FOUNDATIONS OF HUMAN-COMPUTER INTERACTION

MODULE INTRODUCTION:

This module introduces the fundamental components of an interactive system like the human user, the computer system itself, and the nature of the interactive process. Human-Computer Interaction (HCI) focuses on the interactions between human and computer systems with the user interface and therefore the essential processes which produce the interactions.

Lesson 1 discusses the aspects of the user by providing us with a basic overview of the capabilities and limitations that affect the human ability to use computer systems. Lesson 2 considers the computer in a similar approach which has profoundly changed the people to use technology for work and leisure. Wherein the input and output devices are described and explained, and also the effect that its characteristics have an emphasis on the interaction. After knowing the importance side of both humans and computers, the models of interaction between them are thoroughly discussed in Lesson 3. The assessment includes in this module for the students to test and to help them whether or not they have understood the topic matter covered.

MODULE OUTCOMES:

At the end of this module, the students must have:

1. discussed the Human-Computer Interaction (HCI).
2. explained the capabilities of both humans and computers from the viewpoint of human information processing.

Lesson 1: The Human

Objectives:

At the end of the lesson, the student must be able to:

1. describe the importance of the human in the field of Human-Computer Interaction (HCI);
2. explain the capabilities and limitations of the human as an information processor to design interactive systems; and
3. discuss how the information being process, apply in reasoning and problem solving, acquire skills, and correct errors.

Lesson Content:

"It is a wide variety of different kind of people and not just technical specialists as in the past, so it is important to design HCI that supports the needs, knowledge and skills of the intended users."

With the rapid growth of computing nowadays has made effective human-computer interaction essential that affects human ability to use computer systems. How human has been interacting with computers that moved a long way. Wherein the journey continues and new designs of innovative technologies and systems further appear every day, thus the research in this area has been growing very fast in the last few decades.

One way to structure this discussion is to consider the user in the same way that highlights these aspects. In other words, to consider a simplified model of what's occurring. Many models are proposed and it useful to contemplate one in every of the foremost influential in passing, to know the context of the discussion that is to follow. As described by Card, Moran, and Newell (1983), the Model Human Processor is a simplified view of the human processing involved in interacting with computer systems. The model comprises three (3) subsystems like the perceptual system, handling sensory stimulus from the surface world, the motor system, which controls actions, and therefore the cognitive system, which provides the processing needed to attach the two. Each of the subsystems has its processor and memory, although obviously, the complexity of those varies depending on the complexity of the tasks the subsystem should perform. The model also includes a variety of principles of operation which dictate the behavior of the systems under certain conditions. [1]

In this lesson, let's take a look first at the human's input-output channels, the senses, and responders, or effectors. Secondly, we will consider the human memory and the way it works. Also, we will then give some thought to how humans perform complex problem solving, how they learn and acquire skills, and why they create mistakes. Lastly, we will discover how these things can help us with the design of computer systems.

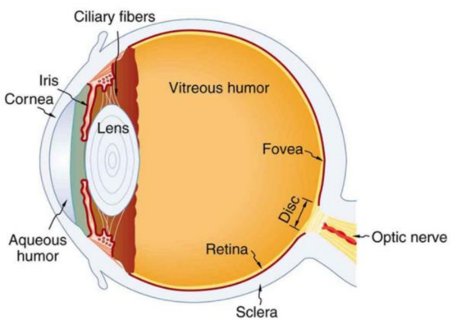
In Human-Computer Interaction by Dix, A., et al (2004) explained that humans are limited in their capacity information process. Wherein this has given an important implication when considering design. The information is received and responses are given through input and output channels such as visual, auditory, haptic, and movement. Information stored in memory sensory, short-term, long-term. Then, information was processed and applied reasoning, problem-solving and skill, error.

A. Input-Output Channels

A person’s interaction with the outside world occurs through information being received and sent which are the input and output. Input in the human occurs mainly through the sense and output through the motor control of effectors. There are five major senses such as sight, hearing, touch, taste, and smell. While, some effectors are limbs, finger, eyes, head, and vocal system.

Vision. Two stages in visual perception are the physical reception of a stimulus from the outside world, and the processing and interpretation of the stimulus. We need to understand both stages as both influences what cannot be perceived visually by a human being, which in turn directly affects the way that we design computer systems.

The Human Eye



(Source:https://courses.lumenlearning.com/ boundless-physics/chapter/the-human-eye/

It is a mechanism for receiving light and transforming it into electrical energy. Light reflects from objects images are focused upside-down on the retina. Where the receptors within the eye transform it into electrical signals which are passed to the brain.

As shown in Figure 1.1, the human eye has some important components. The cornea and lens at the front of the eye help focus on the light-sensitive into a sharp image at the back of the eye, the retina. The retina contains two types of photoreceptors such as rods and cones.

Rods are sensitive to light. This allows us to determine under a low level of illumination. But they have not to resolve fine detail and are subject to light saturation. The cones don't operate either as they're suppressed by the rods. There are approximately 120 million rods per eye which are mainly situated towards the edges of the retina. Rods, therefore, dominate peripheral sight.

Cones are the second type of photoreceptor in the eye. They are less sensitive to light than the rods and might therefore tolerate more light. There are three types of cones, each sensitive to a different wavelength of light. This enables color vision. The eye has approximately 6 million cones, mainly focused on the fovea, a small area of the retina on which images are fixated (p. 14).

Visual Perception

When considering visual appearance, one must understand the strengths and weaknesses of the human eye and the way it perceives size, depth, brightness, and color. The signal maybe is interpreted through the perception of the subsequent issues:

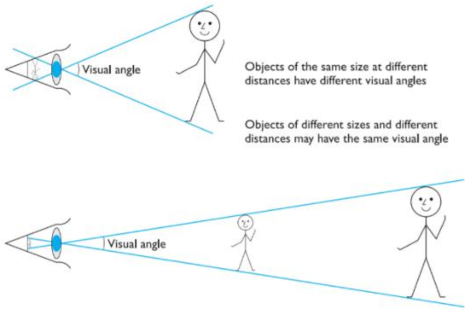


Figure 1.2 Visual Angle (Source: Dix, A., Finlay, J., Abowd, G.D., & Beale, R. (2004). Human-Computer Interaction, 3rd Edition)

Perceiving size and depth. If the visual angle of an object is too small, we will be unable to perceive it at all. Our perception of an object's size remains constant even if its visual angle changes. The law of size constancy indicates that our perception of size relies on factors other than the visual angle such as size, depth, height, and familiarity that provide a clue to the object's distance. Similar to the image above, the size is specified as a visual angle. It illustrates how the visual angle is calculated.

