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Information Technology Standardization: A Classification Process?

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This paper presents a preliminary exploration of standardization as a classification process. Through a comparison of the definitions and an examination of several standards it is suggested that a classification process may be operating in current standardization activities and that making this process explicit might be a useful model for the development of future standards. Further exploration will enable us to test the validity of this relationship and to then exploit it to improve the standards development process, the teaching of standardization, and perhaps open new areas of investigation for classification theorists.

INTRODUCTION

Standardization of information technology (IT) has become a significant part of the technology development and implementation process. The creation of interchangeable and interoperable hardware and software can be facilitated by adherence to standards. The importance of standards has led to an increased awareness of standards development processes (e.g., the role of traditional standards development organizations), the role of individual standards in particular markets, the strategic value of standards for organizations, etc. There has been, however, little discussion of the underlying intellectual activity of standardization. Classic texts in standardization (e.g., Cargill, 1989; Crawford, 1991; Verman, 1973) make little or no mention of the intellectual activities which must occur in a standardization effort.

Preliminary investigation by the author suggests that the classification process might be a useful model for the intellectual process of IT standardization. This paper will explore that idea by first making the argument that classification and standardization serve similar purposes in particular domains, then by analyzing several standards as classification schemes. It is suggested that the similarity between classification and standardization might be exploited in several different ways: 1) by standards developers to facilitate the development process, 2) by students who might use the classification metaphor to build an understanding of standardization, and 3) by classification theorists who might find standardization a fruitful domain for their research. The paper concludes with a discussion of issues which impact the utility of the comparison, as well as some potential areas of research.

CLASSIFICATION AND STANDARDIZATION

Chan defines classification as "the act of organizing the universe of knowledge into some systematic order" (Chan, 1994, p. 259). The resultant organization (the classification scheme) serves to provide an abstraction of reality which is ordered in a way that makes communication about that reality possible, and which facilitates the use of that abstraction for some task. For example, Kwasnik (1993) writes that "as a tool in inquiry, the role of classification is to provide coherent, useful, systematic, explanatory, heuristic, and theoretically sound representation of the entities and relationships among entities in a given domain" (p. 80).

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Standardization has been defined as "the process of formulating and applying rules for an orderly approach to a specific activity for the benefit and with the cooperation of all concerned" (Verman (citing the International Organization for Standardization (ISO)), 1973, p. 20). Some similarities to the definition of classification are immediately obvious. First it is orderly. (We will consider later whether the orderliness of classification is similar to that of standardization.) Like classification, it is orderly in both its formulation and in its application. Secondly, standardization is practiced for a particular purpose (i.e., for the benefit of all concerned). In fact the similarity extends further. Standards (the products of standardization)[1] serve the same purpose in their domains as classification schemes serve in theirs. They provide a useful abstraction to communicate information about reality. Classification schemes tend to abstract a field of knowledge and thus facilitate communication and consensus about where particular instantiations of concepts should be placed within the scheme. Standards abstract from a given technical domain the fundamental elements important to understanding that domain and for creating products which can "interoperate" within that domain (i.e., products which can fill certain niches or functional roles in that domain).

Definitional similarity, as discussed above, while interesting, does not, in and of itself, imply that standardization activities could be enhanced through the explicit inclusion of classification principles. The linchpin for that argument is in the nature of the orderliness of the two resultant products. If the orderliness is similar, then we might assume that the intellectual processes which are used to create classification schemes might have some utility in the creation of standards. The next section of the paper will analyze several different standards to assess whether their orderliness is significantly similar.

THE ORDERLINESS OF CLASSIFICATION

Chan describes how the organizing process of classification occurs:

> The essential act of classification is the multistage process of deciding on a property or characteristic of interest, distinguishing things or objects that possess that property from those that lack it, and grouping things or objects that have the property or characteristic in common into a class. Other essential aspects of classification are establishing relationships among classes and making distinctions between classes to arrive at subclasses and finer divisions. (Chan, 1994, p. 259)

Good classification schemes share several properties. They should order reality into exhaustive classes which are extensible and flexible (to handle changes in the domain) (Taylor, 1992). Foskett (1982) suggests that a classification scheme should maximize the number of unique placements of

1. There is no "standard" definition of standard. The following are illustrative of many of the definitions. A standard is defined by ISO "as a document...that provides for common and repeated use, rules, guidelines, or characteristics for activities or their results aimed at the achievement of the optimum degree of order in a given context." (Mackay, 1991, p. 319.) Cargill writes "a standard is the deliberate acceptance by a group of people having common interests or background of a quantifiable metric that influences their behavior and activities by permitting a common interchange" (Cargill, 1989, p. 13).

