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The Knowledge Cube: Scaffolding for a Body of Knowledge about Information Systems

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THE KNOWLEDGE CUBE: SCAFFOLDING FOR A BODY OF KNOWLEDGE ABOUT INFORMATION SYSTEMS

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Abstract

This paper answers calls for a body of knowledge (BoK) for the IS field. Its new approach for thinking about a BoK provides a path for addressing a longstanding problem in the IS discipline. The paper proposes organizing knowledge as a three dimensional "knowledge cube" that goes beyond compilations of categories of knowledge, sets of generalizations, and sets of documents. The structure of the knowledge cube is based on recognition that "work system in general" is a general case whose subordinate cases include information system in general and project in general. In turn, the special cases have their own special cases. The knowledge cube starts with a 10 X 10 layer for compiling concepts, principles and generalizations, and empirical findings related to the nine elements of the work system framework and "work system as a whole." Those properties are tentatively inherited by special cases, with the caveat that BoK developers may remove properties that are not relevant to special cases and that special cases may have additional properties that are not relevant to more general cases. The paper presents examples that illustrate these points. It also discusses next steps and important issues revealed by the knowledge cube's structure.

1 Need for a Body of Knowledge

This paper responds to calls for action from leading IS researchers related to overarching holistic theories, the lack of a body of knowledge (BoK) for the IS field, and need for broad syntheses that might be understandable to all members of the IS community. For example, Hirschheim and Klein (2003) says that "defining a theoretically appealing, yet practically relevant, action – oriented body of knowledge could provide a type of 'Rosetta Stone' for IS as an applied discipline." (p. 263). It also notes the need for a shared language. "Without such a language, it is difficult to arrive at a consensual core body of knowledge or even to begin framing the issue of coding such a shared BoK for the discipline as a whole. Categorization schemes that make up the subject areas of IS (*cf.* Barki *et al*. 1988; Bacon and Fitzgerald 2001) are a useful start for developing a shared language for the field, but have not led to a discussion on how IS knowledge as a whole should be structured." (p. 244)." Even basic IS concepts are often problematic, as discussed a decade ago in a paper called "Same Words, Different Meanings: Are Basic IS/IT Concepts our Self-Imposed Tower of Babel?" (Alter, 2000). That paper noted that the IS field seems terribly concerned with issues of rigor vs. relevance but somehow seems to tolerate slippery concepts that legitimately mean different things to different people.

The lack of a widely accepted BoK has many undesirable consequences. At minimum, it is an obstacle to communication across sub-communities within the discipline and to teaching disciplinary knowledge to students and other newcomers. Lack of a BoK also contributes to perpetual concerns about the "crisis" in the IS discipline and about the discipline's legitimacy (e.g., Benbasat and Zmud, 2003; Lyytinen and King, 2004; Helfert, 2011).

1.1 What might a body of knowledge look like?

There are many different ideas about what a body of knowledge might look like. Possibilities include:

- BoK as set of guidelines and best practices. (e.g., PMBOK, the Project Management Body of Knowledge (Project Management Institute, 2008) and ITIL, the Information Technology Infrastructure Library, promulgated as best practices for IT service organizations (ITSMF, 2007)
- BoK as revealed in a curriculum guide (e.g., Topi et al, 2010)
- BoK based on categories of expert knowledge (e.g., see Iivari et al., 2004)
- BoK as concepts and principles from widely cited articles (Hassan and Mathiassen, 2009)
- BoK as an accumulation of useful articles (e.g., vom Brocke and Rosemann 2010)

Each of the above approaches to a BoK has shortcomings. A set of guidelines and best practices always leads to questions about exactly which situations are covered and also questions about who had the legitimate authority to decide what should be the guidelines and best practices. A BoK as a curriculum guide is basically directed at newcomers who lack background knowledge. An outline of expert knowledge has the opposite problem of assuming a substantial amount of background knowledge as the basis for understanding the BoK. A BoK consisting of concepts and generalizations from particular articles surely omits a great deal of important knowledge. A BoK that is an accumulation of papers from various viewpoints usually lacks coherence.

