
# Research Design Variables, Part II

# Chapter 4: Research Design Part II

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- Sources of Error in Measurement
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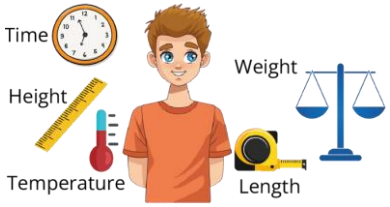
# What is Measurement in Research?




After studying and understanding the different types of quantitative research methods, sampling design, and selecting the proper type of sampling for the study in hand, the researcher has to decide and select the measurement of the study variables.

- **Measurement** is the process of describing some property of a phenomenon under study and assigning a numerical value to it. Measurement requires a scale.
- **A scale** provides a range of values—a yardstick—that corresponds to the presence of the properties of the concept under investigation.
- A scale provides the rules that associate values on the scale to the concept we are studying.
- Properties like weight and height can be measured directly with some standard unit of measurement
- However, it is not that easy to measure properties like motivation to succeed, ability to stand stress and the like

In these cases, the researcher uses predefined and tested scales for these properties.

# The Meaning of Scaling

We can measure concepts through direct and indirect observations:

1. **Direct Observation:** We can measure someone's weight or height. And, we can record the color of their hair or eyes.
2. **Indirect Observation:** We can use a questionnaire in which respondents provide answers to our questions about gender, income, age, attitudes, and behaviors.

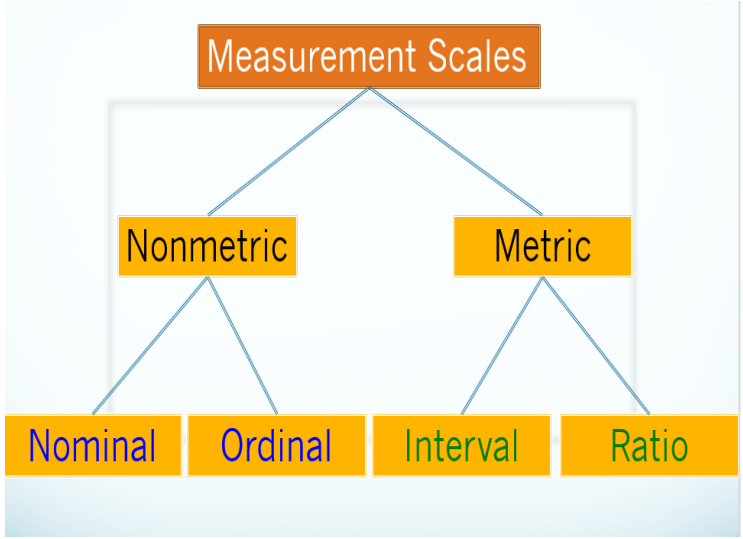
هناك بعض المتغيرات يمكن قياسها كمياً مثل حجم أو مدى التعرض والمشاهدة للتلفزيون بتحديد عدد الساعات والدقائق، أو مرات المشاهدة، وهناك بعض المتغيرات لا يمكن قياسها إلا من خلال مؤشرات تدل عليها، مثلاً لا يمكن قياس المنافع التي يحققها الفرد من قراءة الصحف إلا من خلال مقياس يتضمن مؤشرات متوقعة من القراءة، ويجيب الفرد بالموافقة أو عدم الموافقة على عبارات تعتبر مؤشرات عن هذه المنافع.

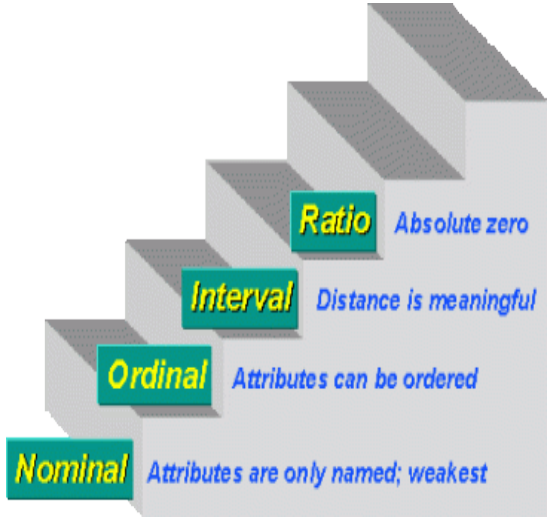
# Primary scales of measurement

- Scales of measurement can be considered in terms of their mathematical properties.
- The most widely used classification of measurement scales are:

  (a) nominal scale; (b) ordinal scale;

  (c) interval scale; and (d) ratio scale.
- The First two are nonmetric the other two are metric.



