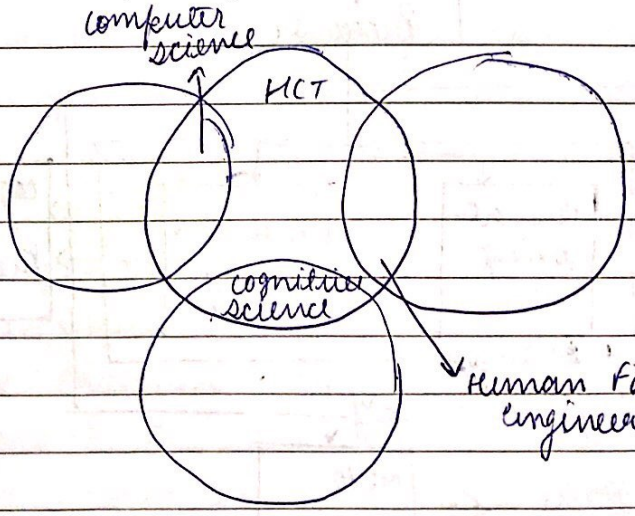
Human Computer Interface (HCI)

~~HCI is~~

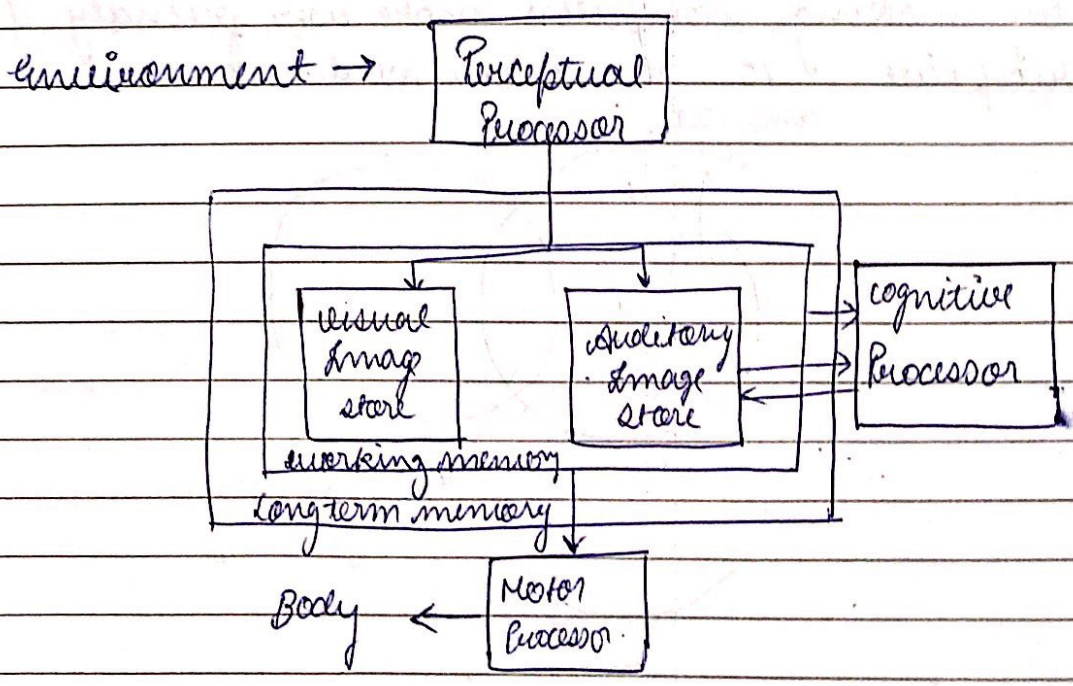
HCI is a discipline in which we study about the way that Human beings (users) and computers interact to ~~over~~ increasing levels of both complexity and simplicity. This is not only about UI design but it is a multidisciplinary field of study focusing on the design of computer technology & the interaction b/w users & computer.

The goals of HCI are to produce usable & ~~self~~ safe functional systems. To understand the factors that determine how people use technology, develop tools and techniques for building a suitable system. The another goal of HCI is to improve the interaction b/w users & computers by making computers more user friendly & receptive to the user's need.