Other questions concern BoKs in general. For example, there is a question of the relative balance between guidelines and processes related to what expert practitioners do versus knowledge about the systems that are the object of their actions. Also, a general problem with the scope of any BoK is that every BoK depends on other BoKs, parts of which might or might not be included within its scope.

This paper proposes a scaffolding (Orlikowski, 2006) for a BoK for IS that goes far beyond categorization of subject areas and that provides a structure for organizing concepts and principles in different academic subcategories within IS. We call this scaffolding a knowledge cube because it is a three dimensional framework for compiling everything from concepts to generalizations and empirical findings within the IS discipline. The scaffolding diverges from other BoK proposals in IS because it places IS in a broader context while also providing a way to look at special cases within IS. Just its structure helps in understanding a number of significant issues related to the IS discipline.

Organization and scope. The next section presents a design theory for a BoK in IS that clarifies the rationale for the proposed BoK. Characteristics, requirements, and principles in the design theory are satisfied by viewing work systems as a general case for the systems of interest, and information systems and projects as special cases. The knowledge cube is a three dimensional grid of cells. Its three dimensions are property types, element types, and system types. Examples are provided that illustrate the kinds of information that would appear in the cells in the knowledge cube. The concluding discussion identifies some of the challenges in developing the proposed BoK and some of the uses of the scaffolding even before the BoK is created.

2 Design Theory for a Body of Knowledge for Information Systems

This section presents a design theory for a BoK for IS. The general approach is consistent with Gregor (2006) and Gregor and Jones (2007). Following the format of a "design theory for systems that support emergent knowledge processes" in Markus et al. (2002), we explain the design theory using a set of situational characteristics that lead to requirements, which in turn lead to principles that are satisfied by the knowledge cube. Many of the characteristics, requirements, or principles are somewhat consistent with Hirschheim and Klein (2003) and Alter (2005) but are inconsistent with premises underlying other proposals related to a BoK for IS (e.g., Iivari et al., 2004; Hassan and Mathiassen, 2009). If expanded to a full journal article, this paper would include a diagrammatic summary of the design theory similar to Figure 7 in Markus et al (2002), a comparison with premises underlying other proposals, and more background about topics such as design theories and knowledge in general. Constrained by page limitations, we simply list relevant characteristics, requirements, and principles.

2.1 Situational Characteristics that a BoK Should Recognize

Characteristic #1. Knowledge in the IS field includes knowledge about information systems in operation, about processes and projects that change information systems over time, and about work related to operating and changing information systems. Important parts of the knowledge about information systems can be communicated and understood independent of knowledge about doing IS-related work such as IS evaluation, creation, and maintenance. In contrast, knowledge about IS evaluation, creation, and maintenance cannot be communicated or understood without IS knowledge.

Characteristic #2. IS knowledge includes concepts, principles and generalizations, and empirical findings that may change over time. Concepts such as speed, efficiency, and reliability were understood and used long before computers existed. Other concepts such as window, flash memory, and ERP are relatively recent. Principles and generalizations that may have been largely valid in the past may not be valid in the future, especially as regards capabilities and features of technology.

Characteristic #3. Much IS knowledge is not unique to the IS field. For example, concepts such as speed, efficiency, and reliability are important concepts in IS while also existing in everyday speech.

Characteristic #4. Much IS knowledge is not stated explicitly in academic journals, but rather is tacit knowledge in the form of generalizations, propositions, or processes assumed by research authors. Also, important parts of the BoK appear in textbooks not directly related to research publications.

Characteristic #5. Basic terminology of the IS field has taken on a broad range of meanings and connotations. For example, IS may mean a technical tool that is used by users or a sociotechnical system with human participants (for implications, see Lee (2010)). Implementation may mean getting software running on a computer or achieving effective use of software in an organization.

Characteristic #6. Concepts and generalizations that are relevant for one type of IS or IS project may not be relevant for another type of IS or IS project.

2.2 Requirements for a BoK Based on the Situational Characteristics

Requirement #1. A BoK should provide a way to organize concepts, principles, and other properties that are relevant in the IS discipline. The organization scheme should be more useful than just a set of categories (as suggested by Hirschheim and Klein (2003)).

Requirement #2. A BoK should organize knowledge that is relevant to students and newcomers, to expert practitioners, and to researchers. In contrast, Iivari et al. (2004) propose a BoK that is basically about expert knowledge.

