and rigorous metamodel, initially presented in Alter (2010a) and most recently revised in Alter (2013a), is more precise about concepts required to support deeper analysis without requiring terminology (e.g., objects and classes) that is impenetrable to most business professionals. Each element of the work system framework is represented in the metamodel, although most are re-interpreted in a more detailed way. For example, information becomes informational entity, technology is divided into tools and automated agents, activities are performed by three types of actors, and so on. Whereas the work system framework does not include the term *user*, the metamodel includes "uses" as a relationship between a participant and a tool (which is one of two guises of technology). Representation decisions in the metamodel try to maximize understandability while revealing potential omissions from an analysis or design process. The metamodel is too complicated to present to most users, but can be applied as the basis of straightforward design inquiries that look at specific entity types and relationships and search for issues and potential improvements.

Theory of Workarounds

A final extension of WST/WSM is a theory of workarounds (Alter, 2014) that elaborates on the WSLC by explaining how some types of unplanned changes occur through the creation and institutionalization of workarounds. The theory encompasses interactions of work system design, goals, incentives, obstacles, agency, monitoring systems, and other factors. It is relevant for design because work system designers should not assume that a work system will operate in accordance with either its idealized specifications or the initial designer or management intentions after its implementation in the organization. It is more realistic to assume that emergent change will occur and that the design of a work system should consider likely directions for emergent change to the extent to which that is possible.

