1. INTRODUCTION TO HUMAN COMPUTER INTERACTION

1.1 Definition of Human Computer Interaction

The term Human-Computer Interaction (HCI) was adopted in the mid -1980s as a means of describing this new field of study. This term acknowledge that the focus of interest was broader than just the design of the interface and was concerned with all those aspects that relate to the interaction between users and computers. Also, unlike the term man-machine studies, it did not imply gender bias.

Human-computer interaction (HCI) is the study and the practice of usability. It's about understanding and creating software and other technology that people will want to use, will be able to use, and will find effective when used. As its name implies, HCI consists of three parts: the user, the computer itself, and the ways they work together. The user can be an individual user or a group of users working together. The computer refers to any technology ranging from desktop computers, to large scale computer systems. For example, if we were discussing the design of a Website, then the Website itself would be referred to as "the computer". Devices such as mobile phones or VCRs can also be considered to be "computers". There are obvious differences between humans and machines. In spite of these, HCI attempts to ensure that they both get on with each other and interact successfully. Although there are still no currently agreed definitions of HCI, the following definition embodies the spirit at that time

" ***A set of processes, dialogues, and actions through which a human user employs and interacts with a computer (Baecker and Buxion, 187, P.40)***

A more recent and broader characterization is provided by this definition

" ***Human-computer interaction is a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them. "***
[ACM SIGCHI Curricula for Human-Computer Interaction [Hewett et al., 2002, page 5]]

1.1.1 History of Human-Computer Interaction

The field of HCI emerged in the 1970s with the advent of personal computers. Initially, HCI research focused on improving the usability of computer systems through the development of user interfaces. The early research efforts were centred around improving the efficiency and effectiveness of human-computer interactions.

As technology progressed, new design paradigms emerged, and HCI research expanded to include the examination of the emotional and social aspects of human-computer interactions. In the 1990s, the field of HCI began to incorporate principles from cognitive psychology, which helped to provide a more comprehensive understanding of human behavior.

1.2 User Interface and HCI

Moran defined user interface as those aspects of the system that the user comes in contact with which in turn means an input language for the user, an output language for the machine and a protocol for interaction (Chi, 1985, p.671). HCI came into existence in the 70's when the use of computer has left the domain of expert. In the 70's more people aside expert can now afford to buy and use the system, this brought about the need for the system must be user friendly

User friendliness was achieved through the user interface but HCI is more than that because apart from user interface one must understand the psychology of the user, economics, how effective can the user achieve its aim.

1.3 The Goals of HCI

The goals of HCI are to produce usable and safe systems, as well as functional systems. These goals can be summarized as " to develop or improve the safety, utility, effectiveness, efficiency and usability of system that include computers" . In this context the term 'system' derives from system theory and it refers not just to the hardware and software but to the entire environment- be it organization of people at work, at home or engaged in leisure pursuits- that uses or is affected by the computer technology in question. 'Utility' refers to the functionality of a system or, in other words, the things it can do. Improving 'effectiveness and 'efficiency' are self – evident and ubiquitous objectives. The promotion of safety in relation to computer systems is of paramount importance in the design of safety critical systems. Usability, a key concept in HCI is concerned with making systems easy to learn and easy to use.

In order to produce computer systems with good usability, developers must attempt to:

- **understand** the factors (such as psychological, ergonomic, organizational and social factors) that determine how people operate and make use of computer technology effectively and to translate that understanding into
- **developing** tools and techniques to enable building suitable systems in order to

- **achieve** efficient, effective, and safe interaction both in terms of individual human- computer interaction and group interactions.
- **put people first**

Underlying the whole theme of HCI is the belief that people using a computer system should come first. Their needs, capabilities and preferences for conducting various tasks should direct developers in the way that they design systems. People should *not* have to change the way that they use a system in order to fit in with it. Instead, the system should be designed to match their requirements.