# Measurement in Research

## 2. Nominal scale

- Are numerical in name only, because they do not share any of the properties of the numbers.
- For instance if we record marital status as 1, 2, 3, or 4 for (single, married, widowed or divorced respectively),
  - we cannot write 4 > 2 or 3 < 4 ; and we cannot write 3 – 1 = 4 – 2, 1 + 3 = 4 or 4 / 2 = 2.
  - أي انه قد تم استخدام الأرقام للتمييز فقط ولا يمكن اجراء حسابات او مقارنات بينها / مثل ارقام الشعب ش1 و ش2 او ارقام الأسئلة في الامتحانات س1 او س2 وهكذا
  - Common examples of nominal data include:
    - Student registration numbers at their college or university
    - Numbers assigned to football players or jockeys in a horse race
    - Numbers assigned to gender, marital status, nationality, etc …

Examples

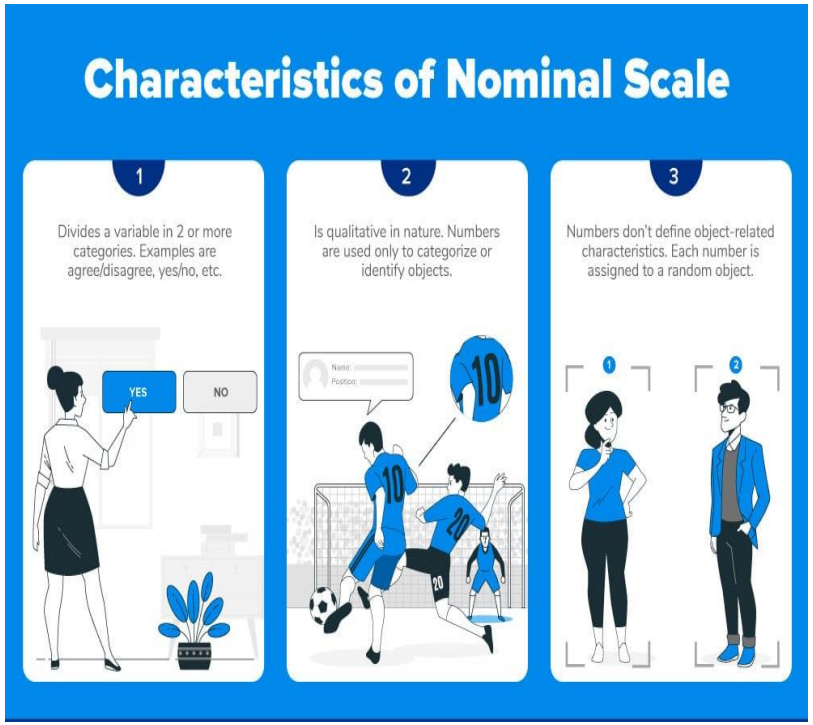
**Gender** ( ) Female ( ) Male

**Marital Status** ( ) Married ( ) Single( ) Divorced

**Nationality** ( ) Turk ( ) Arab ( ) Germen ( ) English

## Characteristics of Nominal Scale:

- In nominal scale a variable is divided into two or more categories, for example, agree/disagree, yes or no etc. It's is a measurement mechanism in which answer to a particular question can fall into either category.
- Nominal scale is qualitative in nature, which means numbers are used here only to categorize or identify objects.
- In nominal scale, numbers don't define the characteristics related to the object, which means each number is assigned to one object. The only permissible aspect related to numbers in a nominal scale is "counting."



# Measurement in Research

## 2. Ordinal Scale

- An ordinal scale is employed when data may be logically **ranked** or **ordered**, but the distinctions between the values are **unknown or unequal**. It is frequently utilized in surveys, rating systems, and ranking exercises.
- An ordinal scale is a ranking scale in which numbers are assigned to objects to indicate the relative extent to which the objects possess some characteristic. An ordinal scale allows you to determine whether an object has more or less of a characteristic than some other object, but not how much more or less.
- Thus, an ordinal scale indicates relative position, **not** the magnitude of the differences between the objects.
- Grocery stores generally rank their hot sauce as, “mild”, “medium”, and “spicy”. We know which one is the hottest and which one is less hot, but we don’t know whether the increase in hotness from “mild” to “medium” is the same as it is from “medium” to “spicy.”


