The Limits of User Consultation in Database Design

La Structuration de Banques de Données: Les Cas Limites de la Collaboration Entre l'Informaticien et l'Utilisateur†

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ABSTRACT

Both traditional database methodologies and human-computer interaction methodologies stress the importance of user consultation in database design, but fail to identify the limits of this process. The limitations of user consultation are especially important when unusual or novel database systems are being contemplated. We explore these limitations in the context of two case studies, and discuss the nature of design for information systems in general.

Les méthodologies actuelles pour la création de banques de données soulignent l'importance de la collaboration entre le créateur informaticien et l'utilisateur. Mais rien dans ces approches n'indique les limites pratiques de ce processus de collaboration. Ces limites s'avèrent très significatives quand on veut élaborer une banque de données tant soit peu innovatrice. Nous examinons ces limites à la lumière de deux de nos propres projets, et nous analysons les principes de base de l'architecture de systèmes d'information.

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1. Introduction.

It is now axiomatic that the proper design of databases and other information facilities should be based on consultations with the eventual users of the system (Albano *et al.*, 1985). The argument for this approach is simple and natural: users have identifiable needs, problems, constraints, and domain knowledge which should exert a large effect on the design, but which is typically unavailable to designers except through user consultation. Systems whose design does not involve the users run the risk of being rejected by them (Maldé, 1986). Many procedures have been developed by researchers in human-computer interaction which can aid designers in user consultation; these include surveys, comparative tests, formal and informal experiments, and user evaluation of rapidly constructed prototypes. While much of interaction research is concerned with comparisons and evaluations of specific systems, there is a growing realization that the study of the user can also lead to new design approaches (Landauer, 1986; Furnas *et al.* 1987).

The injunction to "know thy user" is a worthy one, but in practice requires elaboration. Knowing the user requires first identifying the user, often a non-trivial task in itself. If the users can be identified, then specific problem areas must be defined and appropriate consultation techniques devised to address these issues. The consultation techniques may be limited by users' indifference to the design process or their inability to provide useful feedback except as subjects in an experimental context. Finally, practical issues often limit the amount and type of consultation, or even dictate large parts of the design by organizational fiat.

We have been most interested in the process of user consultation as it applies to the design of databases and information retrieval systems. Traditional databases, such as the ubiquitous *students-course-prof* examples of introductory textbooks, are typically designed by following established methodologies such as those described by Gillenson (Gillenson, 1988). Such methodologies generally promote the determination of user requirements as the first step in database design. However, the components of traditional database design — entities, attributes, keys, relationships — skew consultation so that it often becomes a process of identifying traditional components, rather than an attempt to grasp the fundamental characteristics of the user's situation. Traditional

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components are more rigid and inflexible than real situations, where the boundary between entities may be uncertain or dynamically determined. Furthermore, the representation of associations as relationships or attributes is often arbitrary (Kent, 1981). Finally, the generality of traditional database components extends only to those systems which have similar constraints to commercial applications i.e., records with short fields, stable entities over time, and specific models of concurrency (Härder, Reuter, 1984).

Over the past several years we have had occasion to observe the efficacy of user consultation for the design of non-standard databases such as videotex and electronic dictionaries. Since traditional database design methodologies are difficult to apply in non-standard database design, effective user consultation would seem to be of even greater importance. For the systems we have constructed, an additional reason for involving users is the need to develop significant market interest. Even so, there are some limits to the user consultation process. We explore our experiences in more detail in the next two sections.

2. Case study 1 — videotex databases.

Videotex is an attempt to provide low-cost access to public databases through the use of existing technology including telephone lines and home television (Gecsei, 1982). Videotex systems are typically characterized by centralization of information, heterogeneous data in a homogeneous structure, data collected in small units known as pages, simple menu or keyword-based query facilities, and an emphasis on graphical and iconic information. The most common videotex data structure is hierarchical. Users query the database by repeatedly selecting from menus positioned at the nodes of the hierarchy; alternatively, if keywords are provided, users can move directly to distinguished nodes of the hierarchy.

The menu-hierarchy design was based on hunches about the likely users of videotex and the kind of system they were capable of operating. These hunches were in turn derived from the dominant theme of videotex, which is reduced cost through high volume. The emphasis on volume meant that the most salient characteristic of the perceived user community was its size: the larger the group of users that videotex could embrace, the better could costs be amortized and hence the more successful would videotex be. Size suggested heterogeneity and the need to design for the lowest common denominator in terms of user knowledge and skill (Raymond, Dec. 1986). Furthermore, size meant a diversity of data, much of which would be unschematizable (Tompa, 1981); as a result, traditional database structures would not be applicable.

Videotex in North America was not in general successful. It might be argued that this was in part due to design based on hunches rather proper user consultation, though it would then be difficult to explain the relative success of videotex in Europe. Whether or not this argument is valid, consultation is clearly more difficult when the user group is so loosely defined. Nevertheless, extensive research involving user consultation has been conducted on problems directly related to the design of videotex databases.