Perceiving Brightness. This is the second aspect of visual perception. A subjective reaction to levels of light affected by the luminance of object visual acuity increases with luminance as does flicker. Using higher display luminance leads to an increase in visual acuity.

Perceiving Color. This factor that we need to consider is the perception of color. It is made up of hue (spectral wavelength of the light), intensity (brightness of the color), and saturation (amount of whiteness in the color). The eye perceives color because the cones are sensitive to light of various wavelengths. There are three different types of cones, each sensitive to a different color (blue, green, and red). Color vision is best in the fovea, and worst at the periphery where rods predominate. Note that cones sensitive to color wavelengths, 3-4% of the fovea are occupied by cones that are sensitive to blue light, making blue acuity lower. We should remember that 8% of males and 1% of females suffer from color blindness, and most commonly unable to discriminate between red and green (p.19).

Reading

There are several stages in the reading process:

1. Perceive the pattern of words visually.
2. Decode about an internal representation of language.
3. Syntactic and semantic analysis and operate on phrases or sentences.

Take note, adults read approximately 250 words per minute. Familiar words are recognized by word shape which implies that removing the word shape clues (for example, by capitalizing words) is detrimental to reading speed and accuracy. Experiments have shown that standard font sizes of 9 -12 points, line length of between 2.3 and 5.2 are equally legible.

Hearing. This provides information about the environment like distances, directions, objects, etc.

The Human Ear

Just Just like in vision begins with light while hearing begins with vibrations within the air or sound waves. The ear receives vibrations and transmits it through various stages going to the auditory nerves. The ear has three sections, those are the outer ear, middle ear, and inner ear. Wherein, the outer ear has two parts namely the pinna, which is the structure that is attached to the sides of the head, and the auditory canal, along which sound waves are passed to the middle ear. It protects the sensitive middle ear from damage and amplifies sound (pinna and auditory canal). The middle ear is a small cavity connected to the outer ear.

It transmits sound waves as vibrations to the inner ear. And the inner ear which chemical transmitters are released and cause impulses in the auditory nerve (p. 23).

Processing Sound

As we have observed, the sound is changes or vibrations in air pressure. It has some characteristics which we can differentiate. Pitch is the frequency of the sound. As such, a low frequency produces a low pitch, a high frequency, a high pitch. To ensure that audio is effective, it must be learned the limits of the human ear, and how we decide what sounds we pay attention to. Auditory system filters sounds can attend to sounds over background noise. In interface design usually, the sound is being confined to warning sounds and notification (p. 24).

Touch. This is considered a haptic perception. Touch provides important feedback about the environment**.** It tells us when we touch something hot or cold, and can therefore act as a warning. It also provides us with feedback when we attempt to lift an object. Thus, touch is therefore an important means of feedback, and this is no less so in using computer systems (p. 25).

Movement. In one of the human's inputs and output channels, motor control must need to consider, and how the human moves' affects the interaction with computers. The stimulus is received through the sensory receptors and transmitted to the brain. The brain then tells the appropriate muscles to respond. Each of these stages takes time, which can be roughly divided into reaction time and movement time.

Movement time is dependent on age, fitness, etc. The reaction time varies according to the sensory channel through which the stimulus is received. A person can react to an auditory signal is approximately 150 ms, to a visual signal in 200 ms, and pain in 700 ms. Increasing reaction time decreases accuracy in the unskilled operator but not in the skilled operator. Accuracy and speed of movement are important considerations in the design of interactive systems, primarily in terms of the time taken to move to a particular target or screen. This affects the type of target we design. Thus, the target should generally be large as possible and the distance to be moved as small as possible.

B. Human Memory

There are three types of memory function: sensory memory, short-term memory or working memory, and long-term memory.

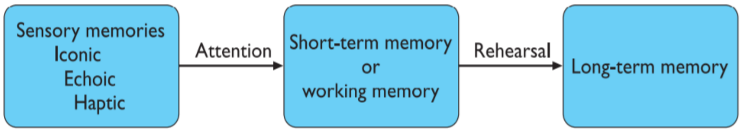


Figure 1.3 A model of the structure of memory
(Source: Dix, A., Finlay, J., Abowd, G.D., & Beale, R. (2004). Human-Computer Interaction, 3rd Edition)

As shown in Figure 1.3 above, the memories interact, with information being processed and passed between memory stores. Once information passes through the sensory system, it enters into sensory memory. From there, it is moved to short-term memory, where it is briefly stored. Information can be accessed and lost very rapidly within short-term memory; it is a place in which information is consciously accessed, examined, and moved along or simply decayed. Once the information has passed through the short-term memory, it is sent to long-term memory, where it is stored in the cortex as semantic or episodic information until activated through recall.

Sensory memory. Acts as buffers for stimuli received through the senses. A sensory memory exists for each sensory channel: iconic memory for visual stimuli in which information remains very briefing in the order of 0.5 seconds; echoic memory for aural stimuli; and haptic memory for touch (p. 28-29).

Short-term memory (working memory). Acts as a 'scratch-pad' for temporary recall of information. It has a limited capacity. There are two basic methods for measuring memory capacity. The first involves determining the length of a sequence which can be remembered in order. The second allows items to be freely recalled in any order. Based on the established experiments by Miller, using the first measure, the average person can remember 7 ± 2 digits.

The given general rule as discussed by Dix, A., et al (2004) (2004), indicates that it's easy to remember 7±2 chunk of information. Therefore, chunking information can increase short-term memory. For example, in the sequence of chunks:

HEC ATR ANU PTH ETR EET

By moving T as the last character to the first position, you get the statement: 'THE CAT RAN UP THE TREE'

Evidence shows that recall of the last words presented is better than recall of those in the middle (recency effect). Short-term memory is not a unitary system but is made up of several components including a visual channel and articulatory channel. The task of sentence processing used the visual channel, while the task of remembering digits used the articulatory channel, so interference only occurs if tasks utilize the same channel. These findings led Baddeley to propose a model of working memory that incorporated some elements together with a central processing executive as illustrated in Figure 1.4 (p. 29-31).