# Measurement in Research

- An Example:

If we have four minerals: gypsum, fluorite, quartz, and diamond. If one mineral can scratch another, it receives a higher hardness number. Then theses will be assigned the numbers from 1 to 4 respectively. Diamond will have number 4 since it has the highest hardness among all, whereas gypsum is assigned the value of 1.

- The numbers we can write 4>1 as diamond is harder than gypsum.
- We can write 2<4 as fluorite is softer than diamond.
- But we cannot write for example 3-1=4-2 because the difference in hardness between are not the same (we don't know the magnitude of extra hardness).

1

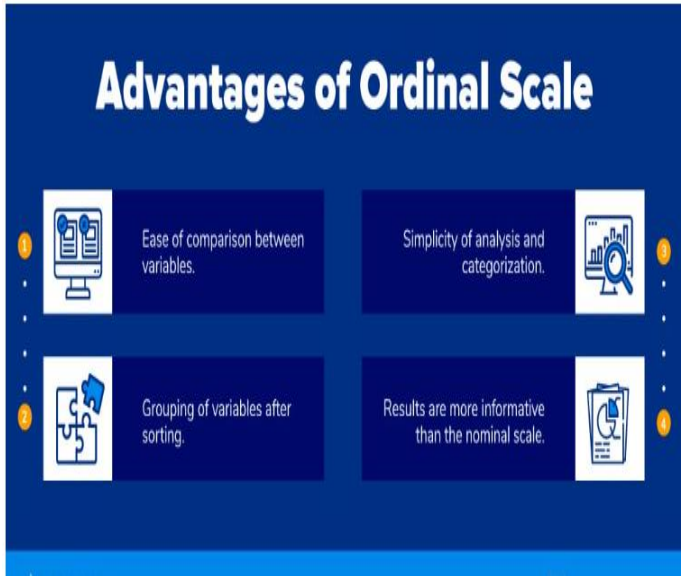
2

3

4

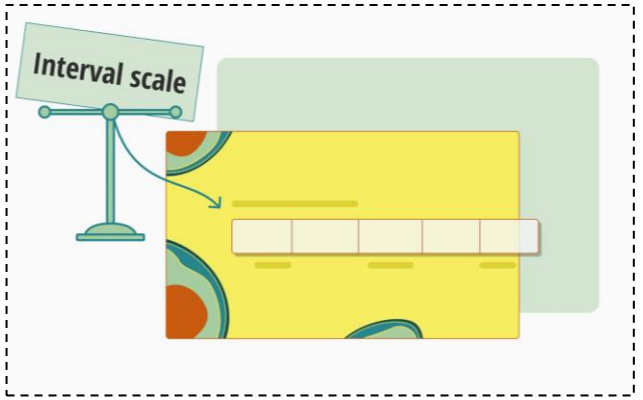
## Characteristics of Ordinal Scale (Advantages):

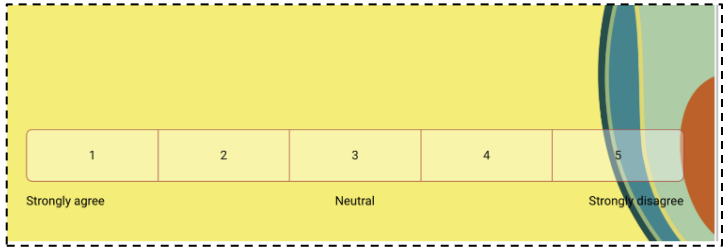
1. The primary advantage of using ordinal scale is the ease of comparison between variables.
2. Extremely convenient to group the variables after ordering them.
3. Effectively used in surveys, polls, and questionnaires, due to the simplicity of analysis and categorization. Collected responses are easily compared to draw impactful conclusions about the target audience.
4. As the values are indicated **in a relative manner** using a linear rating scale the results are more informative than the nominal data.