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concepts within the constraint of providing identifiable relationships between those concepts. Classes should be organized according to the strength and nature of these relationships. These relationships vary based on the domain in which the classification is developed (thereby creating different structures such as hierarchies, trees, and faceted approaches).

THE ORDERLINESS OF STANDARDS

Since the field of standardization has lacked both an explication of the intellectual activities which occur to develop a standard as well as an articulation of necessary features of the products (beyond that they should be useful), one must resort to an examination of the standards themselves to attempt to understand their orderliness. This paper will examine several IT standards according to the orderliness criteria described above for classification schemes. Based on this comparison, an assessment of IT standardization as a classification process will occur.

There are hundreds, if not thousands, of information technology standards. This paper cannot (of course) examine all of them. Therefore it is important to discuss the choice of the standards which will be examined. People have used many different schemes to organize standards into groups. (I will reserve the word classification for my main discussion, though clearly it is appropriate to use it here as well.) Standards have been organized by the producer of the standard, the audience/users of the standard, by the type of activity standardized, and by the level of generality of the standard.

SCHEME	EXAMPLE CLASSES
by audience/user group	company, industry, region, nation international
by producer	traditional standards development organization (SDO), company, industry consortium, other type
by level of specificity	general, specific
by standard type	resource sharing, communications, human-computer interface, operating systems (Molka, 1993)

Figure 1. Types of Organizational Schemes

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<table>
<tr><th rowspan="2">TYPE OF STANDARDS
(Molka, 1993)</th><th colspan="2">LEVEL OF SPECIFICITY</th></tr>
<tr><th>GENERAL</th><th>SPECIFIC</th></tr>
<tr><td>Resource Sharing</td><td>SGML
Standard Generalized Markup Language</td><td>TEI
Text Encoding Initiative</td></tr>
<tr><td>Communications/ Networking</td><td colspan="2">OSI
Open Systems Interconnection Basic Reference Model
(ISO 7498)</td></tr>
<tr><td>Human-Computer Interface</td><td colspan="2">Ergonomic Requirements for Office Work with Visual Display Terminals
(ISO 9241)</td></tr>
<tr><td>Operating Systems</td><td></td><td></td></tr>
</table>

Figure 2. Discussed Standards

(Figure 1 demonstrates these different organizational schemes.) While a full discussion is beyond the scope of this paper, it should make intuitive sense that we might not expect differences (in terms of the standardization-classification comparison) between the groups of standards as organized by the first two schemes, producer and users of standards, since these are external to the standard itself. (I am not suggesting that they do not impact the resultant standard, just that the effects might be considered "random" across those standards.) The other two schemes, since they are associated with the standard itself, might impact the extent to which the standardization-classification comparison is borne out. Therefore, this paper will examine 4 standards representing several of the groups in a matrix of the last two schemes (see Figure 2). These are the Standard Generalized Markup Language (SGML) (ISO 8879, 1986), the Text Encoding Initiative (TEI), the Open Systems Interconnection (ISO 7498, 1984), and Ergonomic Requirements for Office Work with Visual Display Terminals (ISO 9241) (Standards do not exist for all groups or it was not possible to assign a particular standard to one of the groups. Operating system standards were not included since the author lacks sufficient knowledge to discuss them.)

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SGML and TEI

SGML is one of many standards which are intended to facilitate the communication and use of information by encoding it (as more than ASCII text).[1] In particular, it provides a language in which mark-up languages might be expressed. The intent is that by standardizing the metalanguage, a machine will be able to parse any number of mark-up languages (developed in accordance with SGML) even if the specifics of that language are not known. (It does this by providing for a Document Type Definition at the beginning of any marked-up text which explains the coding used in the text that follows.) SGML provides the syntax for the creation of any number of markup languages for any number of different document types. This syntax is that documents consist of elements (logical chunks of content (e.g., a paragraph) which consist of smaller units called entities which may be, for example, characters). Elements may have attributes, which are properties of the elements but which are not present in the content of the element itself.[2] Additionally SGML specifies that relationships among elements can be of many types such as embedded, sequential, etc. What SGML does not do is define any document types, elements, attributes, or relationships between them.