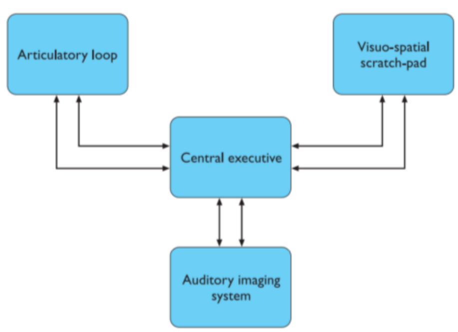


Figure 1.4 A more detailed of short-term memory
(Source: Dix, A., Finlay, J., Abowd, G.D., & Beale, R. (2004). Human-Computer Interaction, 3rd Edition)

Long-term memory. Also known as the main resource. It is intended for the long-term storage of information. As previously shown in Figure 1.3, information is placed there from working memory through rehearsal.

Long-term memory structure. The two types of long-term memory are episodic memory and semantic memory. Episodic memory represents our memory of events and experiences in a serial form. While the semantic memory structured record of facts, concepts, and skills that we have acquired. The information in semantic memory is derived from episodic. Semantic memory structure provides access to information that represents relationships between bits of information and inference. One model for how semantic memory is structured is as a network. Items are associated with each other in classes and may inherit attributes from parent classes. This model is known as a semantic network. As shown in Figure 1.5 illustrates an example of our knowledge about dogs that may be stored in a network (p. 32-33).

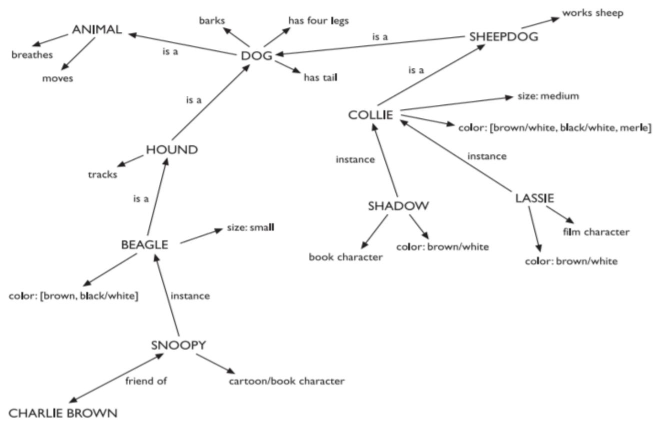


Figure 1.5 Long-term memory may store in a semantic network
(Source: Dix, A., Finlay, J., Abowd, G.D., & Beale, R. (2004). Human-Computer Interaction, 3rd Edition)

Long-term memory processes. The three main activities related to long-term memory are storage or remembering of information, forgetting, and information retrieval.

1. Storage of information. Rehearsal information moves from short-term memory to long-term memory. The total time hypothesis amount retained proportionally to rehearsal time. Distribution of practice effect optimized by spreading learning over time. Wherein, repetition is not enough to learn when information is not meaningful, hence it's more difficult to remember.
2. Forgetting decay information is lost gradually but very slowly. Forgetting interference in which new information acquired causes the loss of old called retroactive interference (e.g if you change telephone numbers, learning your new number makes it more difficult to remember your old one). While proactive inhibition if sometimes the old memory trace breaks through and interferes with new information (e.g when you find yourself driving to your old house rather than your new one). Forgetting is also affected by emotional factors. We tend to remember positive information rather than negative, and highly and highly emotive events rather than mundane.
3. Retrieval Recall Recognition. Information reproduced from memory can be assisted by cues, e.g. categories, imagery. Recognition information gives knowledge that it has been seen before less complex than recall - information is a cue

C. Thinking: Reasoning and Problem Solving

Reasoning. The process by which used the knowledge to draw conclusions or infer something new about the domain of interest. There are some different types of reasoning: deductive, inductive, and abductive.

Deductive Reasoning. Derives the logically necessary conclusion from given premises. For example:

If it is Friday then she will go to work

It is Friday
Therefore, she will go to work.

This is the logical conclusion from the premises which not necessarily true. For example:

some people are babies
some babies cry

Many people infer that ‘some people cry’ which is incorrect since we are not told that all babies are people.

Inductive Reasoning. Induction is generalizing from cases we have seen to infer information about cases we have not seen. This inference is unreliable and cannot prove to be true in all situations. For example, if every elephant we have seen has a trunk, we infer that all elephants have a truck. However, the next one we see maybe trunkless.

Abductive Reasoning. Abduction reasons from a fact to the action or state that caused it. The method uses to derive explanations for the events observed. For example, Sam drives too fast when drunk. If I see Sam driving fast, assume his drunk. Of course, this too is unreliable since there may be another reason why he is driving fast: he may have been called to an emergency. Therefore, this can lead to false explanations.

Problem Solving. Process of finding a solution to the unfamiliar task using knowledge.

Gestalt theory. Claimed that problem-solving is both productive (involves insights and restructuring of the problem) and reproductive (draw on previous experience).

Problem space theory. As proposed by Newell and Simon, problem-solving centers on the problem space which comprises problem states, and problem-solving involves generating these states using legal state transition operators. The problem has an initial state and a goal state and people use the operators to move from the former to the latter. This theory operates within the constraints of the human processing systems, so searching the problem space is limited by the capacity of short-term memory, and the speed at which information can be retrieved.

Analogy in problem-solving. This third element of problem-solving is the use of analogy on how people solve novel problems. One suggestion that must be considered is done by mapping knowledge relating to a similar known domain to the new problem – called analogical mapping. Similarities between the known domain and the new one are noted and operators from the known domain are transferred to the new one. Also, this process has been investigated using analogous stories.

Skills Acquisition. The human can acquire skills through:
- Proceduralization - a mechanism to move from the first to the second. It removes the parts of the rule which demand memory access and replaces variables with specific values.
- Generalization - a mechanism to move the second level to the third. It generalizes from the specific cases to the general properties of those cases.

Errors and mental models. There are several different types of error:
- From changes in the context of skilled behavior.

- From an incorrect understanding, or model, of a situation or system. People build their theories to understand the casual behavior of the system (mental models).

Mental models are often partial: the person does not have a full understanding of the working of the whole system. They are unstable and are subject to change. They can be internally inconsistent, since the person may not have worked through the logical consequences of their beliefs. They are often unscientific and may be based on superstition rather than evidence. Often, they are based on an incorrect interpretation of the evidence.

D. Emotion

In the situation of stress, people will be less able to cope with complex problem solving or managing difficult interface, whereas if people are relaxed, they will be more forgiving of limitation of design. Building an interface that promotes positive responses by using aesthetics or rewards for example makes the system more successful.

E. Individual Differences

We should aware of the individual differences so that we can account for them as far as possible within our intellectual capabilities. Differences may be long-term (sex, physical and intellectual capabilities) or short-term (effect of stress or fatigue on the user). Still other changes through time, such as age.