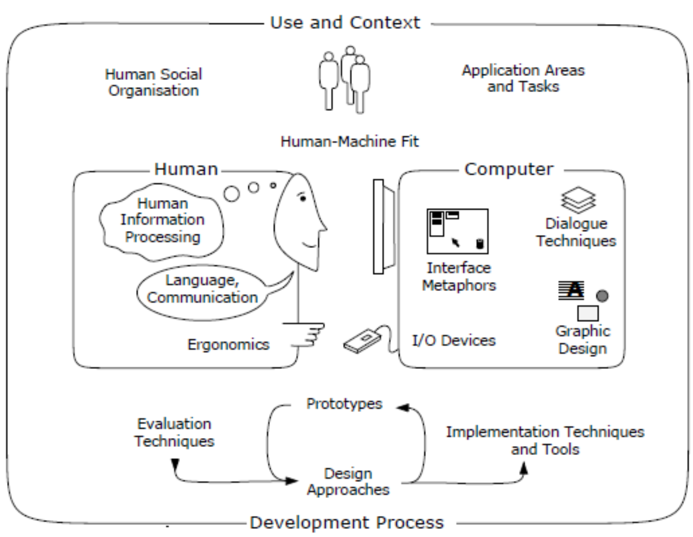

Figure 1.1: The nature of Human-Computer Interaction. Adapted from Figure 1 of the ACM SIGCHI Curricula for Human-Computer Interaction [Hewett et al., 2002]

1.4 Importance of HCI: Productivity

Productivity can be viewed in terms of productivity/individual and productivity/organization

A. **Productivity and Individual**: One way of demonstrating the importance of HCI is by showing tangible benefits. For many aspects of HCI, benefits are largely hidden, intangible and unquantifiable. Productivity and individual can be in terms of improved turnover, greater productivity and flexibility, better use of staff, reduced workforce etc.

B. **Organizational Productivity:** This involves group of people interacting with each other with various natural and man-made objects and with the environment in which they are placed. Introducing new technology, affects the following:

- **Job Content:** who does what , when, how and how much (computers often make things formal rather than less formal).
- **Personnel policies:** probably as a result of changes to job content(Confidentiality of information)
- **Job satisfaction:** motivation, control, financial and other rewards, learning new skills.
- **Power and influence:** which may shift between individuals or groups.
- **Working environment:** changes in space equipment allocation

One may be encountered with negative outcome when one introduces new technology when that happens one can go back to the objectives of introducing the new technology. There may be some effects when new technology is introduced as control but will bring better options when it is introduced as a tool.

1.5 Scope of HCI

The field of HCI is interdisciplinary and requires students of HCI to be familiar with at least some of the relevant disciplines. Figure 1.3 shows the wide range of relevant sources of knowledge and inspiration for developing high- quality HCI. Each disciplinary source, from computer engineering to arts and philosophy, informs parts of the many aspects of HCI development. In this course, HCI is concentrated on in the organizational context. The subset of these sources includes the organizational perspective, the psychological and physiological perspective, the computer perspective and the broader social perspective.

The organizational perspective brings with it a strong influence of behavioral decision making and organizational behavior. This perspective is invaluable for understanding how to analyze the way people perform their tasks at work and how technology can support their work. Furthermore, the organizational perspective is tightly related to the psychological perspective of HCI, particularly the cognitive and affective aspects of HCI. Additionally, the computer science perspective builds on software as well as hardware engineering to design interactive technologies, relying heavily on the psychological and physiological sources.

Finally, the social and global context are also explored to meet the increasingly popular trends of social systems, the expansion of the traditional organization to communities of practice, and systems that are developed and used globally.

1. Computer Science: Computer Science is the systematic study of algorithmic processes that describe and transform information: their theory, analysis, design, efficiency, implementation and application. The fundamental question underlying all of computing is what can be efficiently automated. One of the main contributions of computer science to HCI is to provide knowledge about the capability of technology and ideas about how this potential can be harnessed. In addition, computer science have been concerned about developing various kinds of techniques to support software design, development and maintenance.

2. **Cognitive Psychology:** Psychology is concerned primarily with understanding human behavior and the mental processes that underlie it. To account for human behavior, cognitive psychology has adopted the notion of information processing. Cognitive psychologists have attempted to apply relevant psychological principles to HCI by using a variety of methods, including development of guidelines, the use of models to predict human performance and the use of empirical methods for testing computer systems.

3. **Social and Organization Psychology**: Social psychology is concerned with studying the nature and causes of human behavior in a social context. Its role is to inform designers about social and organization structures and about how the introduction of computers will influence working practices.

4. **Human Factors**: Also known as Ergonomics, its purpose is to define and design tools and various artefacts for different work, leisure and domestic environments to suit the capacities and capabilities of users. The role of the ergonomist is to translate information from the above sciences into the context of design whether for a car seat of a computer system. Its objective is to maximize an operator’s safety, efficiency and reliability of performance to make task easier, and to increase feelings of comfort and satisfaction. Concern from ergonomists and human factor specialist for HCI includes workstation and any kind of hardware design and those aspects of software design that may have adverse physiological effects on humans, such as readability of information on visual display units.