From a classification perspective, SGML might be considered as providing the notational scheme for an implied classification scheme. In its structure, its notation provides for a hierarchical scheme (as depicted in Figure 3). However, it is important to note that since it does not actually specify the elements, etc. for a particular document type, SGML might be implemented in several ways, one of which creates a hierarchical structure, while the other creates a more faceted structure. In Figure 4, these two approaches are illustrated. Example 1 represents the situation where Document Type Definitions are created independently of each other. In each case, the particular document type would be investigated to determine the elements of importance (and then the attributes). It is also possible, as Example 2 of the same figure suggests, to begin with a set of elements which might be utilized in a number of document types with an implementor choosing those elements (facets) of

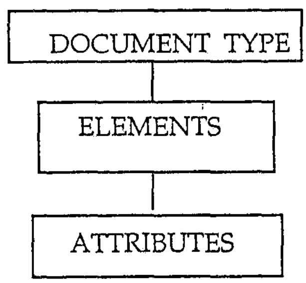

Figure 3. General SGML Structure

1. Much of the information in this section has been synthesized from Nordin, Barnard and Macleod (1993) and van Herwijnen (1994).
2. For example, a memo might be considered confidential without ever specifying in its content that it is, in which case, an attribute might be added to the element called memo.

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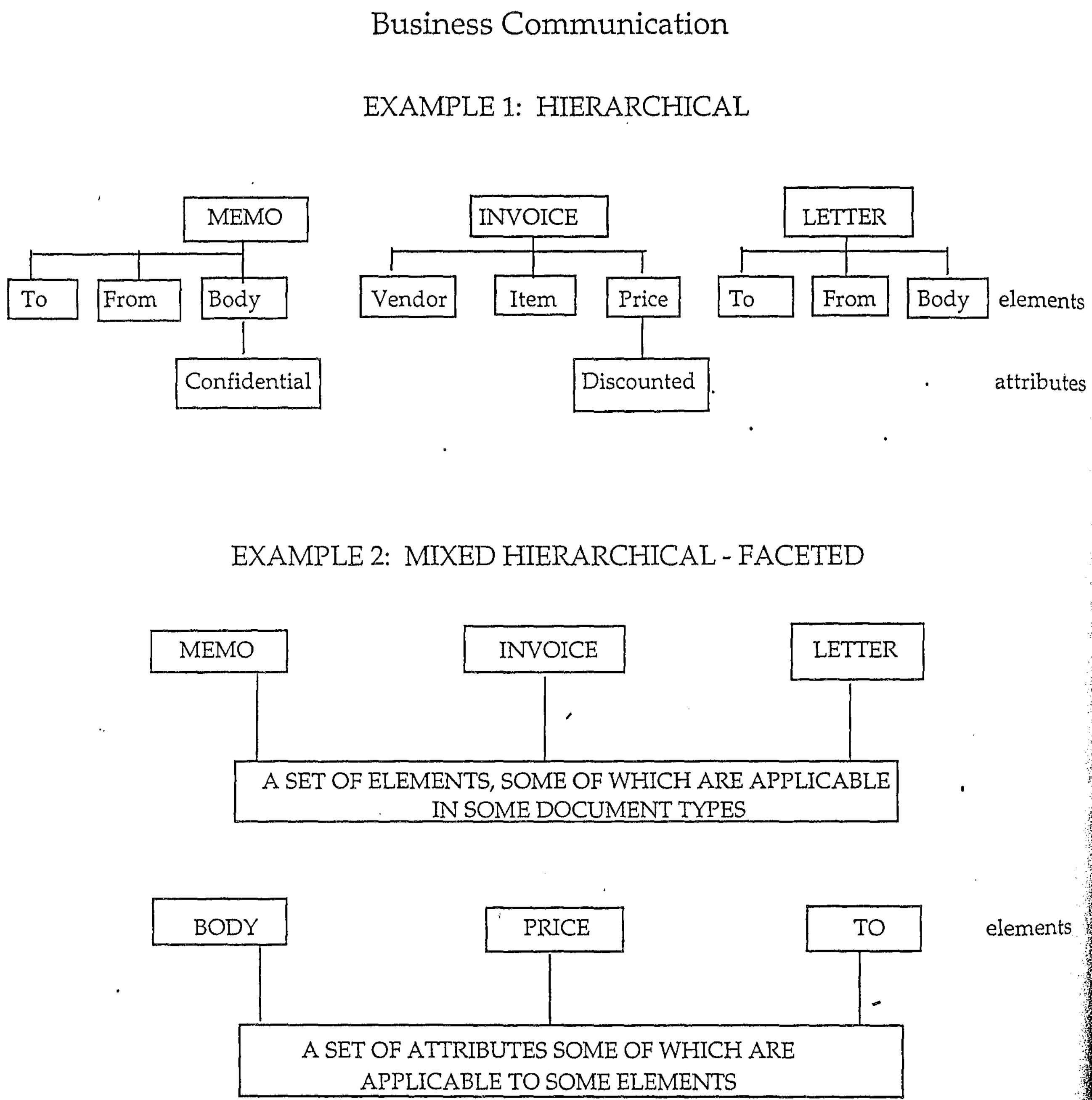

