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HUMAN FACTORS AND USABILITY - WHENCE AND WHITHER?

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INTRODUCTION

In this paper I aim to present a broad perspective of the brief history, the current situation and some of the issues for the near future. Inevitably much will be omitted, but the referenced papers fill many of the gaps. Although aspects of research and human factors knowledge will be prominent, rather more attention will be given to applied problems and design for usability.

WHENCE?

Historical overviews and full literature reviews have been written by Ramsey & Atwood (1979), Shackel (1979) and Gaines (1984), while useful reference lists are given in Shackel (1984) and Burch (1984). The emphasis here will be upon trends and implications.

At the beginning of the digital computer era, the designers of computers were specialists and the users of computers had to become computer specialists. The potential power of this new machine and the speed of computation was so useful for certain scientific disciplines that some scientists found it worth the cost of time and effort to learn how to use it.

In the late 1950's the potential for the computer in industry and commerce was recognised, and the first serious business machines were developed; again, they were designed by computer specialists for use by data processing professionals. From the early 1970's the mini-computer and remote terminal access to the time-sharing mainframe brought computer usage nearer to the layman. However, already the difficulties for the non-specialist and the problems of human-computer interaction were recognised (Shackel 1969, Nickerson 1969, Sackman 1970).

The advent of the micro-computer, in widespread use from 1980, has already caused great growth in the use of computing for many different purposes by non-specialists of all types - from bank clerk to business executive, from librarian to life insurance salesmen and from secretary to stockbroker and space traveller. This widespread growth in non-specialist users has led to even wider recognition in the computer industry of the growing problems in human-computer interaction. If the design of the hardware or software or instructions or operating manuals is too complicated, then the potential new user, who is a 'discretionary user' (Bennett 1979), will not buy or will be disenchanted and not use this new tool.

This rapid growth in computing, leading to the widespread recognition of usability problems is summarised in Figure 1.

Computer type	Approx growth era	Main Users	Issues
Research machines	1950s	Mathematicians Scientists	Size, reliability, users must learn to do every bit of programming
Mainframes	1960s & 1970s	Data-processing professionals supplying a service	Users of the output (business managers) grow disenchanted with delays, costs, lack of flexibility
Minicomputers	1970s	Engineering and other non-computer professionals	Users must still do much programming; usability becomes a problem
Microcomputers (plus applications packages)	1980s	Almost anyone	Therefore usability is the major problem

Figure 1. Growth of digital computers and user issues

From the increase in power and reduction in size and cost of computers has come the great growth and diversity of applications. Recently the convergence of computing with communication facilities has fuelled this growth and diversity, under the embracing title of Information Technology (IT). National and international research and development (R&D) programmes have been established with considerable funding - eg the UK Alvey Programme (Alvey, 1982) and the European Strategic Programme for R & D in Information Technology (ESPRIT). These programmes, and the equivalent work in Japan and the USA, have all placed considerable emphasis upon human-computer interaction and the 'man-machine interface'.

The reason is self-evident from the fact that few if any IT applications involve computer specialists as the users - see Figure 2. While some IT users may well develop considerable expertise because they use the IT tool for perhaps half of each day (such as word-processing secretaries, designers using CAD, etc), others will only use several of the tools intermittently and will never become expert users. Above all, none will be computer-specialists, able to understand its internal intricacies and therefore perhaps more willing to tolerate inconsistencies and other difficulties.

Mainly 'Expert' Users (eg secretaries, designers, librarians)	Mainly 'Non-Expert' Users (eg managers, students, the public)
word-processing	simple word-processing
general accounting	electronic spreadsheet
computer-aided design	simple graphics
computer-aided teaching	computer-aided learning
library systems	viewdata/Prestel
on-line bibliographic search	teleshopping
	telebanking
	electronic funds transfer
	electronic mail
	computer teleconferencing
	electronic journals

Figure 2. Some IT applications involving extensive human-computer interaction. None of the users are computer-specialists, so usability is the major problem.