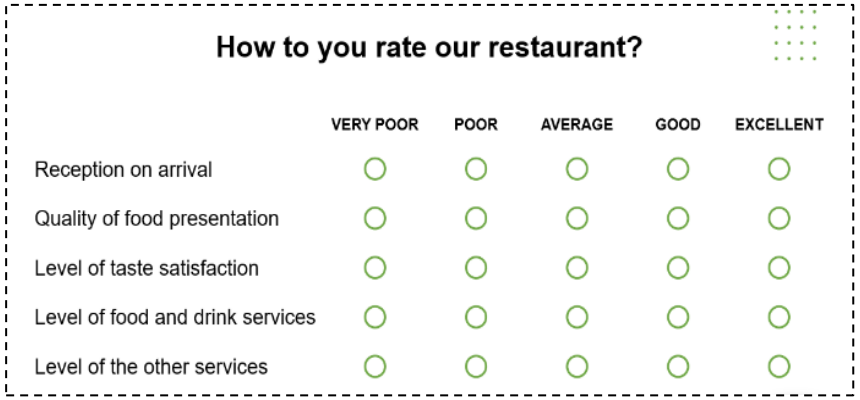


# 3. Interval scale

- In an interval scale, numerically equal distances on the scale represent equal values in the characteristic being measured because it is metric.
- When in addition to setting up inequalities we can also form differences. An interval scale contains all the information of an ordinal scale, but it also allows you to compare the differences between objects.
- The difference between any two scale values is **identical** to the difference between any other two adjacent values of an interval scale.
- There is a constant or equal interval between scale values. The difference between 1 and 2 is the same as the difference between 2 and 3, which is the same as the difference between 5 and 6
- Likert scale is an example of interval scale in research

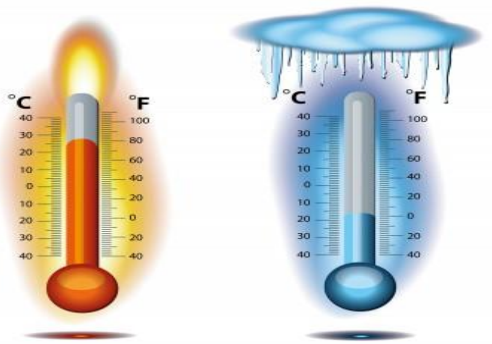


# Example 1 on Interval Scale:

- A common example in everyday life is a temperature scale.
- Suppose we are given the following temperature readings 58°, 63°, 70°, 95°, 110°, 126° and 135°.
- In this case, we can write 110° > 70° or 95° < 135° which simply means that 110° is warmer than 70° and that 95° is cooler than 135°.
- We can also write for example 95° – 70° = 135° – 110°, si
temperature differences are equal in the sense.



Thermometer

# Example 2:

**As a Palestinian, I am proud of my country.**

(5) Strongly agree

(4) Agree

(3) Neither agree nor disagree

(2) Disagree

(1) Strongly disagree

- Interval is a metric scale, so it is possible to calculate the arithmetical means of interval scale.
- Let us assume that 200 citizens have answered the question above as shown in the adjacent table:

| Participation Degree | Frequency |
|---|---|
| 5 Strongly agree | 75 |
| 4 | 64 |
| 3 | 38 |
| 2 | 18 |
| 1 Strongly disagree | 5 |
| **Total** | **200** |

- to calculate the weighted mean which is the mean of all their responses we use the following weighted mean equation:

$$\bar{x} = \frac{w_1x_1 + w_2x_2 + \ldots\ldots + w_nx_n}{w_1 + w_2 + \ldots\ldots w_n}$$

Where,

$x$
is the repeating value
$w$
is the number of occurrences of
$x$
weight
$\bar{x}$
is the weighted mean

**The weighted arithmetic means is** = (5*75) + (4*64) + (3*38) + (2*18) + (1*5) / 200 = 3.93

# Interpretation of the result

To interpret the result we have to compare the resulting weighted average with a standard value. We create five intervals as follows:

Here, we have 5 anchors, the largest value is 5 and the lowest value is 1, so :

- Range of the value = max value – min value = 5-1= 4
- Interval length = range / number of values = 4 / 5 = 0.8

then we can create the following scale:

| Weighted average | Result | Result Interpretation |
|---|---|---|
| 1 – 1.79 | Strongly disagree | Very uninfluential |
| 1.80 – 2.59 | Disagree/ | Uninfluential |
| 2.60 – 3.39 | Neutral | Neutral or do not know |
| 3.40 – 4.19 | Agree | Influential |
| 4.20 – 5 | Strongly agree | Very influential |

The arithmetical means (the average) of the population is 3.93 which means that the population agree that they are proud of their country to an influential level. (درجة كبيرة)

| Weighted average | Result | Result Interpretation |
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| 4.20 – 5 | Strongly agree | Very influential |

**3.93**

- Interval scale can be five, seven or nine-level scale.