Figure 4. Two Examples of SGML Implementation

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importance to a particular document type. The same would be true at the attribute level. These examples are somewhat simplified, not only in the elements and attributes displayed but also by not representing the possibility for elements to contain other elements (such as the element "memo" which represents the entire content of a memo, and "to" and "from" which represent smaller pieces of content in "memo"). However, the above discussion should make clear that SGML, while not itself a fully developed classification scheme, provides for the development of such classification schemes through the specification of the syntax of documents and an associated notation.

TEI is one of the standards which utilizes SGML to develop a markup language for texts in the humanities. As an implementation of SGML, it extends the basic notational scheme by specifying document types to which it applies and the elements and attributes associated with those. The nature of texts in the humanities led to the abstraction of documents which is hierarchically organized. Figure 5 represents a simplified diagram of a prose text as structured by TEI. The basic structure of a text is that the whole text consists of three parts: a front (the prefatory material), the body of the work, and the back (appendices). Within each of these units, there may exist a further hierarchical division of structural elements. For example, a prose work may be divided into chapters and those chapters into subchapters. TEI refers to these as divisions with the largest unit as Division 0. In addition to the structural elements, there may also be elements associated with the content of the document. These elements are not dependent on the hierarchical structure and may exist where appropriate anywhere in the document (University of Virginia, n.d.). For example, an author name may appear in the front, body, or back.

