PUTTING THE HUMAN FACTOR INTO SYSTEMS DEVELOPMENT

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Abstract: As the community of computer users expands beyond experienced professionals to encompass novice users with little technical training, human factors considerations must play a larger role. "Computer shock" and "terminal terror" cannot be cured, they must be prevented by more careful human engineering during the system design phase. This paper offers four approaches to including human factors considerations during system design. These approaches focus on increasing user involvement and emphasize extensive pilot testing. Human factors cannot be added as refinements to a completed design; they must be a central concern during the initial requirements analysis and through every design stage.

Introduction

Every project manager, system designer, and programmer/analyst wants to build "quality" into their system. The traditional attributes of quality have been high reliability, ease of maintenance, correctness, on-time delivery, good cost effectiveness, and efficient use of hardware resources. In recent years, there has been a growing recognition that human factors considerations are an important component of quality.

Everyone in the computer community has become aware of the importance of ease of use, user friendliness, simplicity, flexibility, and elegance in the design of interactive information and computer systems. Unfortunately, we are only beginning to measure these vague qualities and to ensure that they emerge during the system development process.

There is no foolproof path to quality human engineering in interactive systems, but these four related approaches may be useful:

- Create like an inspired inventor
- Think like a clever scientist

- Manage like a shrewd executive
- Test like an energetic astronaut.

It goes without saying that you also need the loving care of a parent, the wisdom of a prophet, the coordination of a symphony conductor, and the imagination of an artist, but these skills are beyond the scope of this paper.

Create like an inspired inventor

The absence of firm guidelines for interactive systems design presents a challenge and a grand opportunity for dramatic new ideas. The successful designer will not be content with the first set of commands that come to mind, but will explore a wide variety of approaches. Why stick to command languages with complex syntactic forms which are hard to learn and remember. Why not try menu selection, graphic displays, form-fill-in, cursor movement, touch panels, voice input/output, joysticks, or dual displays (Martin, 1973; Mehlmann, 1981). When you try to find six ways of providing the necessary functionality, you begin to understand your problem better and may come up with multiple front ends to satisfy different user communities. If you have many ways of solving a problem then you can begin to consider what the attributes of a good solution are. In any case, the process of brainstorming can provide clearer insights.

But just dreaming up multiple ideas is not enough. Thomas Edison stressed that invention is 1% inspiration and 99% perspiration. To put yourself in the position where you can create six alternative designs, you must do a great deal of background work to understand the problem. Interviewing users, writing requirements, consulting with management, and learning about previous efforts in this application domain are necessary precursors for the creative act.

Once you come up with the half dozen approaches, much work remains to be done in filling out the details and following through to deal with negative side effects of a clever design. Edison had working light bulbs for many years before he found the right combination of materials to make a bright and durable bulb.

Think like a clever scientist

Interactive systems designers are increasingly aware of the value of thinking like an experimental scientist.

The reductionist approach of scientific research requires that individual issues be treated first, before examining more complex interactions. A good scientist will consider independent variables that can be changed, separately from dependent variables that are to be measured.

For example, in designing and interactive system a crucial independent variable may be the display rate, which might have several possible levels - 30, 60, or 120 characters per second. A good designer will evaluate the impact of the independent variable levels on the dependent variables, which might be human performance time, user error rates, and user satisfaction. Performance time and error rates are relatively easy to measure and user satisfaction can be assessed by questionnaires (Norman and Anderson, 1981).

The competent designer can informally consider how certain user groups (novice users, infrequent knowledgeable users, and frequent users) and tasks (menu selection, command language, text editing display, or fill-in-the-blanks) might be effected by differing display rates. For frequent users of menu selection higher display rates are more important than for novice users of fill-in-the-blanks. If there is a high volume of information displayed then higher display rates will speed task performance and probably increase user satisfaction, but a slower rate may reduce errors. Of course, the designer has to consider the interaction of the display rate variable with response time delays and hardcopy vs. softcopy devices. It's not simple, but the methodical thought processes of the experimental scientist can provide worthwhile insights and relatively low cost in time and resources (Shneiderman, 1980).

Manage like a shrewd executive

Designing a sophisticated interactive system requires the coordination of many people's efforts. Successful designers know that an interactive system may change the job requirements for clerical workers and managers. When administrators have immediate access to detailed performance information, the role of middle level managers changes. When clerical staff can make decisions based on complete up-to-date information, the role of team leaders changes.