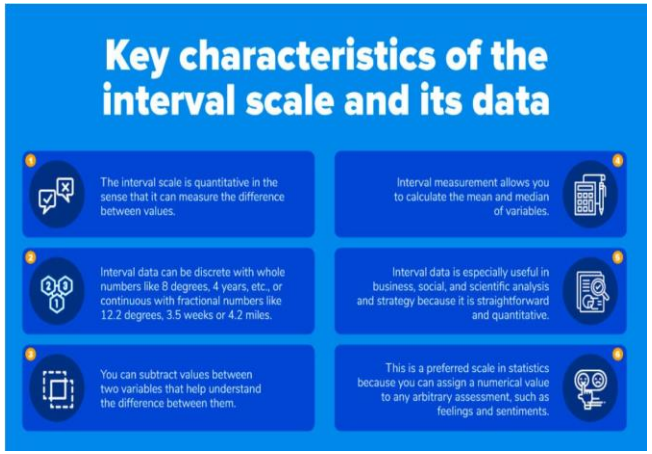
| Strong positive | Positive | Neutral | Negative | Strong negative |
|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) |

| Strongly agree | Agree | More or less agree | Undecided | More or less disagree | Disagree | Strongly disagree |
|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |

An example of a 5-point and 7-point Likert Scale.

## Characteristics of Interval Scale :

1. The interval scale is preferred to nominal scale or ordinal scale because the latter two are qualitative scales. The interval scale is quantitative in the sense that it can quantify the difference between values.
2. Interval data can be discrete with whole numbers like 8 degrees, 4 years, 2 months, etc., or continuous with fractional numbers like 12.2 degrees, 3.5 weeks or 4.2 miles.
3. You can subtract values between two variables that help understand the difference between two variables.
4. Interval measurement allows you to calculate the mean and median of variables.
5. Interval data is especially useful in business, social, and scientific analysis and strategy because it is straightforward and quantitative.



**Characteristics of Interval Scale :**

6. Interval scale **still lacks** one property. **It lacks a true zero.**

In other words, a value of zero does not indicate the absence of the attribute being measured; it simply represents an arbitrary point on the scale. For example, 0°C on the Celsius scale doesn't mean the absence of temperature; it's just a point chosen as the freezing point of water.
Because of the absence of a true zero, operations such as multiplication and division are not meaningful on an interval scale. For instance, if we have temperatures of 20°C and 10°C, it wouldn't make sense to say that 20°C is "twice as hot" as 10°C because there's no true zero point to anchor such comparisons.

(**Zero cant be used as a reference point**)

## 4. Ratio scale

- Ratio scale represents the actual amounts of variables. Measures of physical dimensions such as weight, height, distance, etc. are examples.
- When in addition to setting up inequalities and forming differences we can also form quotients (i.e., when we can perform all the customary operations of mathematics).
- Ratio data includes all the usual measurement (or determinations) of length, height, money amounts, weight, volume, area, pressures etc.

## Characteristics of Ratio Scale:

1.Ratio scale, as mentioned earlier **has an absolute zero** characteristic. It has orders and equally distanced value between units. The zero point characteristic makes it relevant or meaningful to say, “one object has twice the length of the other” or “is twice as long.” (A zero value indicates the absence of this characteristic)

2.Ratio scale **doesn’t have a negative number,** unlike interval scale because of the absolute zero or zero point characteristic. To measure any object on a this scale, researchers must first see if the object meets all the criteria for interval scale plus has an absolute zero characteristic. (so it is used for variables that cant be negative)

3.Ratio scale provides unique possibilities for statistical analysis plan. In this scale, **variables can be systematically added, subtracted, multiplied and divided (ratio).** All statistical analysis including mean, mode, the median can be calculated using it.

3. Ratio scale **has units** which have several unique and useful properties. One of them is they allow unit conversion. Take an example of calculation of energy flow. Several units of energy occur like Joules, gram-calories, kilogram-calories, British thermal units. Still more units of energy per unit time (power) exist kilocalories per day, liters of oxygen per hour, ergs, and Watts.

# Examples of ratio scale questions

- **Miles per hour:** Speed is an easy example of the ratio scale. Because there is a true zero value—the absence of forward motion—it's easy to plot and visualize speed data
- **Time:** Time spent can be measured on a ratio scale, since "negative time" doesn't exist. If you're researching how long it takes customers to make a purchase on your website, you would measure from the moment they initiate the purchasing process to the final "place your order" command. (the second they entered, is the reference point)
- **Weight:** Weight also has a true zero, making it appropriate for ratio scales. Whether you're measuring in milligrams, kilograms, ounces, or pounds, a ratio scale allows you to understand the relationship between different weights.
- **Age:** Age is one of the most common attributes that can be plotted on ratio scales. Companies often use this in market research and customer demographic studies. Because no one can be younger than zero, you'll know the true value of each age group, and how they relate to others. For example, 40-year-olds are twice as old as 20-year-olds, but half the age of 80-year-olds.