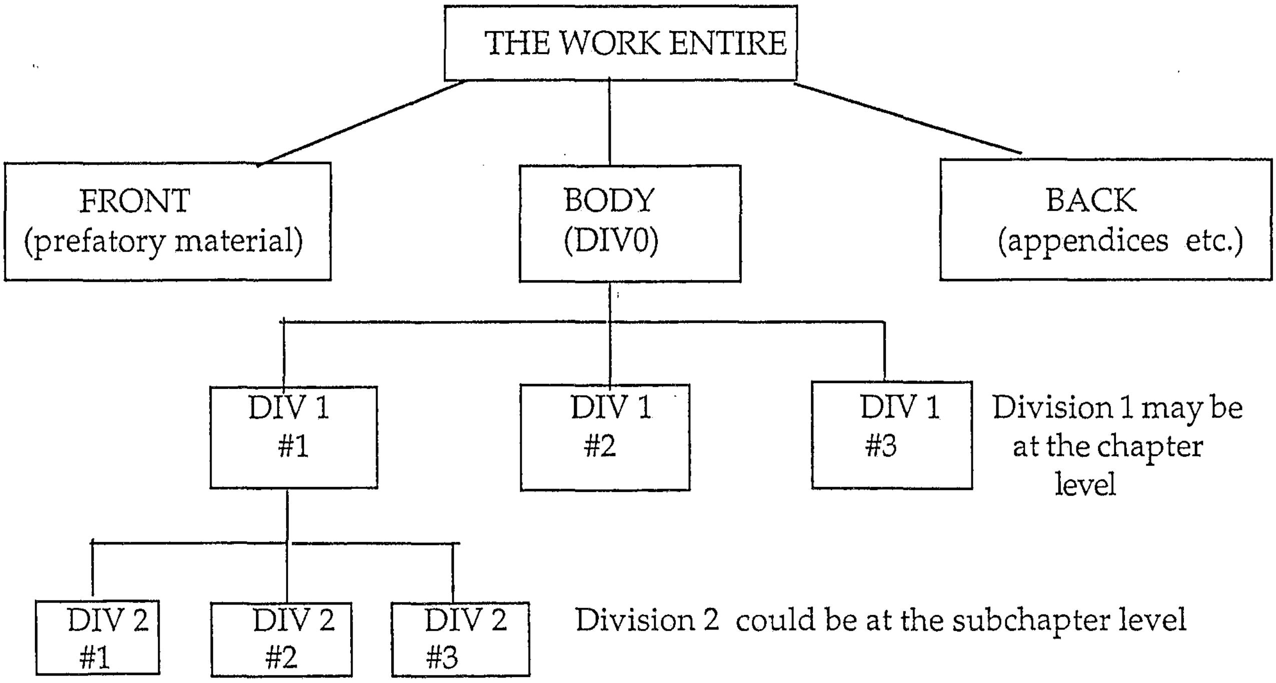

Figure 5. Simplified TEI Structure for Prose Work

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TEI, like SGML, displays a classificatory structure. The relationships between elements within the domain (texts) are of a variety of types including hierarchical, ordinal, and faceted. Like classification schemes, SGML and TEI abstract reality by presenting a structure which is "necessary and sufficient" to describe the entities of interest in that domain (i.e., documents). SGML and TEI are particularly interesting from a classification perspective because of the complexity of the structures created (with hierarchical, ordinal, embedded, and faceted relationships).

Layer	Definition
1. Physical	Is concerned with the transmission of unstructured bit stream over physical link; involves such parameters as signal voltage swing and bit duration; deals with the mechanical, electrical, and procedural characteristics to establish, maintain, and deactivate the physical link.
2. Data link	Provides for the reliable transfer of data across the physical link; sends blocks of data (frames) with the necessary synchronization, error control, and flow control
3. Network	Provides upper layers with the independence from the data-transmission and switching technologies used to connect systems; is responsible for establishing, maintaining, and terminating connections across networks.
4. Transport	Provides reliable, transparent transfer of data between end points; provides end-to-end error recovery and flow control.
5. Session	Provides the control structure for communication between applications; establishes, manages, and terminates connections (sessions) between cooperating applications.
6. Presentation	Performs generally useful transformations on data to provide a standardized application interface and common communications services; examples include encryption, text compression, reformatting.
7. Application	Provides services to the users of the OSI environment; examples include transaction server, file-transfer protocol, network management.

Table 1: The OSI Layers (Source: Stallings (1993, p. 25-26)

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THE OPEN SYSTEMS INTERCONNECTION

As a third example of a standard as a classification scheme, let us investigate the ISO Open Systems Interconnection (OSI) Basic Reference Model (ISO 7498, 1984) OSI is intended to act as a model to facilitate the development of standards that can enable disparate computers to communicate (i.e.,

1. Do not create so many layers as to make the system engineering task of describing and integrating the layers more difficult than necessary.
2. Create a boundary at a point where the description of services can be small and the number of interactions across the boundary are minimized.
3. Create separate layers to handle functions that are manifestly different in the process performed or the technology involved.
4. Collect similar functions into the same layer.
5. Select boundaries at a point which past experience has demonstrated to be successful.
6. Create a layer of easily localized functions so that the layer could be totally redesigned and its protocols changed in a major way to take advantage of new advances in architecture, hardware or software technology without changing the services expected from and provided to the adjacent layers.
7. Create a boundary where it may be useful at some point in time to have the corresponding interface standardized.
8. Create a layer where there is need for a different level of abstraction in the handling of data, for example, morphology, syntax, semantic.
9. Allow changes of functions or protocols to be made within a layer without affecting other layers.
10. Create for each layer boundaries with its upper and lower layer only.
Similar principles have been applied to sublayering:
11. Create further subgrouping and organization of functions to form sublayers within a layer in cases where distinct communication services need it.
12. Create, where needed, two or more sublayers with a common, and therefore, minimal functionality to allow interface operation with adjacent layers.
13. Allow by-passing sublayers.