5. **Linguistic:** This is the scientific study of language. HCI has several issues that may be better understood by applying knowledge and theories from linguistics. For example, in the early days of command languages, there was some debate about whether or not the object to which a command applied should come before or after the command itself. When deleting a file called ‘fred’ for example, should you type delete ‘fred’ or ‘fred’ delete. A field closely related to HCI that has benefited from linguistic theory id AI. Within HCI itself understanding the structure (syntax) and meaning (semantics) is important in developing natural language interface and more recently conversational analysis which is being used to understand how individuals and groups interact with computers in natural environments

6. Artificial Intelligence (AI): AI is concerned with the design of intelligent computer programs which imitate different aspects of intelligent human behavior. In particular, the focus has been representing knowledge structures that are utilized in human problem – solving. AI knowledge and methods, such as the use of production rules, have been applied to HCI in connection with the development of tutoring and expert systems with intelligent user interfaces. However, the relationship of AI to HCI is mainly concerned with users needs when interacting with an intelligent interface. These include for example, the use of natural language and speech as a way of communicating with a system and the need for the system to explain and justify its advice. It has also help to reduce the mental tasks that many user encounter when using computer system.

7. **Philosophy, Sociology and Anthropology**: These disciplines are not directly connected with the actual design of computer system same way as hard sciences. Their contribution to HCI is to obtain accurate description of the interaction between users, their work, the technology they use and the environment in which they are situated. One application of social science methods has been to characterize computer supported cooperative writing (CSCW), which is concerned with sharing software and hardware among groups of people working together. The aim is to design tools and ways of working which optimize the shared technology so that maximum benefit can be obtained by all those who use or are affected by it. For example, a study might be carried out in a work place to assess how existing computer systems and software are used. The results may then point out areas where changes to work practices could increase the use of the

systems. In addition it might suggest the implementation of new, emerging types of groupwares, which is software specifically designed to be used by more than one person.

8. **Graphics and Design**: Design contributed to the creative skills and knowledge used in designing HCI. Engineering is an applied science which relies heavily on model building and empirical testing.

1.6 Factors in HCl

<table>
<tr><td colspan="2">ORGANIZATIONAL FACTORS
training, job design, politics, roles, work organization and staff relations</td><td>ENVIRONMENTAL FACTORS
Noise, heating, lighting, ventilation</td></tr>
<tr><td>HEALTH AND SAFETY FACTORS
Stress, headaches,
musculo-skeletal disorders</td><td>cognitive processes and capabilities
THE USER
Motivation,
Enjoyment,
Satisfaction,
Personality,
Experience level</td><td>COMFORT FACTORS
seating,
equipment layout</td></tr>
<tr><td colspan="3">USER INTERFACE
Input devices, output displays, dialogue structures,
use of colour, icons, commands, graphics, natural language,
3-D user support materials, Multi-media</td></tr>
<tr><td colspan="3">TASK FACTORS
easy, complex, novel,
task allocation, repetitive,
monitoring, skills, components</td></tr>
<tr><td colspan="3">CONSTRAINTS
Costs, timescales, budgets,
staff, equipments, building structure</td></tr>
<tr><td colspan="3">SYSTEM FUNCTIONALITY
Hardware, software application</td></tr>
<tr><td colspan="3">PRODUCTIVITY FACTORS
Increase output, increase quality, decrease costs, decrease errors,
decrease labour requirements, decrease production time,
increase creative and innovative ideas leading to new products.</td></tr>
</table>

Figure 1.3: Factors in HCI

1.7 Challenges in HCI

New improved hardware and software technologies are opening up new possibilities for HCI. Special devices enable users to grab and move virtual objects in a virtual space, or even to move through that space in virtual reality. Multimedia applications, in which sound, dynamic and static graphics, video and text are intermingled, are now common. Recent developments in telecommunications, such as the Integrated Services Digital network (ISDN) and high definition TV are enabling increasingly large amounts of different types of information to be channeled through networks. Images, video, sound and text can be transmitted with minimum loss of efficiency and quality. Information held in databases across the world is becoming accessible to people in their own homes. These changes bring two important challenges to HCI designers:

- How to keep abreast of changes in technology
- How to ensure that their designs offer good HCI as well as harnessing the potential functionality of the new technology.

2. USABILITY OF INTERACTIVE SYSTEMS

2.1 Definition of Usability

Definition 1: The ISO defines usability as "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use." [ISO, 1998].

Definition 2: The extent to which a system with given functionality can be used efficiently , effectively, and satisfactorily by specified users to achieve specified goals in a specified context of use.

The three measurable usability attributes defined by ISO [1998] are:

• Effectiveness: accuracy and completeness with which users achieve specified goals.

• Efficiency: resources expended in relation to the accuracy and completeness with which users achieve goals.