# Examples of ratio scale questions

The following are the most commonly used examples:

**1. What is your height in feet and inches?**

- Less than 5 feet.
- 5 feet 1 inch – 5 feet 5 inches
- 5 feet 6 inches- 6 feet
- More than 6 feet

**2. What is your weight in kgs?**

- Less than 50 kgs
- 51- 70 kgs
- 71- 90 kgs
- 91-110 kgs
- More than 110 kgs

**3. How much time do you spend daily watching television?**

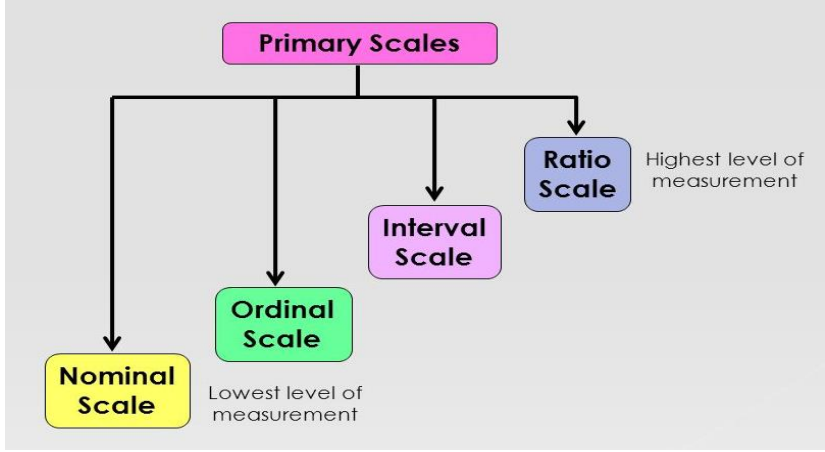
- Less than 2 hours
- 3-4 hours
- 4-5 hours
- 5-6 hours
- More than 6 hours

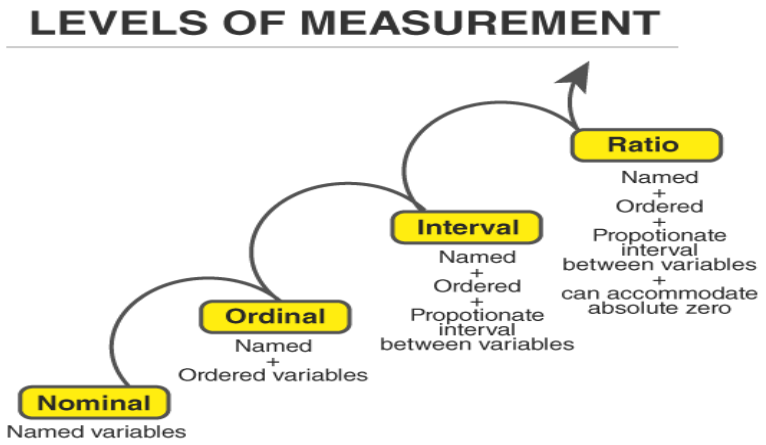
To summarize the scales of measurement, here are their properties.

| Level of Measurement | Can categorize data? | Can order/rank data? | Can add or Subtract data? | True or Meaningful Zero? | Preciseness |
|---|---|---|---|---|---|
| Nominal | Yes | No | No | No | Least precise |
| Ordinal | Yes | Yes | No | No | Little precise |
| Interval | Yes | Yes | Yes | No | Precise |
| Ratio | Yes | Yes | Yes | Yes | Most precise |

| الرقم | نوع المقياس | الهدف منه ( خصائص الأرقام ) | أمثلة | وحدة القياس | حالة الصفرفي المقياس |
|---|---|---|---|---|---|
| 1 | الاسمي | التميز بين الأشياء | الذكر 1<br>الأنثى 2 | لا يوجد | لا تنعدم لسمة المقاسة بوجود الصفر لأنه ليس حقيقي |
| 2 | الترتيبي (الرتب) | التمييز والترتيب بفروقات ليس شرط أن تكون متساوية لسمة المقاسة | 1 ممتاز<br>2 جيد جدا<br>3 جيد | لا يوجد | |
| 3 | الفئوي (المسافة) | التمميز والترتيب بفروقات متساوية لسمة المقاسة ويمكن استخدام المتوسط الحسابي والإنحراف المعياري | قياس درجات الحرارة المئوية | يوجد وحدة قياس | |
| 4 | النسبي | أفضل أنواع المقاييس المعروفة لأنه يحتوي على جميع ما سبق بالإضافة إلى نقطة صفر مطلق و تستخدمه معظم العلوم الطبيعية | قياس الطول<br>قياس الوزن | يوجد | الصفر هنا حقيقي وتنعدم السمة المقاسة بوجود الصفر |