Requirement #3. As with the BoK in many practical fields such as nursing, the BoK of IS should be large. (E.g., the BoK for nursing includes not only nursing practices but also anatomy, physiology, microbiology, chemistry, and other disciplines.) There should be no artificial constraint that a BoK for IS can be presented in its entirety in a short article, or even in a single book. The only practical form of a BoK for IS may be a series of books or a computerized artifact based on a formal structure.

Requirement #4. The formal structure of a BoK should be sufficient to determine where any particular concept or generalization belongs.

Requirement #5. The formal structure of a BoK for IS should make it as easy as possible to compile the BoK. It should be possible to modify or extend the BoK based on a variety of research techniques such as gathering expert opinion and text mining of documents.

Requirement #6. The initial goal in creating a BoK should focus on producing a consistent and comprehensive set of concepts and generalizations that covers most of the IS field. It should not assume, unrealistically, that everyone in the IS field will use exactly the same terminology once a version of the BoK is created. Production of any plausible instantiation would be a major step forward.

2.3 Principles for a BoK Based on the Requirements

Principle #1. A BoK should encompass concepts, principles and generalizations, and empirical findings. Relevant concepts may or may not be part of everyday speech. In addition to principles and generalizations, a BoK should include empirical findings wherever possible.

Principle #2. Based on systems concepts and systems thinking, a BoK should contain concepts, principles and generalizations, and empirical findings related to IS components and IS as a whole. It should cover both levels because IS are more than the sum of parts that they depend on individually.

Principle #3. A BoK should recognize that systems in organizations change over time, and that change processes combine planned change (projects) and emergent (unplanned) change.

Principle #4. A BoK should exploit the hierarchical structure of inheritance between more general cases and special cases, thereby making the creation of the BoK more efficient by filling in tentative versions of subordinate layers based on concepts and generalizations in a more general layers.

Principle #5. A BoK for IS should integrate basic knowledge and expert knowledge. A BoK for IS should not be subdivided into a BoK for novices and a BoK for experts even though extracts from the BoK might be created and organized to support needs of people in either group.

3 Work System as a General Case of Systems in Organizations

Before presenting the knowledge cube that is designed to satisfy the above requirements and principles, it is necessary to introduce the view of systems that it is based on.

Work system as the basic construct for systems in organizations in the BoK. The basic construct for the proposed BoK is "work system," a general case for thinking about systems within or across organizations. A work system is a system in which human participants and/or machines perform work using information, technology, and other resources to produce products and/or services for internal or external customers. Typical business organizations 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. Almost all work systems in business and governmental organizations rely on IT in order to operate efficiently and effectively.

It might seem surprising that the basic construct for a BoK for information systems is the more general term *work system*. An important advantage of using work system as the basic construct is that information systems and projects are both special cases of work systems.

General case and special cases. Work system is a general case for thinking about systems within or across organizations. Many special cases that are important in the IS discipline should inherit concepts and other knowledge from the general case:

- Information systems are work systems whose processes and activities are totally devoted to processing information through activities including capturing, transmitting, storing, retrieving, deleting, manipulating, and displaying information. (Alter, 2008)
- Projects are work systems designed to produce a set of products and then go out of existence.
- Supply chains are inter-organizational work systems that provide supplies and other resources required for the operation of organizations.
- Self-service work systems (e.g., ecommerce) involve customers performing processes and activities using resources (e.g., ecommerce web sites) provided for their use.
- Totally automated work systems (including totally automated IS) are work systems all of whose processes and activities are performed by software, machines, and other devices.
- Work systems are assumed to be sociotechnical systems by default even though some of them may be totally automated systems that contain no human participants (e.g., totally automated IS). People

who create and maintain those programs, machines, and other devices are participants in other work systems that create or maintain the automated work systems.

Special cases of work systems inherit many properties from work systems in general, but as special cases may have at least some properties that are not properties of work systems in general. Proceeding hierarchically, each high-level special case has its own special cases. For example, special cases of IS include transaction processing systems and management reporting systems. Special cases of projects include projects that install commercial software and projects that develop software using agile approaches. The most useful hierarchical structure for special cases of IS, projects, and other top level special cases of work system is not obvious.