F. Psychology and the Design of Interactive Systems

To apply a psychological principle or result properly in design, it is essential to understand thoroughly its context, both in terms of where it fits in the wider field of psychology and terms of the details of the particular experiments. Like for example, the measures used, and the subjects involved. The principles and results from research in psychology are distilled into guidelines for design, models to support design, and techniques for evaluating design.

Guidelines. General design principles and guidelines have been derived from the theories we have discussed. Some of these are relatively straightforward. Like in the recall, it is assisted by the provision of retrieval cues so that interfaces should incorporate recognizable cues wherever possible. Others are more complex and context-dependent.

Models to support design. The psychological theory has led to the development of analytic and predictive models of user behavior the same with guidelines and principles. Some of these include a specific model of human problem solving, others of physical activity, and others attempt a more comprehensive view of cognition. As we have observed, some predict a typical computer user how would behave in a given situation while others analyze why particular user behavior happened. As such, this is just based on cognitive theory.

Techniques for evaluation. Techniques that provide are invaluable tools for the designer of interactive systems.

Lesson 2: The Computer

Objectives:

At the end of the lesson, the student must be able to:

1. explain the elements that affect the interaction; and
2. discuss the several factors that can limit the speed of the computer when designing an interactive system:

Lesson Content:

To know how humans, interact with computers, we need to have an understanding of both parties in the interaction. In the previous module explored aspects of human capabilities and behavior of which we need to be aware in the context of human-computer interaction. This module 2 considers the computer and associated input-output devices and investigates how the technology influences the nature of the interaction and style of the interface. We will concentrate principally on the traditional computer but we will also look at devices that take us beyond the closed world of keyboard, mouse, and screen. As well as giving us lessons about more traditional systems, these are increasingly becoming important application areas in HCI.

A computer system is formed from various elements. Each of the subsequent elements affects the interaction:

- input devices - text entry and pointing
- output devices - screen, audio
- paper input and output
- memory - RAM, permanent storage media
- processing - the speed of processing, networks

A typical computer system

As shown in Figure 2.1 below a typical computer system where there is the computer 'box' itself, a keyboard, a mouse, and a color screen.

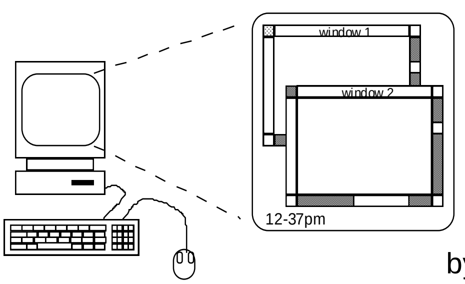


Figure 2.1 A typical computer system (Source: Dix, A., Finlay, J., Abowd, G.D., & Beale, R. (2004). Human-Computer Interaction, 3rd Edition)

These devices dictate the styles of interaction that the system supports. If we use different devices, then the interface will support a different style of interaction. The computer is the main source in the interaction that runs the program.

As explained in Human-Computer Interaction, 3rd Edition by Dix, A., et al (2004), the input devices for interactive use, allowing text entry, drawing, and selection from the screen are discussed as follows:

- text entry: traditional keyboard, phone text entry, speech and handwriting
- pointing: principally the mouse, but also touchpad, stylus, and others
- 3D interaction devices

A. Text Entry Devices

The Alphanumeric Keyboard. The keyboard is considered as one of the most common input devices use nowadays. It is used for entering textual data and commands. The vast majority of keyboards have a standardized layout and are known by the first six letters of the top row of alphabetical keys, QWERTY.

The QWERTY Keyboard

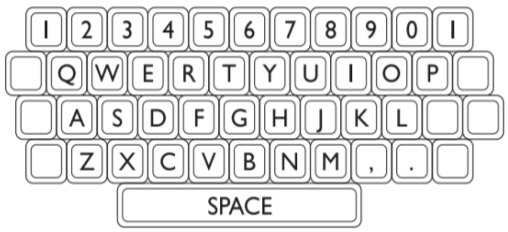


Figure 2.2 The standard QWERTY keyboard (Source: Dix, A., Finlay, J., Abowd, G.D., & Beale, R. (2004). Human-Computer Interaction, 3rd Edition)

Figure 2.2 shows the layout of the digits and letters on a QWERTY keyboard is fixed. It is the most common standard layout and with principal text entry device, although it has a slight difference between UK and USA keyboards. The name comes from the first six letters in the top left letter row. Other keyboard designs allow faster typing but a large social base of QWERTY typists produces reluctance to change. Usually connected by an umbilical cord. Allows rapid entry of text by experienced users.

Handwriting Recognition. With the advent of technology, utilizing handwriting recognition has many advantages over using a keyboard. It is therefore attractive as a method of text entry, although there are some disadvantages with handwriting recognition. Handwritten text can be input into the computer, using a pen-based and a digesting tablet which is a common form of interaction. The problems in handwriting recognition are coping with different styles of handwriting. In doing so, handheld organizers being released now incorporate handwriting recognition technology and do away with a bulky keyboard.

Potential: vast - gesture recognition, sign language interpretation, etc.

Speech recognition. A promising area of text entry, but it has been successful for some years and is still used in very limited situations - single user and limited vocabulary systems. There has been a problem with an external noise interfering and imprecision of pronunciation e.g. those that are heavily influenced by local dialects.

B. Positioning, Pointing, and Drawing

Mouse. A handheld pointing device, a very common and easy to use for desktop computers.

Touchpad. Touchpads are touch-sensitive tablets usually around 2–3 inches (50–75 mm) square. They are operated by stroking a finger over their surface, rather like using a simulated trackball. The feel is very different from other input devices, but as with all devices users quickly get used to the action and become proficient.

Trackball and thumbwheel. A pointing device consisting of a ball held by a socket containing sensors to detect a rotation of the ball about two axes - like an upside-down mouse with an exposed protruding ball. Used when high precision is needed like in Computer-Aided Design (CAD). The ball is rotated inside static housing; relative motion moves the cursor. Requires buttons for picking. Size and “feel” of trackball itself important. Requires little space, was one time popular for portable and notebook computers.

Joystick. An indirect input device consisting of a small palm-sized box with a stick or shaped grip sticking up from it that points on a base. It is a simple device with which movements of the stick cause a corresponding movement of the screen cursor. There are two types of joystick such as the absolute and the isometric or velocity-controlled joystick. In the absolute joystick, the movement is an important characteristic, since the position of the joystick in the base corresponds to the position of the cursor on the screen. While isometric (velocity-controlled) joystick, the pressure on the stick corresponds to the velocity of the cursor, and when released, the stick returns to its usual upright centered position. Usually provided with buttons for selection, either be on top or front like a trigger.