However, the growth of attention to the consequential human factors and usability aspects was slow to develop. Through the 1960s such work as existed was scattered and mostly, in the USA especially, related to military systems. Through the 1970s significant work developed though still largely in small, somewhat isolated groups. But in 1980 the recent considerable growth was crystallized in four books (one from a conference), to be followed by several books each year thereafter, by a second main journal in 1982 and by seven major conferences in 1982-84 - see Figure 3.

1959	1st recorded paper in the literature (on 'Ergonomics of a Computer Console' Shackel 1959, reported by Gaines 1984)
1969	1st major conference ('International Symposium on Man-Machine Systems')
1969	'International Journal of Man-Machine Studies' started
1970	Foundation of HUSAT Research Centre, Loughborough University
1970-73	4 seminal books published (Sackman, Weinberg, Winograd, Martin)
1976	NATO Advanced Study Institute on 'Man-Computer Interaction'
1980	Conference and book on 'Ergonomics Aspects of Visual Display Terminals' (Grandjean & Vigliani 1980)
	Three others books (Cakir et al, Damodaran et al, Smith & Green)
1982	Journal 'Behaviour and Information Technology' started
1982 to 1984	7 major conferences held in USA, UK and Europe with attendances ranging from 180 to over 1000 with an average of 485
1985	Journal 'Human-Computer Interaction' started

Figure 3. Growth of attention to ergonomic aspects of human-computer interaction (see Gaines 1984 for a review)

WHERE ARE WE NOW?

In General

Thus there has been some marked growth in the last few years. But the extent of general ergonomics knowledge and theory directly applicable to the design of computer and IT systems was very limited in 1980, and has only advanced a little since then. The approach described by Damodaran et al (1980) is still the most useful guide, but there are few general findings which can be applied. As yet most research in ergonomics still has to be specific to the tasks, equipment and situation involved.

Nevertheless, the recognition of the importance of human factors is widespread in the computer industry today. Moreover, money is being spent to build up human factors resources; a short survey of 15 large US computer companies in 1984 received statements of growth of human factors staff from x 2 to x 5 with an average of x 3; of the 1200 participants in the CHI '85 Conference in the USA in April over 80% were from industry. Further, human factors specialists now report generally that they are consulted much more by their company designers.

Again, the working position of the human factors staff is often higher, not only operating at tactical but at strategic levels. For example, alongside the Operational Strategy by which the British Government DHSS is over 10 years developing a 30,000 terminal system to run all the main Social Security procedures, HUSAT (1983) has prepared and is implementing the Human Factors Strategy.

HUMAN FACTORS RESEARCH

As is shown by the growth in the numbers of books, journals, conferences and papers published, there has certainly been an increase in research. However, the subject is so complex and the quantity of work so small in the past that in proportion little has been done. Nevertheless some trends can be seen (cf. Committee on Human Factors 1983 and Shackel 1984 for references and details).

Most researchers in Europe now consider that hardware issues are of less importance. As Schmidtke said (Shackel 1984) "much has been done on workstation and environment issues and on terminal hardware, but now software ergonomics is the important need", and similarly Bullinger said "the main ergonomic problem now is not the chair and desk and VDT but to develop software to improve the screen display and the whole organisation of the information which is displayed". In this area of software ergonomics, work in the USA is steadily moving ahead of that in Europe. There is certainly work of high quality going on in Europe, such as at Stuttgart and Cambridge, but there is far too little of it.

Again, it is agreed widely that much work and major developments are needed in theory, especially in cognitive ergonomics. A quarter of the experts studied in the survey (Shackel 1984) drew attention to this issue, for example Krueger "there is a serious lack of cognitive theory to subserve work in software ergonomics". Similarly Green stated "another problem is the theoretical basis for the field of human computer interaction because so much work and advice has to be done on an ad hoc basis. We need a new psychology of the man-machine interface". The work of Card, Moran & Newell (1983) is a first step in this direction, which also shows how much is yet to be done. From the content of this present conference, and also from evidence elsewhere, it is pleasing to note how much work is beginning to develop in this important area.