Human Memory

- Sensory memory (Moment lease memory)
- Short term memory (working memory)
- Long term memory (life-time memory)
  - Implicit
    - Procedural Memory
  - explicit
    - Declarative Memory (Facts/events)
      - episodic memory (events/experiences)
      - semantic memory (facts/concepts)



Relation b/w STM & LTM and working

* User Interface :-

The user interface is the part of computer & software that people can see clear, touch, hear, talk or understand directly or indirectly. The UI is essential to interact with machine in terms of I/p & O/p. The common mechanism for i/p & o/p are based on text, image, voice, object, smell sound, strength etc.

→ Importance of UI -

1.) When design interface defines the capabilities of the system.
2.) A good interface can reduce the complexity of,
3.) An interface with different components can increase the confusion and provoke to make mistakes so the classification of components & placing (appearance) can reduce the mistakes and guide towards user friendlyness.
4.) A good interface design is required because poor design can lead to frustration, agression and stress for the user.

→ Benefits of good Design :-

1.) Increased performance.
2.) Make user friendly.
3.) Decrease training cost & time.
4.) Less support is required.
5.) Generate more satisfaction.
6.) Economic approach.

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Advantages & disadvantages of Graphical Interface:-

Advantages:

1.) Symbols recognized faster than text
2.) Faster learning.
3.) Faster use & problem solving.
4.) Easier remembering.
5.) Natural Approach.
6.) Exploits visual cues
7.) Fosters more concrete thinking.
8.) Provides context.
9.) Error free or less error
10.) Increased feeling of control.
11.) Immediate feedback.
12.) Predictable Responses.
13.) Easily reversible actions.
14.) Less anxiety.
15.) More attractive.
16.) May consume less space.
17.) Provides multi-language platform.
18.) Support transition from CLI.
19.) Easily augmented with text display.

Disadvantages:-

1.) Greater design complexity.
2.) Learning of new system functions (Including pointing/directional devices)
3.) Replaces National languages with S/W.
4.) Human comprehension limitations.
5.) Lack of experimentally-derived design guidelines.
6.) Window manipulation Requirements.

7.) Production limitation (Licensing issues)
8.) Few tested icon exists.
9.) Insufficient for expert users.
10.) Inefficient for touch methods.
11.) Imperfect style of interaction.
12.) Changes preferences in different users.
13.) Increased chances of clutter and confusion.
14.) Hardware limitations.
15.) May consume more storage space.
16.) More investment required.

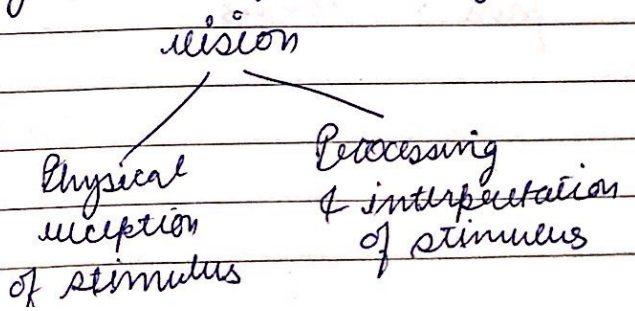
The Human :-

Humans are limited in their capacity to process information. This has important implication of design.

Cognition :- Cognition is the process by which the sensory input is transformed, reduced, elaborated, stored, recovered or used

* Specific Kinds of Cognitive Processes :-

1.) Attention
2.) Perception & Recognition
3.) Memory
4.) Learning
5.) Reading, speaking, listening.
6.) Problem solving, planning, Reasoning, and decision making



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Reading :-

→ visual pattern matching.
→ Language representation decoding.
→ Interpreted using knowledge of syntax, semenantics pragmatics.

Hearing :-

→ Sound recognition
→ pitch - frequency
loudness - amplitude
timbre - quality or type.
→ Filtering sound.

Touch :-

→ stimulus received via receptors. (in skin)
- thermo
- noise
- mechano.

Memory :- (discussed)

Movement :

Response time = Reaction time + movement time

Reaction time:
visual - 200 ms
Auditory - 150 ms
pain - 700 ms

movement time:
Depends on age, fitness, environment.