Work system framework. The work system framework (Figure 1) identifies nine elements that are part of even a rudimentary understanding of a work system. The framework outlines a static view of a work system's form and function at a point in time and is designed to emphasize business rather than IT concerns. It covers situations that might or might not have a tightly defined business process and might or might not be IT-intensive. Figure 1 says that work systems exist to produce products and services for customers. The arrows say that the elements of a work system should be in alignment. The elements of the work system framework are defined in Alter (2008).

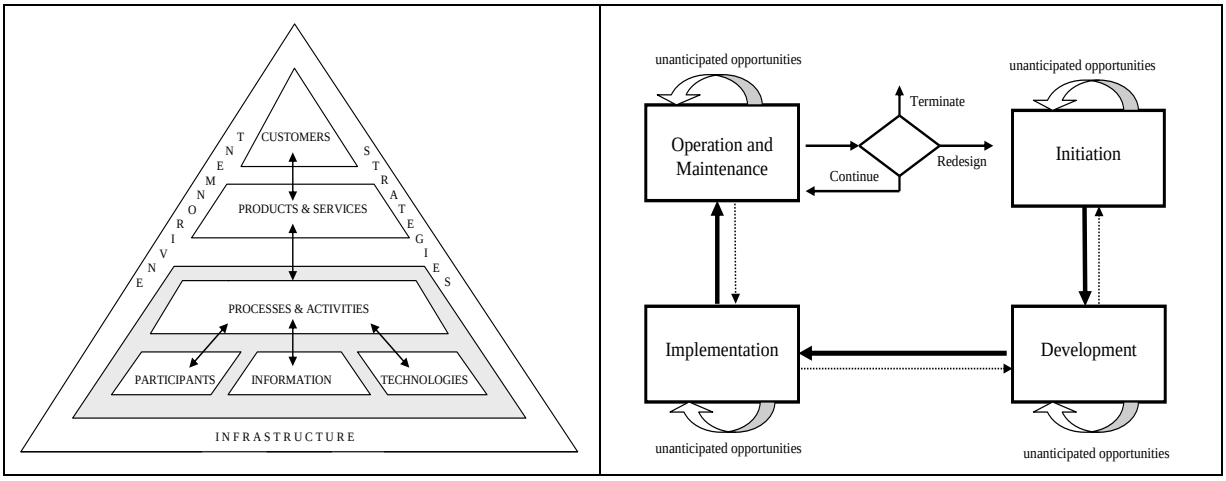


Figure 1. Work system framework and work system life cycle model (Alter, 2006, 2008)

Work system life cycle model. The WSLC (Figure 1) expresses a dynamic view of how work systems change over time through iterations involving planned change and emergent (unplanned) change. (Alter, 2006; 2008). 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. Development may include any of the following: software development, software acquisition, software configuration, creation of new procedures, creation of documentation and training materials, and acquisition of any other resources needed for implementation of the new version of the work system. The WSLC represents emergent change using inward-facing arrows representing ongoing adaptations, bricolage, and workarounds that change aspects of the current work system without separate allocation of significant project resources.

4 Proposed Scaffolding for Organizing IS Knowledge

The requirements and principles in the design theory summarized earlier are consistent with a unique way of thinking about a BoK for IS. The basic idea is that the BoK consists of concepts, principles and

generalizations, and empirical findings all of which can be organized using a three dimensional matrix that might be called a "knowledge cube" (Figure 2). This approach for organizing a BoK clarifies and simplifies preliminary ideas presented in a cumbersome form in Alter (2005). This section identifies the dimensions of the knowledge cube and explains steps toward populating its cells with the concepts, principles and generalizations, and empirical findings that constitute the knowledge in the IS field.