Two approaches can be discerned in research relevant to the design of videotex databases. The first is formal evaluation of specific defects in menu-hierarchies. The implicit assumption of this approach is that the menu-hierarchy is an appropriate database design which can be significantly improved by tuning various parameters for optimum performance. Three key defects that were studied were user disorientation during navigation, optimum arrangement of the hierarchy (the "depth/breadth problem"), and labelling and structure of menus. Research efforts in this area were by no means insignificant; a recent survey covers eighty papers (Raymond, Nov. 1986).

The goal of evaluation research was to test design rules of the form "menus should have between three and seven items", or "menus should be structured alphabetically rather than by category", or "maps can keep users oriented". Though evaluation research provided a large number of interesting experiments and anecdotal results, there are numerous problems in applying it to realistic situations. For example, many of the studies involved small hierarchies with little or no semantic content, and hence differed significantly from the average videotex database. If consistent design rules had emerged from these studies, designers would be more confident about extrapolating the results to real videotex systems; however, the results were often contradictory or confusing. For example, no clear rules could be drawn from fourteen studies of the ‘‘depth/breadth’’ problem; some suggested that a moderate number of items per menu was optimal; others suggested that a large number of items per menu was optimal; some suggested that for certain problems the number was immaterial. In order to extract information from these studies, designers must indulge in comparative evaluation of experimental technique and the various definitions of ‘‘optimality’’ chosen by researchers. No simple methods exist for making such comparisons.

We chose a different tack in our videotex research, focusing on novel data structures and query methods for videotex systems. These efforts included experiments with multiple hierarchies (Schabas, Tompa, 1983), the design of systems for personalization of data structures (Raymond, 1984; Tanguay, 1986), experiments with the use of Venn diagrams for boolean keyword querying (Böggild, 1986), experiments with a desktop metaphor for personal data structures (Raymond *et al.*, 1986), and the design of a hypergraph model for page-oriented databases (Tompa, 1987). The implicit assumption of this approach was that the menu-hierarchy is fundamentally limited, and hence significant improvements can only be achieved by replacing menus, the hierarchy, or both. Accordingly, we attempted to expand the number of options available to the database designer, and develop a theory of their characteristics.

Our research generally supported the notion that average users could make effective use of more advanced structures. Though some interesting designs were developed and tested, they did not lend themselves to immediate application in commercial videotex systems because of the necessary investment for system redesign. Furthermore, comparing the new designs to existing ones is difficult because they differ not only in the means of performing tasks, but in the tasks of which they are capable. Again, designers are reduced to judging the relevance of a number of competing approaches to a specific design situation.

Judging the effectiveness of these research approaches is difficult, since the success of videotex was largely determined by factors other than database design (Raymond, Dec. 1986). Both approaches were founded on a sincere desire to make the user the focus of the system, but both suffered in terms of translating user consultations to real designs. The evaluative approach is more sensitive to inaccuracy in the definition of the user community. If the user sample is not representative of the community, then the optimization may be flawed. More importantly, if a highly diverse user group is involved, then optimization may be impossible, because the concept of an ‘‘average user’’ is invalid.

User consultation works best for a fixed, identifiable user group with specific, expressed needs. Consultation has its greatest effect when the user community exhibits a homogeneity of information requirements which can be exploited to gain leverage in information structuring or retrieval. Commercial databases are effective because they support a small set of views on commercial data that satisfy the majority of required transactions. The videotex user community was neither fixed, nor identifiable, nor did they have specific needs. In fact, videotex service providers were indifferent to most characteristics of their user community other than its size; they preferred to offer generic database services. Instead of designing a system to support a specific group’s activity, the most common process was to identify a perceived information need that might be met with existing technology, and then attempt to fulfill it. This process has been described as ‘‘putting the cart before the horse’’, or ‘‘a solution in search of a problem’’; in our terms, it is using the requirements to define the user community. Such a process significantly erodes the value of user consultation.

3. Case study 2 — the Oxford English Dictionary.

The computerization of the Oxford English Dictionary is our current project. The OED is the largest and most scholarly dictionary of written English, requiring more than 400 megabytes for the 1928 edition alone, not including the more recent Supplement. The OED is being computerized to support typesetting, to improve the editing and updating process, and to enable users to search and make extractions of the content of the dictionary.

The OED is a highly structured document. Each entry in the dictionary consists of a number of parts, including the main form of a word, its part of speech, pronunciation, etymology, a list of variant forms, and a set of senses or meanings for the word. The senses of an entry are numbered and may be nested; each contains a short definition and usually a set of illustrative quotations. Some complex entries have hundreds of senses and thousands of quotations. Entries often contain lists of combinations, which are also usually accompanied by quotations; entries may also contain editorial notes, tables, chemical formulae, and other types of information. Entries vary in size from ten characters to almost half a megabyte.