Touch-sensitive screens (touchscreens). Detect the presence of a finger or stylus on the screen. Direct pointing devices e.g. common in airports with self-service terminals.

Advantages: Fast, and require no specialized pointer. Good for menu selection. Suitable for use in a hostile environment: clean and safe from damage.

Disadvantages: Finger can mark screen. Imprecise (finger is a fairly blunt instrument!) - difficult to select small regions or perform accurate drawing. Lifting arm can be tiring and can make the screen too close for easy viewing.

Stylus and light pen. Both stylus and light pen can be used for fine selection and drawing, but both can be tiring to use on upright displays and are harder to take up and put down when used together with a keyboard. A light pen is a computer input device in the form of a light-sensitive wand used on the monitor. It allows the user to point to displayed objects, or draw on the screen like a touch screen but with greater positional accuracy. In operation, the pen is held to screen and detects burst of light from screen phosphor during display scan.

Stylus, light pen, and touchscreen are all very direct in that the relationship between the device and the thing selected is immediate. In contrast, mouse, touchpad, joystick, and trackball all have to map movements on the desk to cursor movement on the screen.

For a direct pointing device, it's accurate (can address individual pixels), and can be used for fine selection and drawing. The problems for pen, it can obscure the display, a fragile, can be lost on a busy desk, and tiring on the arm.

Digitizing tablet. A more specialized device is typically used for freehand drawing but may also be used as a mouse substitute. Digitizing tablets are capable of high resolution and are available in a range of sizes. Sampling rates vary, affecting the resolution of cursor movement, which gets progressively finer as the sampling rate increases. The digitizing tablet can be used to detect relative motion or absolute motion but is an indirect device since there is a mapping from the plane of operation of the tablet to the screen. It can also be used for text input; if supported by character recognition software, handwriting can be interpreted. Problems with digitizing tablets are that they require a large amount of desk space, and maybe awkward to use if displaced to one side by the keyboard.

Eyegaze. A very fast and accurate device, but the more accurate versions can be expensive. It is fine for selection but not for drawing since the eye does not move in smooth lines. Also, in real applications, it can be difficult to distinguish deliberately gazing at something and accidentally glancing at it. Allows controlling the cursor with your eye movements.

Cursor keys and discrete positioning

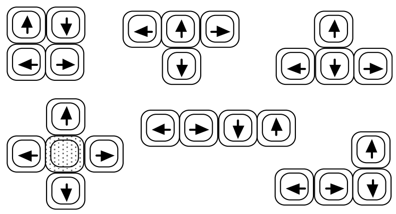


Figure 2.3 Various cursor key layouts
(Source: Dix, A., Finlay, J., Abowd, G.D., & Beale, R. (2004). Human-Computer Interaction, 3rd Edition)

As shown in Figure 2.3 is various cursor key layouts. Four keys (up, down, left, right) on the keyboard. Very, very cheap, but slow. Useful for not much more than a basic motion for text-editing tasks. No standardized layout: line, square, "T" or inverted "T", or diamond shapes are common.

C. Display Devices

The following output display devices for interactive use are:

- different types of screen mostly using some form of a bitmap display
- large displays and situated displays for shared and public use
- the digital paper may be usable soon.

Technologies. It is important to discuss several different technologies, in particular, CRT and LCD screens and the common properties of all bitmap display devices. Also, consider some more recent display methods including large displays, situated displays, and digital paper.

Cathode Ray Tube

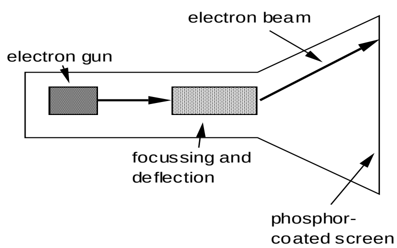


Figure 2.4 CRT screen
(Source: Dix, A., Finlay, J., Abowd, G.D., & Beale, R. (2004). Human-Computer Interaction, 3rd Edition)

The cathode ray tube (CRT) is usually one of the predominant computer screens. It is a cheap display device and has fast enough response times for rapid animation coupled with a high color capability. Stream of electrons emitted from the electron gun, focused and directed by magnetic fields, hit the phosphor-coated screen which glows as illustrated in Figure 2.4.

Concerns regarding emissions of radiation are as follows:

- X-rays: largely absorbed by screen
- Ultraviolet (UV) and infrared radiation (IR) from phosphors in insignificant levels
- Radiofrequency emissions, plus ultrasound (~16kHz)
- An electrostatic field leaks out through the tube to the user. Intensity is dependent on distance and humidity. Can cause rashes.
- Electromagnetic fields (50Hz-0.5MHz). Create induction currents in conductive materials, including the human body. Two types of effects attributed to this: visual system - high incidence of cataracts in VDU operators, and concern over reproductive disorders (miscarriages and birth defects).
- Take extra care if pregnant.

The following hints which are advantageous to health:

- do not sit too close to the screen;
- do not use very small fonts;
- do not look at the screen for long periods without a break;

- do not place the screen directly in front of a bright window; and
- work in well-lit surroundings.

Liquid Crystal Displays (LCD). In LCD, they have no radiation problems associated. This can be found on portables, notebooks, and desktops. These displays utilize liquid crystal technology and are smaller, lighter, and consume far less power than traditional CRTs.

LCD is less tiring than CRT displays, and reduces eye-strain due to the reflected nature of light rather than emitted. The use of super-twisted crystals has improved the viewing angle, and response rates are improving all the time (necessary for tracking cursor accurately).

Digital Paper. Thin flexible materials that can be written electronically, just like a computer screen, but which keep their contents even when removed from any electrical supply.

D. Devices for Virtual Reality and 3D Interaction

Virtual reality systems and 3D visualization which have special interaction and display devices.