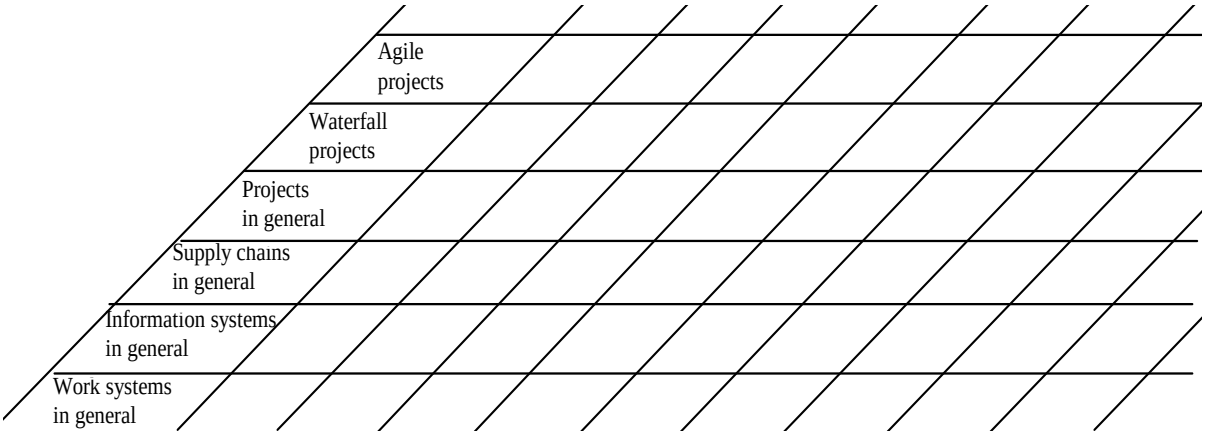
4.1 Three Dimensions of the Knowledge Cube

Figure 2 illustrates the three dimensional knowledge cube as consisting of multiple layers, each consisting of a 10 x 10 two-dimensional matrix whose cells are identified by the intersection of a category within the horizontal dimension and a category in the vertical dimension. The top layer is devoted to work systems in general. Each of the other layers is devoted to a special case of work system. The special cases identified in Figure 2 include information systems in general, supply chains in general, projects in general, and two special cases of projects, waterfall projects and agile projects. Many other special cases would be included in a complete knowledge cube.

Horizontal dimension (types of properties): The knowledge cube contains 10 columns, one each for a distinctive group of properties. A first cut at the likely groups of properties include 1) components and phenomena, 2) actions and methods, 3) characteristics, 4) aspects of performance, metrics, and goals, 5) risks and obstacles; 6) standards and rules 7) exceptions, workarounds, and situations requiring special action 8) relationships, 9) principles and generalizations 10) empirical findings. Properties in the first eight columns are words or phrases. Consistent with Hirschheim and Klein's (2003) call for a shared language, the first four columns refer to properties that are generally associated with 1) nouns, 2) verbs, 3) adjectives, and 4) adverbs. For example, the characteristics in the third column are descriptive properties. The next four columns are categories of concepts that are often important in IS. For example, related to column 5), Alter (2006, p.65) lists over fifty common stumbling blocks and risk factors. Likewise, concepts that can be categorized as 6) standards and rules 7) exceptions, workarounds, and situations requiring special action and 8) relationships are often essential for understanding how specific systems operate and why they operate one way and not another. The principles and generalizations in the ninth column are guidelines, ideally stated in complete sentences so that they can be understood. The empirical research findings in the tenth column are textual summaries of whatever empirical findings are deemed worthy of inclusion (an interesting decision by an individual or committee). Thus, the last two columns involve applications of concepts rather than just concepts *per se*. The last column is included mainly for making the BoK as valuable as possible for analysts, designers, and researchers. Important BoK issues related to the horizontal dimension and the other dimensions will be discussed later.

Vertical dimension (work system elements). The knowledge cube contains 10 rows, one for each of nine work system elements and one for work system as a whole. The first nine rows are needed because properties of work system components (processes and activities, participants, information, technologies, and sometimes customers if they are participants) and of other, non-component elements of the work system framework all affect the performance of the work system. The tenth row for work system as a whole is needed because some properties such as capacity, resilience, and scalability are emergent properties of a work system as a whole, rather than properties of individual elements.

Depth dimension (layers for special cases of work systems). The knowledge cube contains a layer for each relevant special case. The top layer consists of ten columns and ten rows, with each cell containing a particular type of concept or a generalization/principle or an empirical finding for work systems in general. Other layers contain concepts, principles, and empirical data for special cases such as information systems, supply chains, projects, and special cases of each of those cases. Each layer has a hierarchical relationship to some of the other layers, but not all. For example, waterfall project is a special case of projects in general, which in turn is a special case of work systems in general; on the other hand, waterfall project is a not a special case of information system or supply chain.