In designing a database for the OED (a process which continues to this day), the basic issues point directly to user consultation: who uses this data? how do they use it? how would they like to use it? Serious efforts have been made to involve users both before and during the design process. These efforts included lengthy consultations with editors and lexicographers at Oxford University Press (Tompa, 1985; Raymond, Warburton, 1986), attempts to model both dictionary and real-world entities using the entity-relationship approach (Tompa, 1987; Tompa, Blakeley 1984), an extensive worldwide user survey conducted jointly by Oxford University Press and the University of Waterloo (Benbow *et al.*, 1987), and the creation of a special fellowship to encourage extended visits from scholars in computing and the humanities. These efforts have certainly added to our knowledge of the dictionary and have influenced the design of the database.

The problems of determining the user community for the electronic OED bear some resemblance to that of videotex. Though a community of OED users does exist, they will certainly not be the only (or even the major) users of the electronic OED. Several of our survey respondents noted that they saw little or no reason to employ an electronic database that provided the facilities we envisaged. We have learned that the community which knows about the OED is much larger than the community which actually uses the OED on a daily or weekly basis. Furthermore, our visiting fellows consist largely of people who do not use the OED in its printed form. The relative impenetrability of the print version, its cost, the need to consult two books (Supplement and 1928 edition), and other factors have resulted in a select group of users for the printed book. As these constraints are removed, the user group broadens.

One important result of consultation is the realization that the electronic OED should not be reduced to a database of facts about English. It is necessary to retain not only the content of the OED, but also its current form and organization. Though the basic structure of the OED can be expressed very simply, deep understanding requires intimate familiarity with its numerous exceptions. This familiarity is of importance when posing any but the simplest queries. For example, a user might be interested in obtaining a list of Biblical citations in the OED. More than half of the existing citations would be missed if the user was unaware of the twenty different versions of the Bible cited in the OED, some with the author identified as “Bible”, some with the work identified as “Bible”, and some — like most citations from the Wyclif and the Coverdale — without the string “Bible” anywhere in the content of the quotation. Traditional database design methods might regularize these “inconsistencies” in order to simplify querying. However, we have learned that exceptions, inconsistencies, and even errors carry information that is significant to scholars who wish to interpret the OED with historical accuracy. In addition to being a source of citations and information about English, the OED is itself an artifact about which much information must be made accessible if users are to query the OED effectively.

Our user consultations have proved less satisfactory in clarifying the specific types of access and update that should be provided for the electronic OED. The OED's lexicographers can tell us a great deal about the design of the current manual system, but it is difficult for them to give us more than a general idea of their requirements for an electronic system. Similarly, end users can tell us how the currently employ the dictionary, but their vision of future uses is limited. Both lexicographers and users frame their requirements in terms of database systems and approaches with which they are familiar. They emphasize automation of the most tedious parts of their existing task, rather than projecting into advanced uses. Most importantly, they tend to think of approaches which do not require restructuring of their working methods. Yet the greatest scope for the electronic OED is in uses which have not been previously contemplated. A successful database design must take such possibilities into account.

Several of our significant ideas for database and query languages have evolved not from a study of user requirements, but instead from intuition or extrapolation from other environments and tasks. For example, we are currently investigating the use of grammars to define database schemas (Gonnet, Tompa, 1987); this notion arose from extensive experience in building a parser to check the text. Another example is found in the ability of our text searching program PAT to identify the relative frequency of strings with specified prefixes. This capability arose because the data structure naturally supported it, not because it was requested by the users or because we knew in advance that such a facility was desirable. This facility is extremely useful for finding repeated citations, for creating lists of the most frequently cited authors or works, for determining the distribution of quotations by date, and other types of frequency-related information. A third example is the notion of using graphs of statistical data about the OED as a query language (Raymond, Nov. 1987). This idea was the accidental result of having plotted certain interesting data about the OED, and then observing the need to learn more about entries corresponding to specific regions of the plot. We believe that it is unlikely that user consultation could result in the specification or even vague suggestion of facilities such as we have developed. In each case the facility was conceived and built before its full power was clearly understood.

4. Conclusions.

> ...conventional design wisdom [says] if only we knew what they wanted, we could do it. (Caplan, 1982, 24)

The goal of traditional database design is a measured, top-down approach that moves gracefully from user requirements to finished software product. Our experiences with videotex and the OED suggest that this is not always a reasonable goal. As in the case of videotex, the user group may be poorly defined, and the consultation process may provide conflicting results. As in the case of the OED, the users may think that computerization can provide an answer, but are unaware that its most powerful influence is to change the question. For at least these two case studies, it is not users who determine design, but *design which determines the users*. The design of a videotex system or an electronic dictionary defines those who are capable, willing, and interested to use it.

> What affects us so strongly when we see an MG or a beautifully balanced knife is that someone has pleased us by making what we wanted and never knew we wanted. (Caplan, 1982, 25)

Some requirements can be determined by consulting the user, but others are unstated and often unknown. Such requirements are often best addressed through the artistic component of design. Brownowski describes the triangle of design constraints: the processes of design, the materials of construction, and the uses of the product. (Bronowski 1978). The "fallacy of the iron tower" is the contention that the area within this triangle — the freedom of the designer — can be shrunk to a single point. That this cannot be done is evidence of the limits of user consultation in database design.

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