Other general areas of research will be considered under the heading of 'Research Gaps and Needs' later in the paper; the only other general topic considered here is that of health hazards. The main findings of research to date reveal the importance of good ergonomic work-place design to minimise many aches and pains regularly reported at present because of poor equipment, work-place or environment design (Grandjean & Vigliani, 1980). But no evidence has been found to date to support any of the union claims and newspaper stories of harmful radiation or other effects (Pearce 1984). The problem of course is that it is never possible to prove a negative. The best that can be done is to arrange a co-ordinated series of comprehensive longitudinal studies; there must be cause for concern that hardly any such studies are in hand at present.

Finally, although issues of methodology are not in general being considered here, attention should be drawn to a useful paper reviewing such issues by Eason (1983). After discussing research aims and frame-work for such studies, he then considers the eight aspects of what he proposes to be an idealised strategy:- field investigation, multi-disciplinary design teams, socio-technical perspective, real use, ordinary users in their normal circumstances, longitudinal studies, evolutionary studies, and formulation and testing of proposed methods and standards. The growing numbers coming into this field and developing applied research in this area would do well to consider his recommendations.

USABILITY DESIGN - Issues & Definitions

Research about and suggested methods for good usability design have become major topics in the last few years; in the IFIP INTERACT '84 Conference Proceedings (Shackel 1985) at least 37 out of 153 papers were directly or substantially related to design questions. The relevant issues include design procedures, ergonomics design framework, design guidelines, user models to assist designers, evaluation methods, industrial design aspects, and integrating human factors into the design process. Papers specifically addressing some of these topics were also presented at the ErgoDesign '84 Conference (ErgoDesign 1984).

However, one of the most important issues is that there is, as yet, no generally agreed definition of usability and its measurement. This issue will be considered in two parts, first the general framework and then the definitions.

The general framework for usability embraces the four principal components of any work situation:- user, task, system and environment. Good design for usability depends upon achieving successful harmony in the dynamic interplay of these four components (this framework is based upon earlier similar approaches by Bennett, 1972 & 1979, and Eason 1976). Therefore, usability can be defined in terms of the interaction between user, task and system in the environment.

The definition of usability was probably first attempted by Miller (1971) in terms of measures for 'ease of use', and these were developed further by Bennett (1979) to describe usability. The concept of usability was first discussed and a detailed formal definition was attempted by Shackel (1981b), and Bennett (1984) modified and developed the definition. I have integrated and developed further these approaches, and now propose a formal operationalised definition of usability in Figure 4.

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Proposed Operational Definition of Usability

Usability can be specified and measured by means of the operational criteria defined below. The terms should be given numerical values when the usability goals are set during the design stage of 'requirements specification'.

For a system to be usable the following must be achieved:

Effectiveness

* The required range of tasks must be accomplished at better than some required level of performance (e.g. in terms of speed and errors)
* by some r equired percentage of the specified target range of users
* within some required proportion of the range of usage environments

Learnability

* within some specified time from commissioning and start of user training
* based upon some specified amount of training and user support
* & within some specified re-learning time each time for intermittent users

Flexibility

* with flexibility allowing adaptation to some specified percentage variation in tasks and/or environments beyond those first specified

Attitude

* and within acceptable levels of human cost in terms of tiredness, discomfort, frustration and personal effort
* so that satisfaction causes continued and enhanced usage of the system

Figure 4 Definition of Usability proposed in terms of goals and operationalised criteria which can have numberical values specified and measured.

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This definition has now been formulated so that numerical values can be specified during the design stage of user requirements specification. In that stage of the design process, various system attributes are specified and the usability attributes should be specified in just as much detail as any other aspect of the intended system. An example of a table giving the detailed System Attribute Specifications for useability attributes is given in his figure 6 on page 181 by Bennett (1984).