	1	2	3	4	5	6	7	8	9	10
1. Work system as a whole										
2. Customers										
3. Products and Service										
4. Processes and actvities										
5. Participants										
6. Information										
7. Technologies										
8. Environment										
9. Infrastructure										
10. Strategies										

** The three dimensions represent types of properties (numbered horizontally like an x-axis), types of elements that have the properties (treated like a y-axis) and special cases of work systems (treated as a z-axis.)*
** The types of properties (the numbered columns) include: 1) components and phenomena, 2) actions and methods, 3) characteristics, 4) aspects of performance, metrics, and goals, 5) risks and obstacles; 6) standards and rules 7) exceptions, workarounds, and situations requiring special action 8) relationships, 9) principles and generalizations, 10) empirical findings.*

Figure 2. The knowledge cube: a three dimensional matrix for organizing the body of knowledge for systems in organizations.

4.2 Examples of Contents of Cells in the Knowledge Cube

We provide several examples that illustrate the types of contents that would be organized within the knowledge cube. First is an example of characteristics in the work system layer. Next is an example of principles in that layer. The third example is of actions that would be in a different layer for a work system described as "designing modifications of a work system." A special case of the latter work system is "designing modifications of an information system."

Example of concepts for the work system layer. Each of the bulleted items below is a characteristic of processes and activities within a work system. Therefore each of these terms or some synonym

would appear in the work system layer (the top layer) in the cell for characteristics (column #3) of processes and activities (row #4). Many other concepts would appear as well.

- 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

This particular cell was chosen as an example because these characteristics can be quite important in designing systems, yet are barely mentioned or are omitted altogether in most systems analysis and design textbooks for IS. Each of these characteristics can also take the form of a design goal, such as "we need to make this work less error-prone" or "we need to change the rhythm by making the activities less scheduled and more responsive" or "we need to make this system more complex because it does not recognize important issues that could be included explicitly."

Entering these characteristics in the cell in column #3, row #4 at the work system level could automatically trigger their *tentative* inclusion in corresponding cells in all immediately subordinate special cases, such as IS in general and projects in general. All of these characteristics are relevant to projects and to IS that have human participants. Inheritance cannot be totally automatic, however, because some concepts that are relevant in higher layers may not be relevant in a lower layer. For example, *variety of work* is relevant to work system in general but not relevant to totally automated IS. This demonstrates that inheritance across layers can facilitate the specification of subordinate layers but must be treated as tentative and subject to modification by BoK developers.

Example of principles for the work system layer. Ideally, there should be a set of principles that provide guidelines for people who evaluate or design systems in organizations. Table 1 presents a set of principles that combine previous sociotechnical principles (Cherns, 1976) with additional principles

<table>
<tr><td colspan="2">Customers</td><td colspan="2">Products & Services</td></tr>
<tr><td colspan="4">#1: Please the customers.
#2: Balance priorities of different customers.</td></tr>
<tr><td colspan="4">Processes and Activities</td></tr>
<tr><td colspan="4">#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.</td></tr>
<tr><td colspan="2">Participants</td><td>Information</td><td>Technologies</td></tr>
<tr><td colspan="2">#10: Serve the participants.
#11: Align participant incentives with system goals.
#12: Operate with clear roles and responsibilities.</td><td>#13: Provide information where it will affect action.
#14: Protect information from inappropriate use.</td><td>#15. Use cost/effective technology.
#16: Minimize effort consumed by technology.</td></tr>
<tr><td>Infrastructure</td><td colspan="3">#17: Take full advantage of infrastructure.</td></tr>
<tr><td>Environment</td><td colspan="3">#18: Minimize unnecessary conflict with the external environment</td></tr>
<tr><td>Strategies</td><td colspan="3">#19: Support the firm’s strategy</td></tr>
<tr><td>Work System as a Whole</td><td colspan="3">#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.</td></tr>
</table>

Table 1. Principles related to work systems in general (Alter, 2006; Alter and Wright, 2010).

that were added for various reasons. These principles were validated somewhat informally based on individual opinions with six groups of Executive MBA students with extensive business experience. (Alter and Wright, 2010). The final section will return to the question of who should use which criteria to decide which principles and generalizations should be included.