The computer :-

components :- i/p devices
o/p devices
memory units.
processing units

classification

size based → House based / office based
→ Hand held

Recent trends in devices :-

→ Text entry devices.
→ Hand writing recognition.
→ speech / voice recognition.
→ Positioning / Pointing / Drawing
→ Touch sensitive control.
→ Stylus for magnetic surface / characters.

Display devices :-

→ Resolution → stereoscopic vision
→ Aspect Ratio → VR helmet design
→ Color depth

VR & 3D Interaction (Input devices)

→ 3D mouse — roll (Y), pitch (X), yaw (Z)
→ Data glove
→ VR helmets.
→ virtual controllers.
→ whole body tracing

Sounds:

→ Beeps, bangs, clonks, whistles and whirrs.
→ for error Indication.
→ Action confirmation eg: key press, mouse click

Touch:

→ Vibration
→ Simulation
→ Haptic Devices

Texture, smell and taste

* **Interaction:** It is a translation or communication b/w user & machine to achieve the goal with predefined process (task) for any specific domain (~~work~~ working) (work area).

* **Donald Norman's Model :-**

This model is based on user's view of the interface for execution & evaluation of task.
Following 7 stages are defined as:

1.) user establishes the goal.

execution loop
2.) Formulate Intentions.
3.) Specifies actions at interface
4.) Executes actions

} ⇒ Gulf of execution ⇒ user's formation of action ≠ Action's followed by system

evaluation loop
5.) Perceives system state
6.) Interprets system state.
7.) Evaluate system state with goal.

} Gulf of evaluation ⇒ user's expectation of changed system state ≠ Actual presentation of this state.

* Humans Error :-

Slip & mistake.

☺ → understand system and goal

☺ → correct formulation of action.

☹ → Incorrect action.

☹ → may not even have right goal.

* Ergonomics :

Physical characteristics of interaction such as arrangement of controls & displays, surrounding environment, health issues, use of colors, ~~&~~ etc. is known as ergonomics.

Interaction styles :-

1.) **Command Line Interface (CLI)** - It is the way of expressing instructions to the computer directly through function keys, single characters, short abbreviations, ~~all~~ whole words ~~words~~ or a combination. It is suitable for repititive task and used by expert users. Eg: Dos, Unix, dBase III, word star, Quattro / Lotus 1 2 3.

Languages { ANSI C / TURBO C 3.0
GW Basic
Q Basic

2.) **WIMP Interface** : (Windows Icon Menu Pointer) (GUI)

3.) **Natural Language Processing (NLP)** : It is speech recognizat^n process ~~or~~ and also called typed natural language

system. This system is hard and vague to implement, therefore subsets of keywords are created along with voice & speech recognization.

4.) Menu: Set options displayed on the screen.
→ restricted form of full WIMP system.
→ dropdown menu.
→ contextual menu / flying menu

5.) Query Interface < QBA / SL

6.) Forms fill
↳ spread sheets

7.) 3D interface

* Shneidermon's Golden Rule: (Interface design)
S.G.R have 8 golden rules are considered for user interface design those are as follows:-

1.) Rules of consistency:-
consistence sequence of actions should be required in similar situations when user interface is design.
Identical terminology should be used in prompts, menus, help screen & consistent command should be employed throughout.

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2.) Enable frequent user to use shortcut.
As the frequency of use increases so the users desire to reduce the no. of interaction & to increase the pace of interaction. Abbreviations, function keys, hidden command & macro facilities are helpful to an expert users.

3.) Offers informative feedback:-
For every operator actions, there should be a system feedback for frequent and minor actions while for infrequent & major actions the response should be more substantial.

4.) Design dialogue to yield closure:-
Sequences of actions should be organised into groups with a beginning & middle & end the informative feedback and a completion of a group of action gives the operator satisfaction of accomplishment & indication there the way is cleared to prepare for the next group of action.

5.) Offer simple error handling:-
As much as possible design the system so the user cannot make serious error. If an error is made the system should be able to detect error and offer simple mechanism for handling the error.

6.) Permit easy reversal of action :-
This feature relieves the anxiety since the user knows that errors can be undone ; it thus encourage exploration of unfamiliar options. The units of reversibility may be a single action or a complete group of actions.