When users and purchasers make decisions about systems, their decision depends not only upon usability but upon an assessment balancing various factors; they probably consider also how useful the system will be, whether they feel it is suitable and they would like to use it, and how much it will cost, both financially and in terms of the personal, social and organisational consequences. Without stating such a precise relationship between these terms as has been suggested in the definition of usability, it is thought that the relevant factors are associated in some form of trade-off paradigm such as that in Figure 5. This paradigm helps to place usability in its balanced position with functionality; as computers become cheaper and more powerful, it seems certain that usability factors will become more and more dominant in the acceptability decisions made by users and purchasers.

System Features				Costs
Usability	)		(	Effort to learn & use
Utility (functionality)	)	versus	(	Skill loss, job risk
Likeability	)		(	Financial costs

(implicit or explicit cost-benefit analysis)
gives decision on

Acceptability
Purchase
Use

or

Not

Figure 5 Usability in the trade-off equation which leads to the decision of acceptability (or not).

USABILITY DESIGN - Process & Precepts

The place of human factors in relation to various stages of the design process, and the best procedures for assisting designers to achieve good usability design, have been studied intuitively and empirically for many years. Maister & Farr (1967) showed some of the problems designers have in utilising human factors information; handbooks and textbooks of various sizes have been produced (McCormick 1970-80, Van Cott & Kincade 1972); however, these and similar works were concerned with general ergonomics in relation to general systems. Relatively few attempts have been made to give prescriptive advice on how to bring ergonomics into the design process (cf. Christensen 1971, Shackel 1971, 1974 Chapt 2); moreover, it is only recently that an attempt has been made to do this in relation to the design of computer systems (Damodaran et al 1980).

However, in the last few years two strands of development appear to be converging towards a common set of precepts. Based upon a wide range of research and design experience at the HUSAT Research Centre, Eason (1982) described various issues involved in the process of introducing information technology, and proposed an evolutionary system development process; this includes various ways of involving examples of the users, pilot systems, trials and experiments, progressive implementation of facilities, evaluation of users, user support and assistance to help the learning by the organisation. Some of these procedures are reported by Miller & Pew (1981) as being used by them in the course of a large system development study. Moreover, Gould & Lewis (1983) have similarly devised a methodology from their experience and have proposed four precepts for design for usability which in essence are very similar; they also give examples of the use of simulation and prototyping as part of the usability development process.

From these various approaches, one can synthesise and propose a set of fundamental features which will probably find widespread acceptance by experienced human factors specialists as key precepts for the process of design for usability. These are listed in Figure 6 below. The essentials of these fundamental features are as follows.

<u>User-Centred Design</u> - designers must understand who the users will be and what tasks they will do. This requires direct contact with users at their place of work. If possible, designers should learn to do some or all of the users' tasks. Such studies of the users must take place before the system design work starts, and design for usability must start by creating a usability specification.

<u>Participative Design</u> - a panel of expected users (e.g. secretaries, managers) should work closely with the design team, especially during the early formulation stages and especially when creating the usability specification. To enable these users to make useful contributions, they will need to be shown a range of possibilities and alternatives by means of mock ups and simulations. A valuable procedure, although not easy, is to write the parts of the operating manual describing the interface and how to use it; user tests of a drawing of the interface with this draft manual can prevent problems before they occur.

Experimental Design - Early in the development process the expected users will actually do pilot trials and use the simulations, and later the prototypes, to do real work. Whenever possible alternative versions of important features and interfaces should be simulated or prototyped for comparative test evaluation. These studies should be formal and empirical, with measures of the performance and the subjective reactions of the users. Thus, ease of learning and ease of use can be assessed and difficulties revealed.

Iterative Design - The difficulties revealed in user tests must be remedied by re-design, so the cycle:design, test & measure, re-design - must be repeated as often as is necessary until the usability specification is satisfied.

User Supportive Design - This area is often left until a very late stage in the design process, and then some documentation and 'help' screens are written in a hurry at the last minute; the other aspects of user support are usually left to others by the designers, who are often unaware of their relevance and importance. Careful attention to all these support facilities can significantly assist usability.