Table 2: Principles Used in Defining the OSI Layers (Source: Stallings (1993, p. 25) citing ISO 7498)

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transmit data). It consists of specifications for seven hierarchically related layers of functionality necessary to accomplish that communication. (See Table 1 for details on the layers) Each layer is dependent on the layers below it for providing the prerequisite functionality for the functionality defined for the layer itself. Therefore an important part of the OSI model is the specification of the functionality at each layer. Each layer is related to its adjacent layers by the services which it provides to those layers.[1] Standards developers work within a particular layer creating individual standards which provide the functionality specified for the layer and which can provide the necessary services to adjacent layers.

These layers might be considered "classes" in a classification scheme. Each class has its own set of characteristics (functions and services). There are some functions which occur in several of the layers, most notably, management functions (Harris, 1990). However, OSI considers management functions to be outside the 7 layers; one way to depict the management functions is as a separate class which is related (not in a hierarchical fashion) to some of the other layers. The concepts of function and service (as well as some other features) are consistent across the layers. Functions and services might therefore be considered facets of the classes.

OSI looks very much like a classification scheme. It organizes a domain (the functionality necessary for computer communication) into a number of mutually exclusive and exhaustive classes (the layers) which have function and service facets and which are related in a hierarchical fashion. Additional support for the idea of OSI as a classification scheme comes from the principles used in defining OSI (Table 2). The principles essentially specify that OSI should have the features of a good classification scheme as discussed earlier. The layers should be chosen to minimize overlap and facilitate the unique placement of functions (principles 3, 4). The layers should be related, in this case, hierarchically (principle 10). Finally, the layering should be done so as to facilitate the task at hand: the creation of individual standards to handle computer communication (principles 1, 5, 7).

HUMAN-COMPUTER INTERACTION STANDARDS

The final standard to be discussed in this paper is ISO 9241: Ergonomic Requirements for Office Work with Visual Display Terminals. The domain of this standard is the set of components of a computer system which have an ergonomic impact. This includes hardware, software, task design and the physical environment (Billingsley, 1993). ISO 9241 attempts to partition ergonomic concerns into several areas. At the highest level these are the task and environment, hardware, and software concerns (see Table 3 for the parts of ISO 9241). In these 3 areas, the standard further breaks down the domain into subparts. Within these subparts are a set of guidelines which should be followed when designing for that part of the ergonomic environment. The standard represents a simple hierarchical classification scheme.

1. An analogy to clarify the distinction between functions and services might be that of a series of ponds connected by streams. Each pond has a particular task to accomplish, such as filtering the water (i.e., the functions of the pond). The service component would specify that this pond was to send water (of a particular level of purity) to the next pond. Therefore, the next pond doesn't need to have awareness of what the upstream pond did, it only is aware of the output of that pond. In OSI, information about layer functionality doesn't have to be transmitted; what is important are the services (i.e., messages) which a layer can receive and transmit.

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INTRODUCTION

1. General introduction

TASK AND ENVIRONMENT

2. Guidance and task requirements
5. Workstation layouts and postural requirements
6. Environmental requirements

HARDWARE ERGONOMICS

3. Visual display requirements
4. Keyboard requirements
7. Display requirements with reflections
8. Requirements for displayed colors
9. Requirements for non-keyboard input devices

SOFTWARE ERGONOMICS

10. Dialogue principles
11. Usability statements, dialogues
12. Presentation of information
13. User guidance
14. Menu dialogues
15. Command dialogues
16. Direct manipulation dialogues
17. Form filling
18. Question and answer dialogues
19. Natural language dialogues

Table 3: ISO 9241 Parts
(Source: Abernethy (1993), p.12-13)

What is interesting about ISO 9241 it not that it resembles a classification scheme, but that is represents an example where the classification does not seem to be successful. Authors such as Billingsley (1993), Brown (1993), and Abernethy (1993) all point to flaws in the standard. While some problems are logistical, all three authors point to the lack of a good conceptual or scientific basis for the partitioning of the domain. We don't understand the interactions between the components as defined by ISO 9241 which might impact the actual human-computer interaction. Brown writes "the scientific evidence on which to base standards is often not readily available" (p.5). Billingsley goes further in suggesting that the classification structure itself is to blame. "The separation of software design requirements into independent parts of the ISO 9241 standard further compounds the problem" (p. 24) because it is probably the combined impact of all design decisions which will affect the ergonomics of a product.