7.) Support Internal locus of control.
Experienced operators strongly desire the sense that they are in charge in the system & the system responds to their actions. Design the system to make users the initiators of actions ~~rather~~ rather than the responders.

8.) Reduce the short-term memory load :-
The limitation of human info processing in short term memory requires that displays be kept simple, multiple page displays be consolidated window motion frequency be reduced sufficient training time be allocated for course mnemonics & sequence of actions.

* General Principles of User Interface Design:-

1.) Aesthetically pleasing
2.) clarity
3.) compatibility
4.) configurability.
5.) comprehensibility
6.) consistency.
7.) Control
8.) Directness
9.) Flexibility
10.) familiarity.
11.) efficiency
12.) Predictability
13.) Recovery
14.) Forgiveness
15.) Responsiveness
16.) Transparency
17.) simplicity.

* Nielsen's 10 Heuristics for VI design:-

Jacob Nielsen has given 10 rules of VI design based on usability, those are called Heuristics because they are broad thumbrules based on previous experience & not specific guidelines for usability. They are as follows:-

1.) Visibility of system status (visibility Heuristic):
The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.

2.) Match Between System · Real world (Real · Word Heuristic)
The system should speak user's language with words, phrases & concept familiar to user rather than system oriented terms.

3) User control & freedom (control Heuristic)
users often choose system functions by mistake & will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue.

4.) Consistency & status (consistency Heuristic)
Users should not have to wonder whether different words, situation or action means the same thing.

5.) Error Prevention (
Error prevention is better than good error messages which is a careful design which prevents a problem from occuring in the first place. either eliminate error from conditions or check from those conditions & present users with a confirmation option before the come in to the action.

6.) Recognition rather than recall :-
minimise the user's memory load by making objects, actions & options visible. Instructions for use of the system should visible or easily retrievable when & where required.

7.) Flexibility & Efficiency of use :-
Accelerators may often speed up the interaction for the expert users and not the novice users, allow users to tailor frequent actions.

8.) Aesthetic & minimalist design :-
Dialogues should not contain irrelevant information or rarely needed information.

9.) Help users to Recognize, diagnose & recover from errors :-
Error messages should display on plain language, precisely indicates the problem and constructively suggests a solution.

10.) Help & Documentation :-
Even though it is better if the system can be used without documentation, it may be necessary to provide help & documentation at certain point of time. Such information should be easy to search, focused on task & precised.

* Contextual Inquiry :-
Contextual Inquiry is an ethnographic research method that helps to understand what persons do and why they do it. The method was created as a way of capturing work's complexities such as information flow, working environment & sequence of routine task. Contextual inquiry relies on 3 main

principles:
→ focus
→ context
→ partnership.

It is a semi-structured interview method to obtain information about the context of use. where users are first asked set of standard questions & then observe & question while they work in their own environment.

* Basic Guidelines:

1) Suspend Judgement
2) Be curios
3) Have a plan
4) Treat the participants with respect.

* Process:-

1) Identify a focus
2) use focus to identify the context to understand.
3) Identify the participants you ask to work with.
4) Reach out participants & observe ~~your~~ with scheduling

* Goals:

In depth understanding of the
→ Context
→ Activities, tasks
→ Pain points, Issues
→ Behaviour
→ Process, roles, Input & output.

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* Cognitive Walkthrough:-

The cognitive walkthrough is a usability evaluation method in which one or more evaluators work through a series of task & ask a set of questions from the perspective of the user. The focus of cognitive walkthrough is on understanding system's learnability for new & frequent users. CW was originally designed as a tool to evaluate mockup & use systems like ATM's while heuristic evaluation is where an evaluator explores a user interface & looks for common problems based on categorised interface design factors.

1.) Is effect of current action same as user's goal? (conceptual model)
2.) Is action visible
3.) will user recognize action as the correct one (labeling signifiers)
4.) will user understand feedback.

* Difference b/w HE, CW, VT

	Heuristic evaluation	Cognitive Walkthrough	Usability Testing
who →	system specialist	New user	end user
what →	examines if the system in question abides by recognized usability principles.	Performs list of specific tasks.	uses system for its intended purpose, as if he/she would be in a realistic situation at home/work etc.