• Satisfaction: freedom from discomfort, and positive attitudes towards the use of the product.

Usability in Context

Nielsen [1993b] defines usability in the context of overall system acceptability, as shown in Figure 1.

Six Usability Attributes

Combining the three ISO usability attributes with Nielsen's five usability attributes, leads to the following six usability attributes:

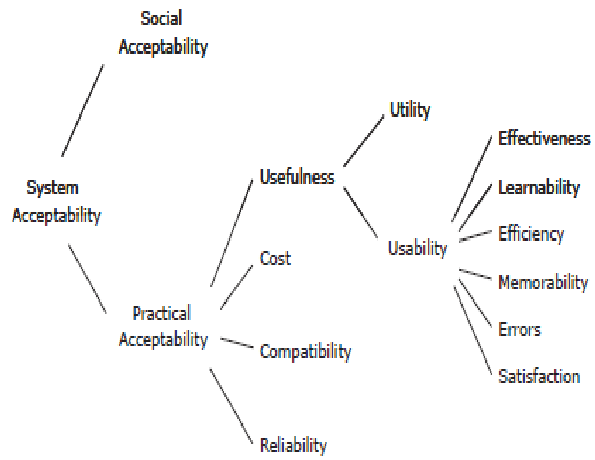

Figure 2.1: A model of the attributes of system acceptability, based on Figure 1 of [Nielsen, 1993b].

1. Effectiveness: completeness with which users achieve their goal.
2. Learnability: ease of learning for novice users.
3. Efficiency: steady-state performance of expert users.
4. Memorability: ease of using system intermittently for casual users.
5. Errors: error rate for minor and catastrophic errors.
6. Satisfaction: how satisfying a system is to use, from user's point of view.

Measuring Usability Attributes

• Effectiveness: decide on definition of success. For example, number of substitution words spotted in a text, or binary measure of success (order completed or not).

• Learnability: pick novice users of system, measure time to perform certain tasks. Distinguish between no/some general computer experience.

• Efficiency: decide definition of expertise, get sample expert users (difficult), measure time to perform typical tasks.

• Memorability: get sample casual users (away from system for certain time), measure time to perform typical tasks.

• Errors: count minor and catastrophic errors made by users while performing some specified task. For example, number of deviations from optimal click path.

• Satisfaction: ask users' subjective opinion (questionnaire), after trying system for real task.

2.2 Usability goals

- Effective to use
- Efficient to use
- Safe to use
- Have good utility
- Easy to learn
- Easy to remember how to use

2.3 Usability Evaluation

There are four types of evaluation, according to the purpose of the evaluation:

- Exploratory - how is it (or will it be) used?
- Predictive - estimating how good it will be.
- Formative - how can it be made better?
- Summative - how good is it?

[Andrews, 2008] are adapted from those of several authors [Stone et al., 2005; Rubin, 1994; Lockee, Moore and Burton, 2002; Ellis and Dix, 2006].

(1) Exploratory Evaluation

Explores current usage and the potential design space for new designs.

- Done before interface development.
- Learn which software is used, how often, and what for.
- Collect usage data – statistical summaries and observations of usage.

(2) Predictive Evaluation

Estimates the overall quality of an interface (like a summative evaluation, but a prediction made in advance).

- Done once a design has been done, but before implementation proceeds.

(3) Formative Evaluation

Informs the design process and helps improve an interface during design.

- Done during interface development.
- Learn why something went wrong, not just that it went wrong.

• Collect process data – qualitative observations of what happened and why.

(4) Summative Evaluation

Assesses the overall quality of an interface.

• Done once an interface is (more or less) finished.

• Either compare alternative designs, or test definite performance requirements.

• Collect bottom-line data – quantitative measurements of performance: how long did users take, were they successful, how many errors did they make.

Modified Soup Analogy

Extending Robert Stake's soup analogy [Stake, 1976; Lockee, Moore and Burton, 2002]:

"When the cook tastes other cooks' soups, that's exploratory.

When the cook assesses a certain recipe, that's predictive.

When the cook tastes the soup while making it, that's formative.

When the guests (or food critics) taste the soup, that's summative."

Usability Evaluation Methods

The methods of usability evaluation can also be classified according to who performs them:

• Usability Inspection Methods

Inspection of interface design by usability specialists using heuristics and judgement (no test users).

• Usability Testing Methods

Empirical testing of interface design with real users.

Figure 2.2 illustrates some of the different inspection and testing methods, grouped by purpose and by who performs them.