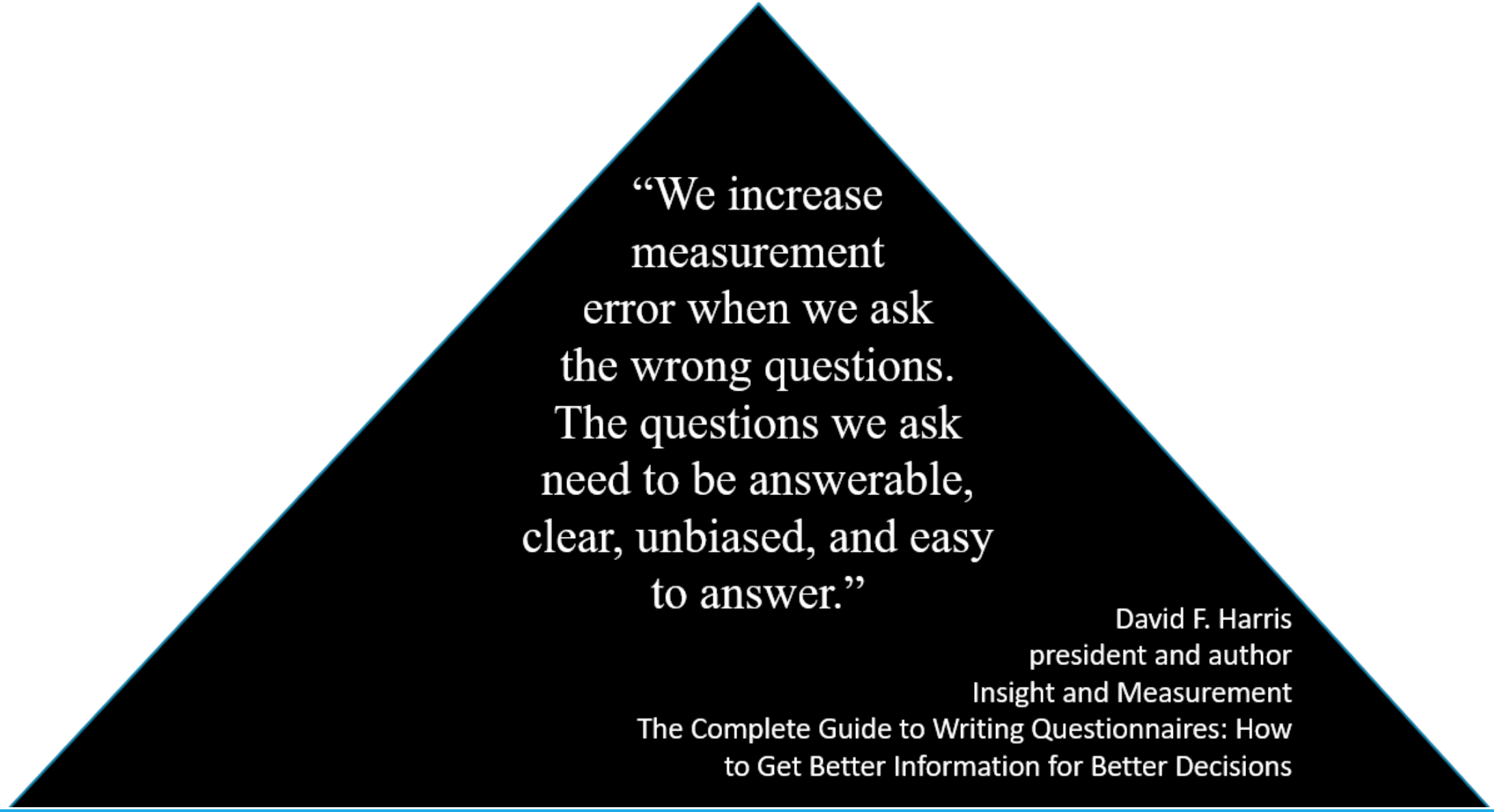
# Levels of Measurement



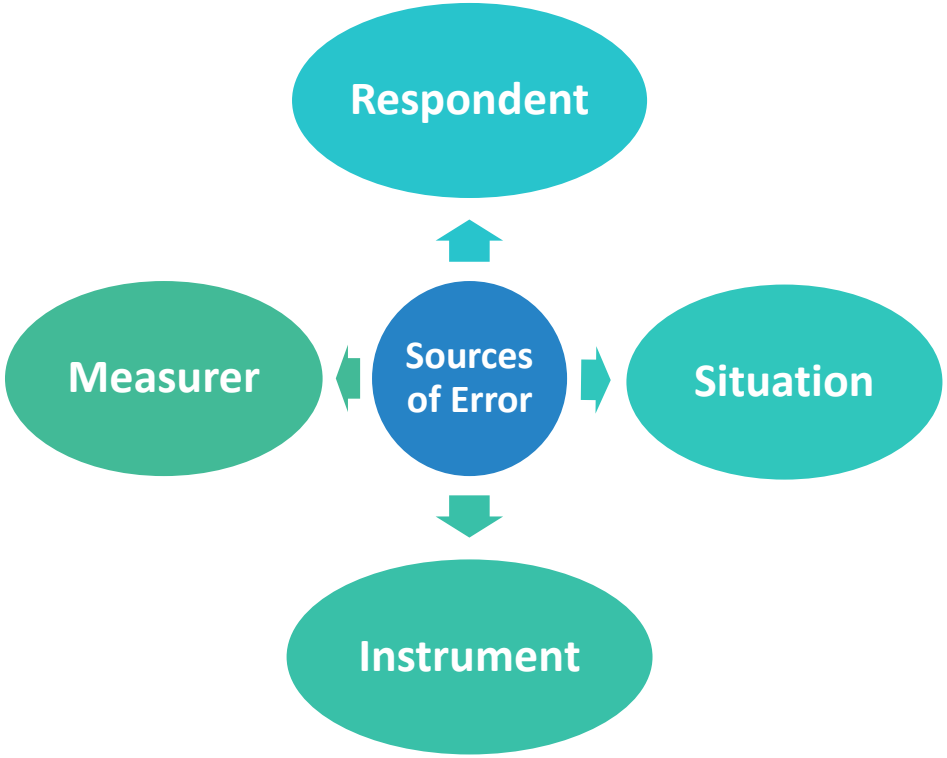

| | | |
|---|---|---|
| Nominal | Classification | |
| Ordinal | Classification | |
| | Order | |
| interval | Classification | Distance |
| | Order | |
| Ratio | Classification | Distance |
| | Order | Natural Origin |

# Issues with data collection and format



# Sources of Error in Measurement

Measurement should be precise and unambiguous in an ideal research study. This objective, however, is often not met with in entirety. As such the researcher must be aware about the sources of error in measurement. The following are the possible sources of error in measurement



# Sources of Error in Measurement

## 1. The Respondent

- Is the Person who provide the response or fill the questionnaire
- May feel reluctant in expressing strong negative or extreme feelings.
- Not admitting ignorance then guessing
- Transient factors: boredom, fatigue, anxiety...etc. lead to inaccurate or incomplete response

## 2. The Situation

- Is the Conditions around the respondent
- Condition which places a strain on interview.

  For instance, if anonymity or privacy.
- Uncomfortable situation
- Presence of your boss, Camera…

# Sources of Error in Measurement

## 3. The Measurer

- Is the Data collector, Data encoder, Data analyst,
- Error in coding, tabulation or statistical calculations.
- Rewording or reordering questions can distort the response.