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To see if system can comfortably be used based on prior experience in similar systems.	To see if the tasks can be performed in the correct sequence of actions they where designed it.	To give direct i/p on how real users use the system.

Why →

Unit - II

Model Based Design & Evaluation.

→ In 70's cognitive science had defined as a multi-disciplinary project in-compassing linguistic, anthropology, philosophy, psychology & computer science. HCI, became one of the original cognitive science domain.

→ The initial ~~user~~ vision of HCI as applied science was to bring cognitive science method and theories to bear on software development domain.

→ The prominent early example was the Goals, Operators, Methods, & Selection (GOMS) rules model for analysing ~~rooting~~ HCI given by Card, Moran & Newell in 1983.

→ The GOMS model is important because it set a standard for ~~specific~~ scientific & theoritical rigor & innovation that become a defining characterstics of HCI.

→ After GOMS models were classified on the basis of ~~uses after GOMS~~ experience of technology. The

categories are as follows:-
→ Desktop & mental models. (1980-1990)
→ collaboration & communication model (1990-2000)
→ self expression & social change model (2000-2010)

* GOMS Model:-

GOMS is a specialized human information processor model for HCI observation that describes a user's cognitive structure on 4 components. GOMS is widely used method by usability specialist for computer system designers because it produces quantitative & qualitative predictions of how people will use proposed system.

A GOMS model is composed of methods that are used to achieve specific goals. These methods are then composed of operators at the lowest level. The operators are specific steps that a user performs and are assigned a specific execution time. If a goal can be achieved by more than one method then selections rules are used to determine the proper method.

KSLM - GOMS:-

Goals:- They are the symbolic structures that define a state of affairs to achieve.

→ operators: operators are elementic perceptuals, motor or cognitive acts, whose execution is necessary to change any aspect of user's mental state or to affect the method's. describes a procedure for accomplishing a goal. selection

rules are needed when a goal is attempted. There can be ~~one two~~ more than one method available to the user for accompanishing.

- **Key stroke level Model:-**

There are different aspects of an interface to be accurately studied and predicted based on different GOMS variants. The key stroke level model (KSLM) predicts how long it will take an expert user to accomplish a routine task without errors using computer system.

To complete the task simply the KSLM analysing the steps required in the process and rearranging or eliminating unwanted steps to accomplish the task in more efficient way. The KSLM consists of six operators, the first four are

→ physical motor.
→ operators
→ Mental operator &
→ System response operator.

~~KP~~

- K — Key stroke pressed
- P — Pointing to target
- H — Homing the hand to device
- D — Drawing
- M — Mental preparing for physical action
- R — Response time.

CMN-GOMS

→ Stuart Card
→ Thomas P. Moran
→ Allen Newell

This technique requires a strict GOMS structure. The structure is rigid enough that the evaluator represents the task in a pseudocode format and also provides a guide for how to format selection rules. This method can also be used to estimate the load, the task places on the user for example, examining the no. of levels down the task tree that a goal branch ~~is~~ can be used to estimate the ~~no.~~ memory demand task places on the system. The process must remember information about all of the levels above the current branch.

This technique is more flexible than KLM. because the ~~pse~~ pseudocode is in general form & can be executed for different scenarios by going down different branches while in KLM procedure it is a simple list that has to be recreated for each different task.

Remark: To delete a file from explorer

→ GOAL: DELETE_FILE
  * GOAL: SELECT-FILE
    • [Select: GOAL: KEYBOARD-TAB METHOD
      GOAL: MOUSE-METHOD]
    ○ VERIFY SELECTION
  * GOAL: ISSUE-DELETE-COMMAND.

o[SELECT ¥: GOAL: KEYBOARD - DELETE - METHOD
→ PRESS - DELETE.
→ GOAL - CONFIRM DELETE.
GOAL: DROP - DOWN - MENU - METHOD.
→ Move mouse over file icon.
→ click right mouse button
→ Locate delete command.
→ Move mouse to delete. command.
→ Click left mouse button.
→ GOAL: CONFIRM - DELETE.
GOAL: DROP - DRAG - METHOD.
→ Move mouse over file icon.
→ Press - left - mouse Button
→ Locate recycling bin.
→ Move mouse to recycle bin
→ Release left mouse button.