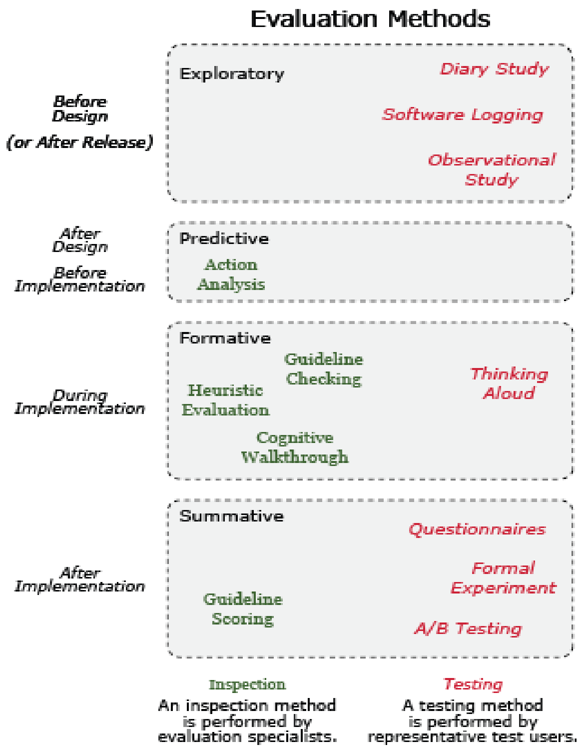

Figure 2.2: Nine common evaluation methods grouped by purpose and by who performs them

2.4 The Usability Engineering Lifecycle

1. Know the User

2. Usability Benchmarking

3. Goal-Oriented Interaction Design

4. Iterative Design:

(a) Prototyping

(b) Formative Usability Evaluation (Inspection and/or Testing)

5. Summative Usability Evaluation

6. Follow-up Studies

The lifecycle is illustrated in Figure 2.3

(1) Know the User

• Qualitative research: observation of users and interviews.

• Classify users according to their characteristics.

• Draw up a user profile for each (potential) class of user, based on behavioural and demographic variables.

- Identify user goals and attitudes.
- Analyse workflow and context of work.
- Exploratory evaluation: which software is used, how is it used, and what is it used for.
- Draw up a set of typical user scenarios.

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(2) Usability Benchmarking

- Analyse competing products or interfaces heuristically and empirically.
- Set measurable usability targets for your own interface.

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(3) Interaction Design

Goal-oriented initial design of interface.

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(4) Iterative Design

“Design, Test, Redesign.”

Build and evaluate prototype interface, then:

- Severity ratings of usability problems discovered.
- Fix problems new version of interface.
- Capture design rationale: record reasons why changes were made.
- Evaluate new version of interface.

until time and/or money runs out.

A cycle of continuous improvement.

Building Prototypes

- Verbal description.
- Paper prototype.
- Working prototype.
- Implementation of final design.

(5) Follow-Up Studies

Important usability data can be gathered after the release of a product for the next version:

- Specific field studies (interviews, questionnaires, observation).

• Standard marketing studies (what people are saying in the newsgroups and mailing lists, reviews and tests in magazines, etc.).

• Analyse user complaints to hotline, modification requests, bug reports.

• Usage studies of longer-term use of product

– Diary studies.

– Software logging: instrumented versions of software!log data.

– Observational studies.

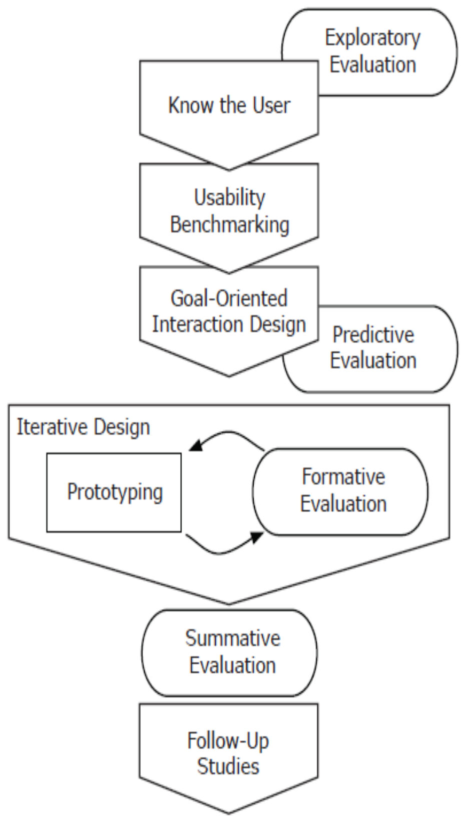

Figure 2.3: The usability engineering lifecycle. Adapted from a figure provided by Martin Loitzl.