Positioning in 3D Space

The 3D Mouse

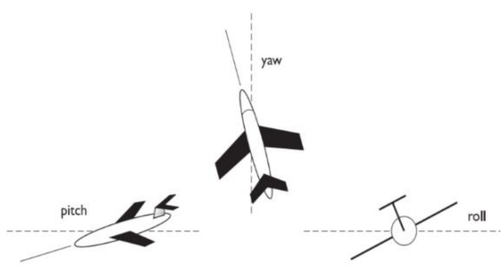


Figure 2.5 Pitch, yaw, and roll
(Source: Dix, A., Finlay, J., Abowd, G.D., & Beale, R. (2004). Human-Computer Interaction, 3rd Edition)

There are a variety of devices that act as 3D versions of a mouse. The 3D mouse has a full six degrees of freedom as its position can be tracked (three degrees), and also it's up/down angle (called pitch), it's left/right orientation (called yaw), and the amount it is twisted about its axis (called roll) as illustrated in Figure 2.5. With the 3D mouse and indeed most 3D positioning devices, users may experience strain from having to hold the mouse in the air for a long period.

Dataglove. An input device for human-computer interaction (HCI) is worn like a glove. It detects joint angles and 3D hand position.

*Advantages***:** easy to use, potentially powerful, and expressive (10 joint angles + 3D spatial information, at 50 Hz).

*Disadvantages***:** Difficult to use with a keyboard and expensive (~£10k/glove).

3D Displays. The 3D images used in virtual reality (VR) have led to new forms of the input device, and they also require more sophisticated outputs. With the rapid change of technology nowadays, all visual displays used with computers are capable of displaying 3D graphics.

Simulators and VR Caves. Before virtual reality (VR), simulator systems pioneered the use of large, interactive displays of 3D computer graphics. Simulators have been used for many applications, including flight simulation, tank and military vehicle simulation, space vehicle simulation, and simulators for entertainment. More general-purpose rooms called caves have large displays positioned all around the user or several back projectors. In these systems, the user can look all around and see the virtual world surrounding them.

E. Physical Controls, Sensors, and Special Devices

The various devices in the physical world:

- physical controls and dedicated displays
- sound, smell, and haptic feedback
- sensors for nearly everything including movement, temperature, bio-signs.

Special Displays

• head-up displays - found in aircraft cockpits
presents data without requiring users to look away from their usual viewpoints

Sound Output (Auditory). Beeps, bongs, clanks, whistles, and whirrs are all used to varying effect and for error indications. Sounds offer an important level of feedback in interactive systems. This appears to speed up interactive performance or confirmation of actions, e.g. key click, doorbell, etc.

F. Paper: Printing and Scanning

Paper output and input: the paperless office and the less-paper office:

- different types of printers and their characteristics, character styles, and fonts
- scanners and optical character recognition.

Printing. Popular printing technology builds up characters on-page, as on the screen, as a series of dots. Allows any character set or graphic to be printed, depending on the resolution of the dots, measured in dots per inch (dpi).

- dot-matrix printers use inked ribbon, with a line of pins that can strike the ribbon, dotting the paper.
- ink-jet and bubble-jet printers tiny blobs of ink sent from print head to paper: ink-jet squirts them, bubble-jet uses heat to create a bubble.

Font and Page Description Languages. Font refers to the particular style of a text. Some typical fonts are Courier, Helvetica, Palatino, and Times Roman. The size of a font is measured in points (pt). The point is a printer's measure and is about 1/72 of an inch. The point size of the font is related to its height: a 12-point font has about six lines per inch.

A page description language (PDL) is a programming language that uses to describe the structure and appearance of a document page. It requires the arrangement of a printed page through commands from a computer that the printer carries out. With this, more sophisticated printers can accept a page description language, the two most commonly used are Hewlett Packard's Printer Control Language (PCL) and Adobe's PostScript. This uses a programming language for printing.

Scanners and Optical Character Recognition. Scanners take paper and convert printed images and documents into a bitmap or in electronic form. There are two kinds of scanner:

- flat-bed: paper placed on a glass plate and the whole page converted into bitmap; and

- hand-held: scanner passed over the paper, digitizing strip typically 3-4” (80 or 100 mm) wide.

These scanners are particularly valuable used in desktop publishing for incorporating photographs and other images, and for electronic document storage and retrieval systems which do away with paper storage (filing cabinet).

G. Memory

The human brain has significantly more storage than an average computer where it can process information exponentially faster than a human brain. The computer memory is divided into two levels such as short-term memory (RAM) and long-term memory (magnetic and optical disks).

RAM and Short-term Memory (STM). Random-access memory (RAM) is held on silicon-chips. Typical access times are of the order of 10 nanoseconds, which is a hundred-millionth of a second, and information can be accessed at a rate of around 100 Mbytes (million bytes) per second. Typical storage in modern personal computers is between 64 and 256 Mbytes RAM. Usually, RAM is volatile when losing information if the power is turned off. Some non-volatile RAM used to store basic set-up information.

Disks and long-term memory (LTM). The long-term memory consists of disks perhaps with small tapes for backup. The existence of backups, and appropriate software to generate and retrieve them, is an important area for user security. There are two kinds of technology used in disks:

- magnetic disks – most common storage media coated with magnetic material are floppy disks which store between 300 Kbytes to 1.4 Mbytes (removable), and hard disks typically 5 Gbytes or larger access time ~10ms, the transfer rate 100kbytes/s; and
- optical disks - use laser light to read and sometimes write on the disk. It is more robust than the magnetic disks. The most common is the CD-ROM (read-only memory). It has a capacity of around 650 megabytes, but cannot be written to at all. They are useful for published material such as online reference books, multimedia, and software distribution. Recordable CDs are a form of WORM device (write-once-read-many) and they are very useful for backups and for producing very secure audit information. Also, there are fully rewritable optical disks, but the rewrite time is typically much slower than the read time, so they are still primarily for archival not dynamic storage.

Virtual Memory. As explained in Computer Business Review (2 October 2019), virtual memory is a feature of an operating system that enables a computer to compensate for shortages of physical memory by transferring pages of data from random access memory (RAM) to disk storage. This means that when RAM runs low, virtual memory can move data from it to a space called a paging file. Definitely, virtual memory stores some programs temporarily on disk which makes RAM appear bigger. This process allows for RAM to be freed up so that a computer can complete the task.

H. Processing and Networks

Processor Speed. The speed of processing can seriously affect the user interface whether it is too slow or too fast. Designers tend to assume infinitely fast processors and make interfaces more and more complicated. But problems occur when processing cannot keep up with all the tasks it needs to do due to the effects of buffering:

- cursor tracking – happens in character-based text editors. The user tries to correct this by either pressing first the cursor-left key or else the cursor-right key and again overshoots; and
- icon wars – occurs on window systems. The user clicks on a menu or icon, and nothing happens (either the machine is busy or slow), so the user clicks on another, then the system responds and windows fly everywhere.