NL-GOMS:-

Fitts' law:-

It is a predictive model of HCI used in human movement & ~~ergo~~ ergonomics. This scientific law predicts that the time required to rapidly move to a target area is a function of the ratio b/w the distance to the target and width of the target. Fitt's law is used to model the act of pointing either by physically touching an object with a hand or finger or virtually, by pointing to an object on a computer monitor using a pointing device.

Fitt's law has been shown to apply under a variety of conditions; with many different

- limbs (hands, feet, lower lip, head mounted sights, eye gaze etc.)
- Manipulanda (Input Devices)
- Physical environment (Including underwater) and
- User populations. (young, old, specialeducated, and drugs participants.)

with advent of NUI and different styles of interactions fitts' law is having more importance in UX or UI design.

By Paul Morris Fitts', proposed a matric to ~~identify~~ quantify the difficulty of target selection task, the matric was based on an information analogy, where the distance to the centre of target (D) is like a signal & the tolerance for the width of the target (W) is like noise. So, index of difficulty $\boxed{(ID) = \log_2\left(\frac{2D}{W}\right)}$ — (1)

Fitts' also proposed an index of performance (IP) in bits per second as a measure of human performance.

$$\boxed{IP = \frac{ID}{MT}} \quad — (2)$$

According to Fitts' "The average rate of information generated by a series of movements is the average information per movement divided by time per movement".

IP is more commonly called throughput (TP) which is used to include an adjustment for accuracy in the calculation. The eqⁿ expresses the relationship b/w MT & D & W task parameters

$$MT = a + b \cdot ID \quad \text{—③}$$

where MT → average time to complete the movement.
a, b → constants that depends on choice of i/p device. (determined by regression analysis.)
D → distance from the starting pt. to centre of the target.

$$MT = a + b \cdot \log_2\left(\frac{2D}{W}\right) \quad \text{by eq ①}$$

W → width of target measured along the axis motion.

Hick's Law (Hick-Hyman law):-

Hick & Hyman both has proposed a law which describes the time it takes for a person to make a decision as result of the possible choices one has, increasing the number of choices with increase in decision time logarithmically. This law assesses cognitive information capacity in choice-reaction experiments. The amount of time taken to process a certain amount of bits in this law is known as rate of gain of information

Hick was stating that the relationship b/w reaction time & the number of choices was logarithmic. while Hyman was responsible for ~~or~~ determining linear relation b/w reaction

time of information transmitted.
This law is related to KISS principle which states that most systems work best if they are kept simple rather than complicated. Therefore, simplicity should be a key goal in design.
The formula of Hick law is defined as:

$$RT = a + b \cdot \log_2(n)$$

where,
RT → reaction time
n → no. of choices present.
a, b → arbitrary measurable constants that depends on the task i.e. to be carried out & conditions under which it is to be carried out.

The application of Hick's law is simple reduce the no. of choices & get a faster decision process but there are exception to the rule. Therefore Hick's law predicts that the time and the effort it takes to make a decision increases with the no. of options; This law can be used to narrow down big volumes of information without overloading the user.

Unit-II

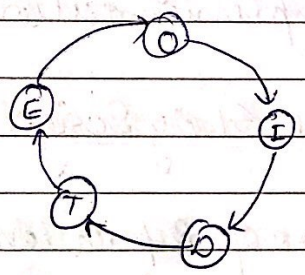
Empirical Research Methods (in HCI)

Empirical research is the research using empirical evidence which is the way of ~~getting~~ gaining knowledge by direct or indirect means such as observation, experience, and the available data-set. This research can be analyzed in both ways quantitative & qualitative. Quantifying the evidence & making sense of it in qualitative form, one can answer empirical questions which should be clearly defined & answerable with evidence collected (set of data).

Research design varies by field and by the question being investigated. The researcher attempts to describe accurately the interaction b/w instrument (computer) & the human (technique, choices, comfort etc.)

→ **Empirical Research cycle :-**

1) Observation
2) Induction
3) Deduction
4) Testing
5) Examination



→ **Observation** - The observation of a concept & inquiry concerning its causes.

Induction :- The formulation of hypothesis i.e. the generalized explanation of concept.

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Deduction - The formulation of experiments that will test the hypothesis.