FIVE FUNDAMENTAL FEATURES OF DESIGN FOR USABILITY

1.	User Centred Design	- focussed from the start on Users and Tasks
2.	Participative Design	- with Users as members of the design team
3.	Experimental Design	- with formal user tests of usability in pilot trials, simulations & full prototype evaluations
4.	Iterative Design	- design, test & measure, and redesign as a regular cycle until results satisfy the usability specification
5.	User Supportive Design	- training, selection (when appropriate) manuals, quick reference cards, aid to 'local experts' 'help' systems, eg :- on-line : context specific help off-line :'hot-line' phone service

Figure 6 To be successful Design for Usability must be based upon these Five Fundamental Features.

Relating these key precepts to the typical stages of the system design process can provide both a first level of elaboration of the precepts and a reminder of the action programmes required. An outline of the usability actions appropriate to the system design stages is given in Figure 7.

USABILITY ACTIONS in the STAGES OF SYSTEM DESIGN

System Design Stage	Usability Actions
Feasibility	Define range of Users, Tasks & Environments to be covered. Do the proposals match the needs? Preliminary functions & operations analyses. Preliminary allocation of functions. Participative Design - panel of users in the design team. Create and formalise the Usability Specification by defining user requirements and setting usability goals.
Research	Studies, often experimental, of human capabilities re system operational concepts. Use pilot studies in the field to explore users' operational needs and to study possible effects upon organisational & social structure.
Development	Detailed analyses of all functions, tasks & operations involving or affecting humans. Design all human factors aspects of equipment & workplaces. Specify all environmental issues. Use guidelines to assist as design ideas are developing. Check design ideas against available human dimension, behaviour & performance data. Test subsystem sections in initial evaluation trials with samples of likely users. Iterative Design - use test results as basis for redesign, and test again. Propose selection criteria (if relevant); develop training scheme; provide for other forms of User Support needed.
Prototype	Extensive laboratory evaluation with samples of likely users. Full field trials with representative actual users in proper working environment. Iterative Design.
Regular Operation	Provide for User Support - provide training, encourage & aid 'local experts', arrange 'hot-line' for help, etc. Gather extensive evaluation data (both objective performance data & subjective attitude data); feed back the evaluation data as check on decisions & predictions made during design; learn from the data - modify the design databases, models & methods for future use.

Figure 7 A synopsis of the various activities needed in the successive stages of system design to improve usability.

It should be noted that these precepts are derived from separate groups, one at a university research centre and the other at the largest computer corporation. The precepts have been recommended separately by many human factors specialists but none before have integrated them in this way and shown their value as a totality from practical examples.

Further, three studies reported at the CHI '85 conference all add illustrative support to usability definition process and design procedures outlined above. Wilson & Whitesid (1985) show the practicality and advantage of specifying usability metrics and formally defining usability goals. Olson (1985) illustrates the benefit of deliberately designing alternative versions for each part of the user interface aspects of a first prototype. Butler (1985) presents a case study to emphasise the value of setting usability goals and measures at the requirements stage, and he also describes the process as 'evolutionary design'.

Other Design Related Areas

It should be noted that useful work is developing in quite a number of areas, but brief reference can only be made to a few.

Evaluation is an important topic. Ghapanis (1981) has reviewed the needs and basic procedures. Hirsch (1981) described the work and procedures of the IBM San Jose human factors centre, which does many evaluation studies. Neal (1983) described a very useful recording and playback facility used at that same centre. Grudin & MacLean (1984) described various methods for measuring performance and preference, and Helmreich (1984) presented the results of user acceptance research. Finally, EIU (1985) is leading the group of consultants commissioned to evaluate the 21 pilot projects supported by the U.K. Government's IT initiative, and their recently published interim report has many useful lessons.

The area of user support (cf. Damodaran 1976,1984) is beginning to receive some of the attention it needs. The design and testing of documentation to meets users' needs is receiving more attention (Smith 1981, Sullivan & Chapanis 1983, Wright 1983, Clement 1984). Also the design of on-line tutorial programs (i.e. a form of CAI) is beginning to be studied (Al-Awar et al 1981, Aldred 1985). The development of a wide range of user support facilities is one of the major strands in the DHSS human factors strategy being implemented by HUSAT (1983).