Limitations on Interactive Performance. The designer needs to understand the limitations of the computer system and must be taken into account when designing an interactive system. With that, there are several factors which limit the speed of an interactive system:

- *Computation bound*. Computation takes ages, causing frustration for the user;
- *Storage channel bound*. The bottleneck in the transference of data from disk to memory;
- *Graphics bound*. This is the most common bottleneck for many modern interfaces. Updating displays requires a lot of effort which sometimes helped by adding a graphics co-processor optimized to take on the burden; and
- *Network capacity*. Many computers networked, whereas shared resources and files on a remote machine, access to printers, etc. But interactive performance can be reduced by slow network speed.

Lesson 3: The Interaction

Objective:

At the end of the lesson, the student must be able to:

1. discuss Norman's model of interaction with execution/evaluation loop; and

Lesson Content:

After having been through with the interactions between human and computer systems respectively, this module helps us to understand what is going on in the interaction between user and system. This addresses the communication between what the user wants and what the system does.

As discussed in Human-Computer Interaction, 3rd Edition by Dix, A., et al (2004), the interaction is the communication between the user and the system. The purpose of the interaction is to aid a user in accomplishing goals from some application domain. Essentially, there are two (2) different forms of interaction:

- batch processing - usually when large quantities of data have to be read into the machine. It requires little user intervention.
- interactive - when the user controls things all the time

A. Models of Interaction

Interaction Frameworks. It is essential to have a framework in order to puts interaction into perspective, and as well as presents a global view of interaction. In Human-Computer Interaction (HCI), Norman's model of interaction is perhaps the most influential. Norman's model concentrates on the user's view of the interface. The interactive cycle is divided into two major phases: execution and evaluation.

The following stages in Donald Norman's Interaction framework (Execution - Evaluation Cycle) are:

- user establishes the goal
- formulates intention (more specific than goal)
- specifies action at the interface (action sequence)
- executes action
- perceives system state after execution
- interprets system state in terms of expectations
- evaluates system state with respect to goal and intentions

As shown in Figure 3.1 the execution/evaluation loop, the user establishes a goal that the user specifies by formulating an intent (more specific intention). Then, the user can determine a sequence of actions that will reach the goal, before it can be executed by the user. After the system responds, the user perceives the new system state which interprets it in terms of his expectations and evaluates with respect to the user's intended goal. If the system state reflects the user's goal then the computer has done what he wanted and the interaction has been successful; otherwise, the user must formulate a new goal and repeat the cycle.

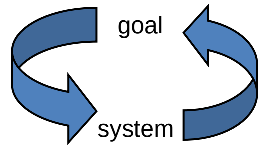


Figure 3.1 Execution/Evaluation Loop

Norman applies this model of interaction to demonstrate to explain why some interfaces cause problems to their users. The term 'Gulfs of Evaluation and Execution' were introduced in Norman (1986). Norman's model (Gulf Model) is useful in understanding the reasons of interface failures from the user's point of view. Whereas, the seven stages of the action model are an elaboration of the Gulf Model. Gulf of Execution represents the difference between the user's formulation of the actions to reach their goals and the actions allowed by the system (user's formulation of actions ≠ actions allowed by the system). While the Gulf of Evaluation is the difference between the physical presence of the system state and the expectations of the user (user's expectation of changed system state ≠ actual presentation of this state).

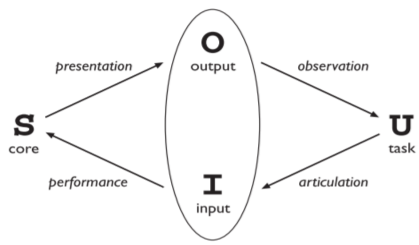


Figure 3.2 General interaction frameworks with Translations between components (Source: Dix, A., Finlay, J., Abowd, G.D., & Beale, R. (2004). Human-Computer Interaction, 3rd Edition)

Using Abowd and Beale's (1991) framework, the interaction has four components: System, User, Input, and Output. Each component has its own unique language. As the interface sits between the User and the System, there are four steps in the interactive cycle and each corresponding to a translation from one component to another as shown in Figure 3.2. The interaction translated between languages where the user articulates the goal in input language which is then translated into core language as operations to be executed by the system. The system transforms itself as described by the operation translated from the input. The output is communicated to the user. User asses output in relation to the original goal (evaluation phase) ending the interaction cycle that forms the four main translations involved in the interaction such as articulation, performance, presentation, and observation/evaluation.

B. Frameworks and HCI

Ergonomics. Based on the discussion of Dix, A., et al (2004), ergonomics (also known as human factors) is the study of the physical characteristics of the interaction on how the controls are designed, where the physical environment in which the interaction takes place, and the layout and physical qualities of the screen. Additionally, ergonomics focus on user performance and how the interface enhances or detracts from this. The following are examples of ergonomics:

- Arrangement of controls and displays
  e.g. controls grouped according to function or frequency of use, or sequentially
- Surrounding environment
  e.g. seating arrangements adaptable to cope with all sizes of users
- Health issues

- e.g. physical (position), lighting, noise, environmental conditions (temperature, humidity), time (excessive use of CRT dangerous to pregnant women)
- Use of color
  e.g. use of red for the warning, green for okay, awareness of color-blindness**,** etc.

C. Interaction Styles

Interaction can be seen in the dialogue between the computer and the user which influenced by the style of the interface. The interaction takes place within a social and organizational context that affects both user and system. Some applications have very distinct styles of interaction. There are a number of common interface styles including:

- command-line interface
- menus
- natural language
- question/answer and query dialogue
- form-fills and spreadsheets
- WIMP
- point and click
- three–dimensional interfaces

Command-line interface. Way of expressing instructions to the computer directly which use function keys, single characters (ipconfig, calc, cmd), short abbreviations (ipconfig, tracert), or whole words commands (ping). A typical example is the Unix/Linux system.

Menus

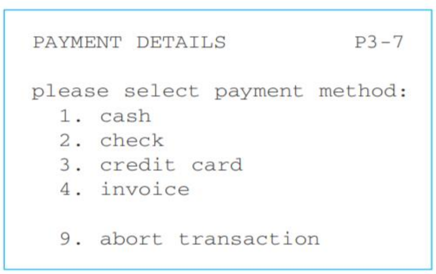


Figure 3.3 Menu-driven interface (Source: Dix, A., Finlay, J., Abowd, G.D., & Beale, R. (2004). Human-Computer Interaction, 3rd Edition)

As shown in Figure 3.3 the menu-driven interface has a set of options displayed on the screen and selected using the mouse, or numeric or alphabetic keys. Since the options are visible, they are less demanding of the user, relying on recognition rather than recall. However, menu options still need to be meaningful and logically grouped to aid recognition. Menu systems can be purely text-based with options presented as numbered choices (recent docs in MS word), graphical selected by arrow/mouse, and combination (e.g. mouse plus accelerators (print options).