Testing :- The procedure by which the hypothesis are tested and data are collected.

Evaluation :- The interpretation of the data of the formulation of the theory that a captured argument which presents the result of the experiments as the most reasonable explanation for the concept.

* **Issues with E-Research** :-

Empirical research is important because it can eliminate the flames of unscientific facts by using scientific practices. But there are following issues involved in empirical research.

1) **Financial Issue** :- In this collecting the data is an expensive process which impact financially on researchers model of E-R implimentation.

2) **Poor Study Design** :

3.) Lack of Replication study
4.) Peer review problems
5.) Research accessibility problem.
6.) Lack of adequate communication.

2. Poor study design :- ER design is based on facts and there relation inadequate relation and incomplete facts create the design inefficient.

3. Lack of replication study :- Inability to reproduce & replicate results for further research. Inheritance of issues can increase the research quality.

4) Problem of Peer review :-
Analysis and review of work done by another researcher is not a common practice in research field which decreases the quality of research work.

5.) Research accessibility Problem :- There are very few platforms available to get the research work on internet as well as offline.

6.) Lack of adequate comm.

→ other than above mentioned issues there are some more issues such as - repeat
→ using statistics to research method.

Research = statistical + statistical + subject
method technique strategies knowledge.

→ Equivalent models ignored → we use suitable model instead of multiple models.

→ over emphasis of fit indices.
→ over emphasis of good estimation methods.

→ confirmative method are used for exploratary analysis.

* Observation & measurements:-

observations are considered as facts or informations gathered from the system. There are two ways of gathering it either manually (human observation) and automatically (through computers, sensors, cameras etc.).

A measurement is a recorded observation which can be scaled on four:

(categorial) Nominal
ordinary
Interval
Ratio

↑ complicated
↓ sophisticated.

① Nominal data/ observation:- Nominal data are arbitrary ~~course~~ course ~~text~~ assigned to attributes usually used for counting & calculating.

② Ordinary data: It associates order or rank to an attribute via which the attribute is any characteristic or circumstance of interest. It is more sophisticated than normal data and used for comparison.

③ Interval Data:- Data which have equal distance b/w adjacent values but no absolute zero is exist. for eg:- temperature (degree, farenheit), distance (m, km, inch, cm

Ratio for this kind of data is not possible while we can find the statistical mean. In research we collect the data on 'Likert Scale'
Likert scale characteristics are -
(i) statement soliciting
(ii) Responses are symmetric around a neutral middle value.
(iii) Relations b/w responses are equal.

(4) Ratio Data :- It is the sophisticated ~~two~~ of the four steps of measurement including absolute zero. Because of absolute zero many different calculations are possible. comparison, summarising, counting are some aggregate function can be executed based on ratio data.

* Research Question :- To get the information based on observation we need some statements or questions in research are known as research questions. The selection of statement / questions is based on following characteristics
→ viable
→ Better than current practice
→ alternative solution
→ Performance & practice
→ weakness.

validity :- A validity is an attribute which checks the correctness over standard value. There are two types of validity →
(i) Internal - which affects observed result due to test conditions.
(ii) external - which results based on people & situation

* ANOVA - (Analysis of Variance)

ANOVA is a collection of statistical models & their associated estimation procedure used to analyse the differences among group means of a sample.
ANOVA is used to test general differences rather than specific differences among means. It also test the degree to which two or more groups vary in an experiment which indicates that there was a significant finding from the research.
The one way analysis of variance (ANOVA) is used to determine whether there are any statistical significant differences between the means of 3 or more independent (unrelated) groups.
For example, a factorial ANOVA is a ANOVA test with more than one independent variable or a 'factor'. It can also refer to more than one level of independent variable.
ANOVA is used to compare the means b/w 3 or more groups while the t-test is used to compare the means b/w two groups.

* Hierarchical Task Analysis:- (HTA)

HTA is more suitable for analysing the task. than ~~ANOVA~~ have a well defined structure. It involves describing the task in terms of task-subtask-hierarchy and a set of plans that define in what order subtask may be performed, or under what circumstances particular subtask are performed at all.

A structured objective approach to describe user's performance of task, hierarchical task analysis originated in human factors. In its most basic form, a