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Let us consider for a moment how an explicit consideration of classification principles might have altered the ISO 9241 development process and the resultant standard. We would begin with a definition of the domain to which the standard applied. The comments of the above authors suggest that a reconsideration of the domain might have been appropriate. Another possible way to define a domain might be to consider the components of human-computer interaction in the context of a particular task (e.g., word processing). The standard as it currently exists may have a domain that is too broad to be successfully described in a classification scheme since different tasks may involve different ergonomic requirements, with the result that we are unable to create classes which facilitate the unique placement of an ergonomic requirement. Within a given task domain, it would be possible (probably through an investigation both of hardware and software functionality as well as user behavior) to understand how to partition that environment into classes which facilitate the development of products which meet the ergonomic specifications. Once a number of individual task environments had been classified, it might be possible to find commonalities among the ergonomic requirements for various tasks which would lead to their being grouped into broader classes. (See Figure 6 for a hypothetical grouping). What we might gain from this approach is a set of ergonomic principles that are holistically related (thereby resolving the problems described above) as well as an understanding of the larger environment in which computer based activities occur.[1]

Another approach might be to retain the same definition of domain (i.e., computer activities which have an ergonomic dimension) but to reconsider the classes utilized. Instead of hardware, software and environment, we might begin with classes associated with particular tasks. This would result in a structure similar to that depicted in Figure 6. These two examples are not intended to suggest that these approaches would have "fixed" the standard but are intended to indicate that an attention to classificatory principles might significantly change individual standards.

This preliminary examination has suggested that the intellectual processes associated with classification might either be identical to those used in some standardization processes (there is no empirical work looking at these processes) or might be usefully transported to the standards development domain where there is a significant concern in improving the process by which standards are developed (see for example Spring, et al., 1994). The 4 standards examined all exhibit some features of classification schemes.

In fact, this preliminary investigation may be doing an injustice to the intricacy of the schemes developed. Standards seem to utilize a number of relationships in conjunction with one another. These may be hierarchies with embedded ordinal units which also contain faceted elements or other complex structures of relationships. The types of classes and facets which are necessary, while no different in purpose from ones with which we in library and information science are familiar, at first glance seem strikingly different in character, including such things as functionality, services, guidelines. The richness of standards as classification schemes can be mined much deeper.

1. This understanding would be useful in a number of ways including the development of software and hardware that would be portable across related task domains and the ability to begin to understand what components of training processes might be transferred to other tasks.