Finally, the importance of organisational issues should not be overlooked. At the Interact '84 conference about 10 papers dealt with such aspects including six gathered into one session; the papers by Bjorn-Anderson (1984) and Pomfrett et al (1984) are particularly relevant. Also, the EIU (1985) report contains relevant lessons about quite a number of organisational issues. However, it must be said that there is especially far too little work in this area.

WHITHER?

Moving from where to whither, there are several obvious needs arising from the present situation which should be or are being addressed. For example, the same problem is evident that arises for all new and fast growing scientific areas; the rapidly increasing number of scientific papers, conference proceedings etc. need to be gathered, indexed and made readily accessible via bibliographic databases not only for books but for journals, conference proceedings and unpublished reports. This topic is already being addressed jointly by HUSAT and IAO via the ESPRIT supported HUFIT project (Human Factors laboratories for Information Technology).

Again, while bibliographic methods are appropriate for researchers, human factors poses a different problem in the process of knowledge transfer to designers. The growing quantity of research results need gathering, co-ordinating and interpreting into guidelines and later design manuals. This is already being done (e.g. Smith & Mosier 1984, Gardner et al 1984). However, a problem already evident is that there are too many such guidelines for a designer to remember or even perhaps to read amid the usual pressures of the design work cycle. Clearly a software tool is needed to encapsulate the knowledge and help the designer find the appropriate guidance relevant to the particular part of his current product design. Some work is already in hand at HUSAT to explore and develop this concept.

Let us now turn to look more broadly at the research gaps and future needs which are evident from the present situation. In the last two years several surveys have been made from which the conclusions indicate various major gaps in knowledge and needs for research (Committee on Human Factors 1983, van Apeldoorn 1983, Shackel 1984). Combining these data gives a list of nine substansive areas needing attention.

Research Gaps and Future Needs

Although these are suggested to be some of the principal research issues to be addressed during the next five years to 1990, of course not all will be finished and many may well overlap into the following decade.

1. Theory Especially in Cognitive Ergonomics

The need for major developments in theory, especially in cognitive ergonomics, was emphasised widely. The work of Card, Moran and Newell (1983) is a first step in this direction, which also shows how much is yet to be done.

2. Cognitive/Software Interface

The recognition of the importance of the cognitive and software interface is shown by the recent attention to this subject by most research groups, and by the recent rapid growth of published work.

3. User Variables and Models of Users

Much basic work is needed, both empirical and theoretical, to develop our scientific understanding of the characteristics and performance of humans as IT users. It is generally agreed that models of user behaviour will be valuable, but the problem is to ensure that the research does not become too theoretical. Good solutions need a concrete task and situation for valid modelling; associating the research with designers may help to ensure that the models have practical relevance. A useful review has recently been presented by Laughery (1984).

4. Measurement Methods

Various shortcomings in measurement methods were emphasised. For example, Bernotat said 'measuring methods have to be improved, especially concerning mental workload and influences from the social environment. Some agreement or even standardisation of basic measuring procedures would help to make data comparable'. For example, the Mosso Ergograph established a 'classic' procedure for measuring muscular fatigue, but there is no equivalent reliable and accurate method to measure mental load and mental 'fatigue' (cf. Moray, 1982, 1983).

5. Knowledge for Usability Design

There is much yet to be researched about usability. As Sanders said 'we need, but do not have, rules for how to design software to be easy to use; also we need rules of when and where to provide 'short cuts' for skilled users, e.g. when using menus. But the real problem here is to understand, to have full knowledge of, the development of skill by the user in such situations'. We need extensive research studies of different types of users, doing different types of task, with different hardware and software tools, so as to establish a comprehensive understanding of the parameters of usability.