This example was chosen to illustrate several aspects of the knowledge cube. First, notice how specific principles would appear in specific cells. For example, "perform the work efficiently" would be in the cell for principles and generalizations (column #9) related to processes and activities (row #4) in the layer for work systems in general. Since all of the principles would be inherited tentatively by immediately subordinate layers, "perform the work efficiently" would be assumed relevant to information systems in general and projects in general unless BoK developers decided otherwise.

This example also demonstrates one of the shortcomings of the structure of the knowledge cube. Notice how principles #1 and #2 are listed under both customers and products and services. Those principles are listed in that way because that is how they were listed in Alter and Wright (2010), whose goal was to validate principles, not to organize them in a BoK. The BoK developers would have to decide whether each of these principles belonged in a cell in the row for customers or in a cell in the row for products and services. A more difficult issue of this general type concerns the location of knowledge related to people, which might appear in the row for *participants* or for *customers*. The BoK developers would have to decide on a convention for locating that type of knowledge.

Example related to a different layer. The layer for work system in general represents a relatively static view of concepts, principles and generalizations, and empirical findings related to a work system's form and function. However, as illustrated by the work system life cycle model (Figure 1), work systems change over time through a combination of planned and emergent (unplanned) change. A number of layers of the BoK should be devoted to how those changes take place. The projects in general layer is relevant to the changes, but is only about projects in general rather than specific types of projects that design changes in work systems.

The bullet points below identify some of the actions that might be performed by a work system design project. It provides a first cut at some of the topics that would be included in column #2 (actions and methods), row #4 (processes and activities) for a layer called "designing modifications of a work system." That layer would tentatively inherit the contents of the cells in higher layers such as projects in general, but it would contain concepts that are specifically relevant to changes in work systems.

- 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)

Aside from demonstrating the types of concepts that might be included in the actions and methods column, this example illustrates the challenge of identifying an effective set of layers for the knowledge cube. We will look at that issue and many others in the next section.

5 Discussion and Conclusions

This paper presented a new way to think about a BoK for IS, thereby providing a path to address a longstanding, unsolved problem that is largely bereft of realistic paths toward practical solutions. The proposed knowledge cube combines four ideas that have not been discussed in combination:

- Organize the knowledge in the IS discipline in the form of a knowledge cube, rather than a set of categories of knowledge, a set of generalizations, or a set of documents.
- Make sure that the BoK covers concepts, principles and generalizations, and empirical findings.
- Recognize that work system is the general case of many special cases that are studied in the IS discipline, such as transaction processing systems and agile software projects.
- Facilitate the development of the knowledge cube by using inheritance from more general cases to special cases that are relevant in the IS discipline.

The direction proposed here calls for a great deal of additional work. This paper contributes to the discussion of a BoK for IS by providing a new approach and raising many issues that any practical BoK would have to address. We close by summarizing next steps and related issues.

Address shortcomings of the three dimensions of the knowledge cube. Each of the three dimensions in Figure 1 may have important shortcomings. The horizontal dimension (different types of properties) may not have the best possible categories. The vertical dimension (elements of the work system framework, plus work system as a whole) may not have sufficient granularity. It may be necessary to extend this dimension by including more of the entity types in a work system metamodel (Alter, 2010) that was developed to bridge the gap between sociotechnical and technical views of systems in organizations. For example, research findings concerning the technology acceptance model (TAM) do not link directly with any particular element of the work system framework, but do link directly with the relationship between *participant* and *tool* in the lower left-hand corner of the metamodel. Additional aspects of something like the metamodel might also be needed to provide an unambiguous location for properties of people in general, since both participants and customers are people or groups of people (except when the customer of a totally automated work system is another automated entity, as happens when totally computerized systems are decomposed). In relation to the third dimension, the appropriate layers for the successive inheritance from work system in general and its immediate special cases are not at all obvious. Ideally, the knowledge cube should have as few layers as possible consistent with accurately representing the BoK. Inheritance from work systems in general to information systems in general and projects in general is relatively straightforward, but what about the successive layers beneath the top layers? It is not clear what structure of layers would capture the important topics within the IS field without generating an excessive number of layers.