Because of these basic upheavals, personnel at all levels must be interviewed and kept informed about progress in the design of an information system. Igersheim (1976) demonstrated by survey that user involvement in the design process is a powerful correlate of success. User involvement not only leads to better design, but creates an atmosphere of interest and enthusiasm for the interactive system (Bjorn-Andersen, 1980).

A second key management point is that project development milestones are useful in focusing attention on the development process. User representatives and management should be called upon to review and sign-off on the requirements, the specifications, the final design, and several implementation stages. These milestones give participants an opportunity to note progress and express concerns, thus furthering the goal of increasing user involvement.

The third management strategy should be to have evaluation mechanisms such as pilot studies early in the design phase and acceptance tests later in the implementation phase. A pilot study might involve typewritten or handdrawn versions of the screen displays to test comprehensibility. A pilot study can be done informally with two or three representative users or more elaborately with an on-screen mock-up involving dozens of trained subjects. Data collection can range from informal comments with stopwatch timing to extensive problem solving situations with computerized collection of performance times and error rates. Informal anecdotal information and subjective questionnaires are also valuable.

Acceptance tests should be more rigorous. For example, the following criteria might be applied to in-house development projects or to software development contracts:

> An acceptance test with _____ typical users must be conducted with the enclosed benchmark set of tasks. After _____ minutes of training, these users must successfully accomplish _____ percent of these tasks within _____ minutes.

More elaborate acceptance criteria would be necessary for many systems which serve diverse classes of users or require extensive training time. The presence of such an acceptance criteria would compel the design team to think very carefully about the human factors issues and would naturally stimulate multiple early pilot studies.

Pilot tests among alternative designs and rigorous acceptance criteria are the norm in industrial design of consumer goods, aircraft, or automobiles, and in architecture.

Test like an energetic astronaut

Critical testing of components and the complete system are the key to success in any design process. Each component of the interactive system is a candidate for testing, from the type font of the characters, to the keyboard arrangement, to the task sequencing, and to the physical environment (Embley and Nagy, 1981). Every system message, every menu selection frame, every screen display format, every cursor movement technique, and every on-line tutorial should be tested. This level of thoroughness is required to produce a high quality system. Not every test has to involve dozens of subjects or days of effort. Some issues such as type font choice or system message wording (Shneiderman, 1981) can be tested in a few minutes with a small number of subjects. Critical issues such as task sequencing, command language syntax, query language styles (Reisner, 1977), or on-line tutorial aids (Relles, 1979) may require many more subjects and several days of testing. Good designers assume every component will be tested, but they must exercise their judgment of how much effort to expend on testing each component.

Good design and thorough testing can take substantial time and resources during the design phase, but the savings during the implementation phase and the system lifetime more than pay for the higher initial costs. A well-designed system is easier and faster to implement and leads to higher user performance after installation. Faster task performance, lower error rates, and higher user satisfaction should be paramount in the designer's mind. Reducing testing to speed the design phase is a poor economy. If commercial aircraft manufacturers are willing to spend great effort in testing wind-tunnel models and in building full-scale mock-ups, then interactive system designers should be willing to test alternate screen displays of keyboard layouts. If NASA is willing to spend $70 million for a shuttle simulator, then interactive systems project managers should be willing to build prototype versions for testing.

Conclusions

The human factors aspects of contemporary interactive systems can be substantially improved. While academic and industrial researchers pursue basic guidelines and fundamental theories, system developers can improve their designs by focusing greater attention on the human factors issues. Just talking about human factors is not enough, some individual or team must be assigned the responsibility for the human interface design and be given the resources to carry out their work. Collaboration with human factors professionals or experimental psychologists can be useful, but these consultants must be brought into the project at the earliest possible stage. It is not possible to add the human factors to a system after the basic design is complete.

Eventually, every system design professional will have training in human factors and experimental methods. Eventually, it will be considered normal to carry out numerous design and pilot studies. When that day arrives, interactive systems will more effectively serve, rather than frustrate users. Novices will look forward to using computers, frequent users will see the computer as a powerful tool which aids them in doing a day's work, and system designers will feel proud of their contribution.

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