6. Procedures and Tools for Designers

Given that appropriate knowledge is available, the next and equally important issue is the methods, procedures or tools by which that knowledge is applied during the design process. Faehnrich emphasised the need to produce rapid prototyping tools of a special type; the idea is to make trial versions or prototypes of human-computer interfaces as 'real products' in the market sense, so that one can talk about 'price' and 'quality' and then ask users for an evaluation of the prototype against these and other factors. However, Eason pointed out that designers may need some help so that the potential learning from prototypes and pilot schemes is actually obtained and used iteratively to produce a better final design.

7. Standardisation Issues

Standardisation is seen by many experts as of almost equal importance with the need to improve knowledge and to improve design methods. Several pointed out a tendency to move rapidly and perhaps prematurely into draft standards. Again, several emphasised that much testing work is needed on proposals for standards, to check them for many different types of user and usage so as to make them truly application independent. This is particularly important for the software interface.

8. System Operation and User Support

Very little was found in the literature on aspects related to system installation and regular operation. More attention is needed to this and to all aspects of user support and to the influence of IT upon work and job structure and functioning.

9. Organisational and Social Issues

The organisational and social aspects range very widely from, for example, the organisational consequences of word processor applicants (cf. Pomfrett et al 1984) to the potential for alienation and loss of identity implicit in the isolated monitoring jobs which may become typical of the automated factory. There are even fewer simple answers to these organisational and social questions than to the other research areas identified above.

NEED FOR A SCIENCE OF USABILITY

In essence the summary above of research gaps and future needs shows the basic requirement to be for a science of usability.

On the one hand, three of the four components in the usability equation, - user, task and usage environment - are all essentially variable; that is, the same system will be used by many different users for different tasks in different usage environments. Again, the same user, task and environment are essentially changeable over time and sometimes as a function of the IT system being used. Therefore the need is for comprehensive, co-ordinated, taxonomic research to study the various levels and combinations of these components in relation to the usability of systems. A good example of the type of study needed to classify types of users and relate their characteristics to system usage has been reported by Potosnak (1984).

On the other hand, the design of systems presents many complex and variable problems. The extent of relevant knowledge available is beyond the scope of any one person. Therefore multi-disciplinary teams are already required to tackle the technology of the system. To deal with the equally complex range of human factors issues involved with usability, the relevant knowledge will only be transferred in the long term by appropriate human factors specialists joining the multi-disciplinary design teams. This is already beginning to happen, for example in the Large Scale Demonstrator Projects which form part of the British Alvey programme, and similarly for some of the large projects supported by the Commission for European Communities in the ESPRIT programme.

As Gaines (1984) illustrates, this process of developing a science of usability and building multi-disciplinary teams will be essential as we move forward to address the challenge and the problems inherent in the programme to develop Fifth Generation computer systems.

CONCLUSION

To meet the need and achieve the results suggested above, clearly much more work and much more collaboration will be essential. Perhaps some attempt should be made to develop such collaboration in the European context. Indeed, this Software-Egonomie '85 Conference and the associated Macinter Workshop, and also the IAO-HUSAT ESPRIT-funded HUFIT project, are further examples of the beginnings of such co-operative work.

Perhaps proposals should be made to the Commission for the European Communities and other funding bodies for a more comprehensive programme. Large sums are being invested in IT system development and in the ESPRIT programme. Surely the requirement is for a programme which will enable the researchers in IT Ergonomics further to improve the quality of their research and especially to increase the quantity and enlarge its scope, so as to be ready to make a proper balancing contribution to the system design programmes of the future. This will only result from a Strategic Programme for Research in IT Ergonomics (SPRITE).

Moreover, a co-ordinated programme is needed which will greatly increase the collaboration between researchers in different countries, especially in Europe. Above all, with regard to design for usability, a programme is needed to increase the contact of the researchers with the system designers and thus ensure that what is developed is not merely a science of usability but also a technology of usability.

The future for software ergonomics is undoubtedly both challenging and exciting. If those working in the field now and in the future can meet the challenge, then the principles and practice of design for usability, as continually developed by researchers in software ergonomics, will become the leading and determining factors of system designs in the future.

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