Natural Language. Expression of interaction instructions in everyday words. Use speech recognition or typed natural language. Language is vague, ambiguous, and hard to do well at a number of levels. Humans rely on context and general knowledge to address the ambiguity. With these, it is essential to try to understand a subset and pick on keywords.

Question/Answer and Query Dialog. This is a simple mechanism for providing input to an application in a specific domain. The user is asked a series of questions (mainly with yes/no responses, multiple-choice, or codes) and so is led through the interaction step by step.

In question/answer interfaces, the user-led through interaction via a series of questions and indeed suitable for novice users. This is frequently used in information systems. While query languages are used to retrieve information from the database. This requires an understanding of database structure and language syntax hence requires some expertise (e.g. SQL).

Form-fills and Spreadsheets. Form-filling interfaces are used primarily for data entry and even in data retrieval applications. The user is presented with a display or screen resembling a paper form, with appropriate values to fill out in certain fields as shown in Figure 3.4.

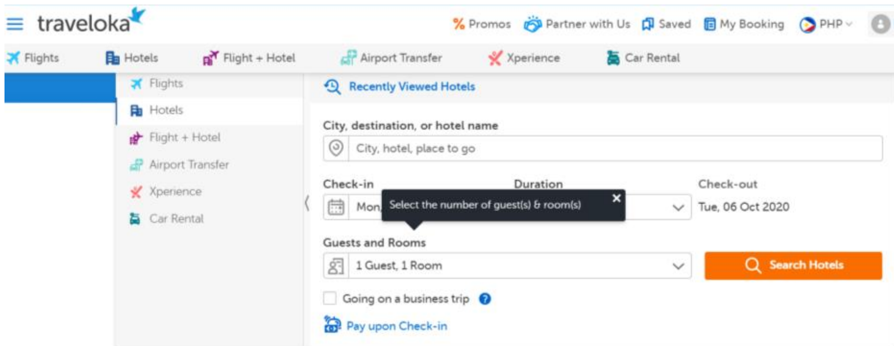


Figure 3.4 Sample form for booking (Source: https://www.traveloka.com/en-ph/)

The spreadsheet contains a grid of cells, each of which can contain a value or a formula. MS Excel is most commonly used today. The formula can involve values of other cells e.g. sum of all cells in this column, where the user can enter and alter data.

WIMP Interface. WIMP stands for windows, icons, menus, and pointers (sometimes windows, icons, mice, and pull-down menus). This is also a default style for the majority of interactive computer systems, especially PCs and desktop machines.

- *Windows.* Areas of the screen that behave as if they were independent terminals. Whereas, is where can contain text or graphics, can be moved or resized, can overlap and obscure each other, or can be laid out next to one another (tiled). Windows has *scrollbars,* allows the user to move the contents of the window up and down or from side to side, and *title bars describe* the name of the window.
- *Icons.* A small picture or image is used to represent a closed window. Icons can be realistic representations of the objects itself, or can be highly stylized.
- *Pointers.* Important component of WIMP style that relies on pointing and selecting things such as icons. It usually achieved with mouse capable of such tasks, also joysticks (high precision pointing), trackball (like inverted mouse), cursor keys or keyboard shortcuts. It considered a wide variety of graphical images.
- *Menus.* A menu presents a choice of operations or services that can be performed by the system (like a restaurant menu) at a given time.

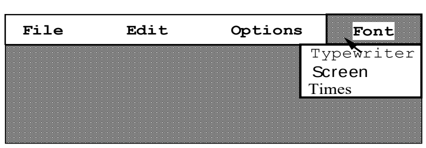


Figure 3.5 Pull-down menu

As shown in Figure 3.5 a pointer moves to the selected of a menu item.

Kinds of Menus. Menu bar often placed at the top of the screen (for example, MacOS) or at the top of each window (for example, Microsoft Windows). Menus are normally dragged down with the following:

- pull-down menu - mouse hold and drag down menu
- drop-down menu - mouse click reveals menu
- fall-down menus - mouse just moves over bar

Pop-up menus often used to present context sensitive options, for example allowing one to examine properties of particular on-screen objects (actions for selected object) e.g. print.

Menus Extras: Cascading menus is a hierarchical menu structure in which item selection opens up another menu adjacent to the item. In keyboard accelerators, the key combinations are the same effect as menu item. There are two kinds of keyboard accelerators:
active when menu open, it's usually first letter; and active when menu closed, Ctrl + letter.

Menus Design Issues: The following are being considered when designing menus include which kind to use, what to include in menus**,** words to use (action or description)**,** how to group items**,** and choice of keyboard accelerators.

- *Buttons*. Individual and isolated regions within a display that can be selected to invoke a specific action. There are special kinds of buttons: radio buttons which set of mutually exclusive choices (choose one), and check boxes which set of non-exclusive choices (can choose more than one).
- *Dialogue boxes.* Information windows that pop up to inform of an important event or request information. For example, when saving a file, a dialogue box is displayed to allow the user to specify the filename and location. Once the file is saved, the box disappears.
- *Palettes.* A mechanism for making the set of possible modes and the active mode visible to the user. It is usually a collection of icons that are reminiscent of the purpose of the various modes.

Teaching Delivery (TLAs)

- Lecture and Class Discussion (Synchronous and Asynchronous Learning)

Assessment:

Discussion Forum (Q and A) via FB Social Learning Group

- Why is it important to know the aspects of the human and computer knowing its capabilities and limitations towards interaction? Explain the capabilities and limitations of the human as an information processor to design interactive systems.

References:

1. Dix, A., Finlay, J., Abowd, G.D., & Beale, R. (2004). Human-Computer Interaction, 3rd Edition. Hillsdale, NJ: Prentice-Hall
2. Techtarget Network. (n.d). HCI (human-computer interaction). Retrieved from http://searchsoftwarequality.techtarget.com/definition/HCI-human-computer-interaction
3. The Human Eye. Retrieved from https://courses.lumenlearning.com/boundless-physics/chapter/the-human-eye/
4. Staffing, Kebbeh. (n.d). Human-Computer Interaction. Retrieved from http://oer.avu.org/handle/123456789/672
5. Human-Computer Interaction. Retrieved from https://www.cs.bham.ac.uk/~rxb/Teaching/HCI%20II/intro.html