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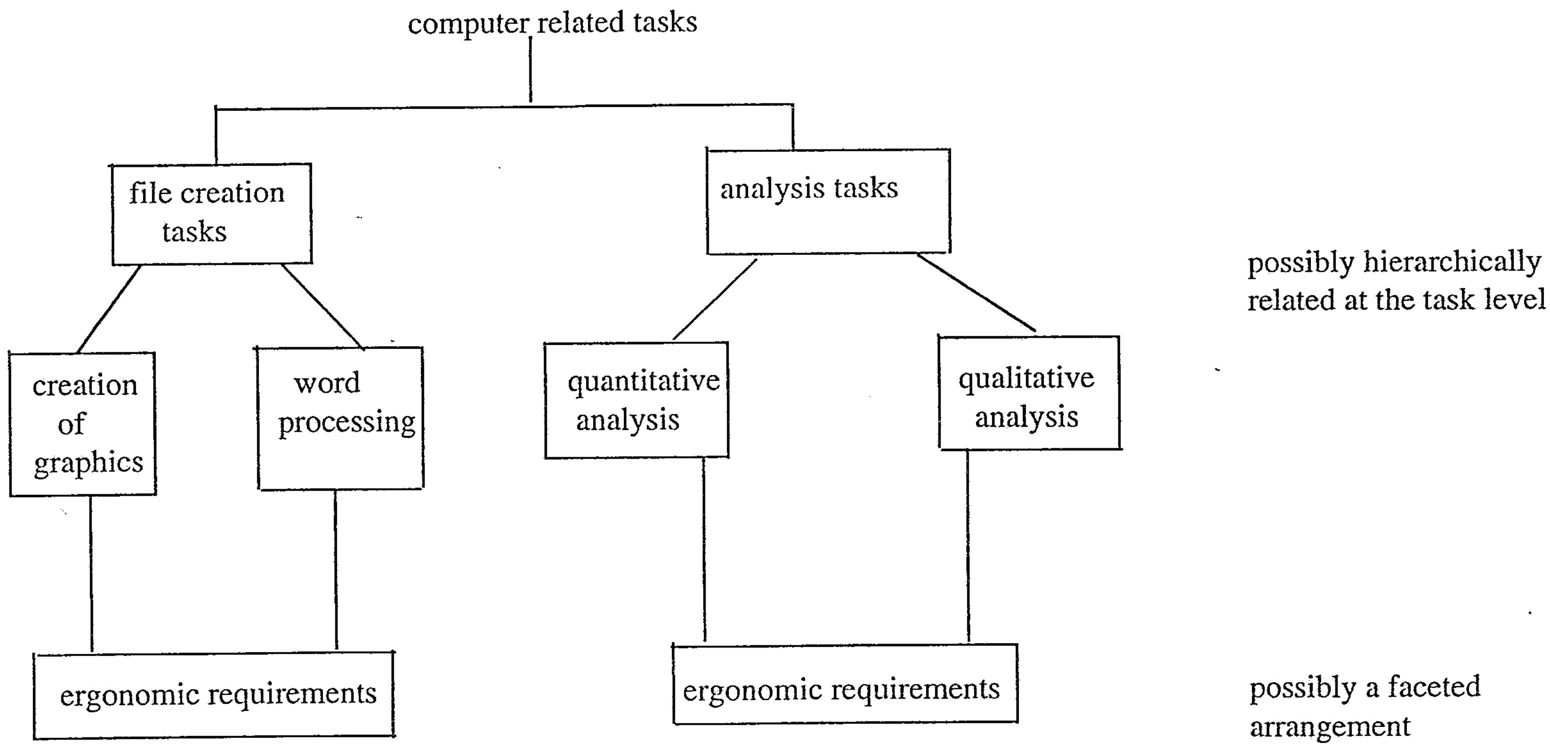
FIGURE 6
HYPOTHETICAL PARTITIONING BY TASK



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FURTHER RESEARCH

There are number of areas in which empirical work might be done to further explore the ideas presented in this paper. One obvious path is to text the hypothesis that standardization is a classification process by collecting empirical data on the standards development process itself. While there has been some empirical work (see Spring et al., 1994), it has tended to focus on the logistical components of the process (suggesting, for example, the use of electronic mail to communicate) rather than the intellectual components. Examination of the process itself would yield insights into the intellectual activities of standardization which could then be compared to those of classification.

Another avenue is to examine additional standards in an effort to understand when a classification scheme is an appropriate model for a standard. As mentioned earlier in the paper, there are a number of ways to classify standards. This paper started with what seemed to be the most logical approach for the purpose at hand. It could be, however, that as further standards are examined the mapping of standards as classification schemes versus those that don't seem to classification schemes might be better fitted to one of the other ways to organize standards. It might also be the mechanism by which an additional classification of standards can be developed. The example of ISO 9241 also suggests that poor classification may have a detrimental impact on the utility of the standard. Further and more detailed analysis of the structure of individual standards might lead to insights about the role of classification in influencing the success of those standards.

A third research area relates to determining the utility of the comparison if it is borne out by further research as outlined above. I have suggested three possible utilizations: 1) by standards developers to facilitate the development process, 2) by students who might use the classification metaphor to build an understanding of standardization, and 3) by classification theorists who might find standardization a fruitful domain for their research. We might test the utility in several different ways. It might be possible to provide some training in classification to standards developers to see whether that improves (the definition of which remains open) the process or the developers' perceptions. The same method might apply to the students. My experience in teaching standards is that the comparison resonates for those students who have previously taken a course in cataloging and classification. Classification theorists, such as this audience, can best determine whether this idea stimulates them to include standardization within their purview.

CONCLUSION

This paper has presented a preliminary exploration of standardization as a classification process. Through a comparison of the definitions and an examination of several standards it was suggested that a classification process may be operating in standardization or might be a useful model for the development of some standards. Further exploration would enable us to test the validity of this relationship and then exploit it to improve the standards development process, the teaching of standardization, and perhaps open new areas of investigation for classification theorists.

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