Compile an initial version of a BoK. A first cut for the layer for work systems in general could be based on any convenient sources of concepts, principles, and empirical data. Those sources could include expert opinion, basic textbooks, books for experts, journal articles, and case studies. A first cut at any immediately subordinate layer could be produced automatically by replicating entries from a higher layer in the inheritance hierarchy. For example, a first cut at the entries for IS in general or projects in general could be created by duplicating entries for work systems in general. Experts could then decide which concepts and principles applied in the subordinate layer, which should be removed, and which should be added because they are relevant to the subordinate layer but not to work systems in general. Applying this approach to understanding IS risks, Sherer and Alter (2004) concluded that more than half of the IS risk factors (134 of 228) in a convenience sample of 46 articles from the IS risk literature were actually risk factors for work systems in general, and not just for IS per se. For example, like most work system change projects, DSS projects and CAD projects tend to encounter trouble when management support is insufficient, staffing is insufficient, knowledge is insufficient, reasons for changes are not articulated, and so on.

Use the work system layer and the immediately subordinate layer to identify the unique BoK related to information systems in general. Start with a good draft of Figure 1 populated with concepts and principles that apply to IT-reliant work systems that include human participants. As a way to identify the unique BoK for IS in general, identify a) concepts that apply to IS in general and to work systems in general, b) concepts that apply to work systems in general but not to IS in general, c) additional concepts that apply to IS in general but do not apply to work systems in general. Depending on the results in a), b), and c), extend the exercise to identify concepts that are related to

special cases of IS (e.g., supply chain IS or accounting IS) and evaluate whether the special cases are substantially different from IT-reliant work systems in general or IS in general. Perform a similar analysis using project as the initial special case, and particular types of projects such as ERP implementation or agile development as the subsequent special cases.

Assess the possible futility of searching for the uniqueness of IS. The exercise of populating the *information systems in general* layer would test a "level-skipping conjecture" in Alter (2005), by which "most of the properties of information systems in general are inherited from work systems in general; very few additional concepts are related to information systems in general but not work systems in general; most of the additional properties of information systems are related to unique features of specific types of information systems." That conjecture might help explain why it is so difficult to generalize about information systems and why the IS field seems to lack a conceptual core. It may turn out that almost all of the useful properties and generalizations about information systems are either about work systems in general or about special cases of information systems. A straightforward way to prove the conjecture invalid is to identify a substantial number of concepts and principles that apply to information systems in general but not to work systems in general.

Compare the proposed knowledge cube with a BoK structure based on other starting points. Assume that the horizontal dimension of Figure 2 (elements of the work system) was replaced with some other set of basic concepts from actor network theory, activity theory, project management, agile software development, or any other organizing principle. It would be very interesting to see whether the idea of a knowledge cube could be maintained, and if so, what would all three dimensions look like and what would be illustrative examples of entries in the various cells. This paper makes no claim about any imagined superiority of its proposed approach. Any meaningful claim of superiority would have to be based on comparisons with other alternatives that simply have not been articulated.

Attain value from an initial version of the BoK. The vision of the knowledge cube is recent, and even a first draft of a fully populated version of the layer for *work systems in general* does not yet exist. The cells in that layer can be used to organize hundreds or thousands of concepts. Populating cells in the first eight columns of that layer with typical concepts that are more closely associated with that cell than with any other cell, the result would be a two dimensional outline of typical concepts that are relevant for analyzing, designing, implementing, and evaluating systems in organizations. Populating the ninth and tenth columns would require identifying principles, generalizations, and empirical findings that are believed to be applicable to most work systems (and hence most IS).

Even a partially populated version of that layer could be valuable in guiding systems analysis and design, helping researchers observe systems analysis and design projects, developing analysis support tools for systems analysis and design, and exploring complementarity with frameworks that might be alternatives to the work system framework. Each of those could be the topic of a separate research projects. Finally, it would be interesting to observe the similarities and dissimilarities in the results when qualified individuals or groups separately attempted to populate the layer for work systems in general and then modify that layer when producing a layer for information systems or projects in general. Explaining differences in the results might reveal important insights about how members of the IS community recognize and interpret IS phenomena.

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