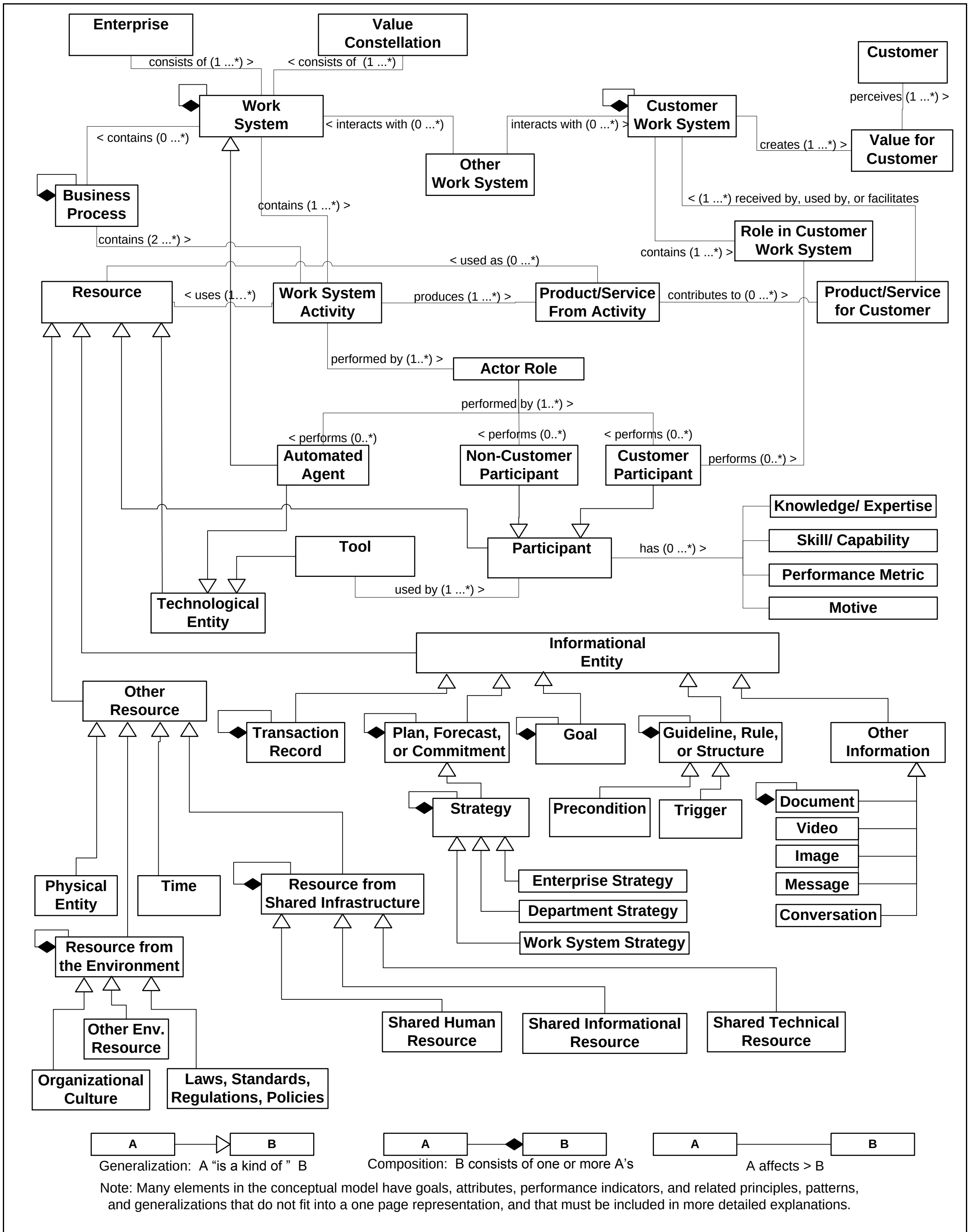

Fig. 3. Work system metamodel, revised version of a metamodel in Alter (2013a)

Conclusion

This paper demonstrated that WST and WSM provide knowledge support for design thinking related to systems in organizations. As noted at the outset, this form of design thinking is not directly relevant to the design of enormous scientific instruments such as the Large Hadron Collider or to designing typical consumer products such as toothbrushes. Instead, design thinking based on WST/WSM proceeds based on knowledge related to systems in organizations. Experience to date indicates that this approach makes sense and can be used by business professionals and IT professionals for some of the design thinking that is required for creating or improving IT-enabled work systems.

Ongoing development of WST/WSM as knowledge support for designing thinking related to systems in organizations should proceed in several streams of research, teaching, and industrial trials. First, the ideas themselves can be developed further. Thus far it seems that WST/WSM provides more specific guidance for designing work systems than is provided by other alternatives, such as general system theory, actor network theory, activity theory, and practice theory. Initial attempts to apply WST/WSM in related areas such as business process management (BPM) and service science seem promising, e.g., Alter (2012b, 2013c). A work system approach might even provide a front-end for object-oriented analysis and design by IT professionals. (Alter and Bolloju, 2012).

Empirical, real world research on the efficacy of WST/WSM in practice is sorely needed since most of the observed applications to date have been through many hundreds of management briefings producing in the context of coursework by employed MBA and EMBA students. As noted in Alter (2013d), real world testing of almost any analysis or design method is difficult. First, real world users may use only part of a method or idea, as shown by Dobing and Parsons (2006, 2008) in relation to uses of UML. Second, and more difficult to deal with, business professionals in real situations are influenced by many factors that are unrelated to the specific topics included in almost any method. As a result, case study research might be the best approach for moving forward, even though it will still be difficult to go beyond testimonials of the type that appear in Truex et al. (2010).

A final stream of research is a search for ways to include insights from other forms of design thinking might help in making practical applications of WST/WSM easier and more convenient. Lessons are surely available from experience with existing analysis and design techniques. Other lessons might be gleaned from other types of design thinking, even from situations such as the collider and toothbrush designs mentioned at the outset.

References

Alter, S. (2006) The Work System Method: Connecting People, Processes, and IT for Business Results, Larkspur, CA: Work System Press.

Alter, S. (2010a) "Bridging the Chasm between Sociotechnical and Technical Views of Systems in Organizations," Proceedings of ICIS 2010, the 31st International Conference on Information Systems.

Alter, S. (2010b) "Design Spaces for Sociotechnical Systems," Proceedings of ECIS 2010, the 18th European Conference on Information Systems.

Alter, S. (2010c) "Including Work System Co-Existence, Alignment, and Coordination in Systems Analysis and Design," Proceedings of the Sixteenth Americas Conference on Information Systems, Lima, Peru.

Alter, S. (2012a) "Challenges for Service Science," Journal of Information Technology Theory and Application, Vol. 13, Issue 2, No. 3, 2012, pp. 22 -37.

Alter, S. (2012b) "Metamodel for Service Analysis and Design Based on an Operational View of Service and Service Systems," Service Science, Vol.4, No. 3, 2012, pp. 218-235

Alter, S. (2013a) "From Resources and Activities to Value for Customers within Systems of Service Systems," Proceedings of SIG-SVC 2013 Workshop, Dec. 15, 2013, Milan Italy.

Alter, S. (2013b) "Incorporating More System-Related Knowledge into Systems Analysis and Design," Proceedings of AMCIS 2013, the Nineteenth Americas Conference on Information Systems, Chicago, Illinois, August 2013.

Alter, S. (2013c) "Using Work System Theory to Link Managerial and Technical Perspectives on BPM," pp. 222-227 in Proceedings of the 2013 IEEE International Conference on Business Informatics, Vienna, Austria, July 2013, Springer.

Alter (2013d) "Work System Theory: Overview of Core Concepts, Extensions, and Challenges for the Future" Journal of the Association for Information Systems, Vol.14, No. 2, 2013, pp. 72-121.

Alter, S. (2014) "Theory of Workarounds," Communications of the Association for Information Systems, Vol. 34, No. 55, pp. 1041-1066.

Alter, S. and Bolloju, N. (2012) "A Work System Front End for Object-Oriented Analysis and Design," 11th Annual Symposium on Research in Systems Analysis and Design, Vancouver, BC, Canada, June 2012.

Alter, S. and Wright, R. (2010) "Validating Work System Principles for Use in Systems Analysis and Design," accepted for publication in the Proceedings of ICIS 2010, the 31st International Conference on Information Systems

Brazel, J.F. and L. Dang (2008) "The Effect of ERP System Implementations on the Management of Earnings and Earnings Release Dates", Journal of Information Systems, Vol. 22, pp. 1-22.

Brown, T. (2008) "Design Thinking," Harvard Business Review, June 2008, pp. 84-92.

Chesbrough, H. and Spohrer, J. (2006) "A research manifesto for services science," Communications of the ACM, (49)7, July, 35-40.

Cross, N. (2006) Designerly Ways of Knowing, Springer.

Dobing, B., and Parsons, J. (2006) "How UML is Used," Communications of the ACM Vol. 49, No. 5, pp. 109-113.

Dobing, B. and Parsons, J. (2008) "Dimensions of UML Diagram Use: A Survey of Practitioners," Journal of Database Management, Vol. 19, No. 1, pp. 1-18.

Eckerson, W. W. and R.P. Sherman (2008) "Strategies for Managing SpreadMarts: Migrating to a Managed BI Environment", *TDWI Best Practices Report*, First Quarter 2008, pp. 1-21.

Ignatiadis, I. and J. Nandhakumar (2009) "The Effect of ERP System Workarounds on Organizational Control: An interpretivist case study," Scandinavian Journal of Information Systems, Vol. 21, No. 2, pp. 59-90.

Kerr, D.V. and L. Houghton (2010) "Just in Time or Just in Case: A case Study on the Impact of Context in ERP Implementations", Australasian Journal of Information Systems, Vol. 16, pp. 5-22.

Kimbell, L. (2011) "Rethinking Design Thinking, Part I," Design and Culture, Vol. 3, No. 3, pp. 285-306.

Lee. Y. 2008, "Design participation tactics: the challenges and new roles for designers in the co-design process," Co-Design, Vol. 4, No. 1, 2008, pp. 31-50.

Owen, C. (2007) "Design Thinking: Notes on its Nature and Use," Design Research Quarterly, Vol. 2, No. 1 pp. 16-27.

Pourdehnad, J., Wilson, D., & Wexler, E. (2011, September). Systems & Design Thinking: A Conceptual Framework for Their Integration. In Proceedings of the 55th Annual Meeting of the ISSS-2011, Hull, UK (Vol. 55, No. 1).

Thatte, S. and N. Grainger (2010) "Feral Systems: Why Users Write Them and How They Add Value", Fifth Pre-ICIS workshop on ES Research, St Louis 2010, pp. 1-16.

Truex, D., Alter, S., and Long, C. (2010) "Systems Analysis for Everyone Else: Empowering Business Professionals through a Systems Analysis Method that Fits their Needs," Proceedings of 18th European Conference on Information Systems, Pretoria, South Africa.

Truex, D., Lakew, N., Alter, S., and Sarkar, S. (2011) "Extending a Systems Analysis Method for Business Professionals," European Design Science Symposium, Leixlip, Ireland, Oct. 2011.