- The overall looks of interviewer may encourage or discourage.

## 4. The Instrument

- It is the tool for data collection (questionnaire)
- Defective measuring instrument/questioners.
- Complex words, poor printing, response choice omissions.
- Difficult to understand
- Ambiguous meaning
- Inadequate space for the response
- Not having clear instruction, lack of logical sequence

# Tests of Sound Measurement (https://www.youtube.com/watch?v=JaVkldof8l4)

- It is an important issue in research.
- It must correctly measure the concepts so that the conclusions & decision will be accurate.
- To understand business research, or really any concept, we must be able to measure it.

***A concept is an abstraction or idea formed by the perception of phenomena like awareness, enjoyment, ease of use …***

# Tests of Sound Measurement

- In research we have to ensure that we are using the correct measure for measuring the variables or concepts.
- Sound measurement must meet the tests of Validity, Reliability and Practicality.

# Tests of Sound Measurement

## 1. Validity (الصدق)

- Validity is the most critical criterion and indicates the degree to which an instrument measures what it is supposed to measure.

# Tests of Sound Measurement

- For example, if you want to measure the mass of an abject you use a weighing scale because it gives you the desired measure. **It measures the mass**
- **أي ان المقياس المستخدم يقيس ما صمم لقياسه**

# Tests of Sound Measurement

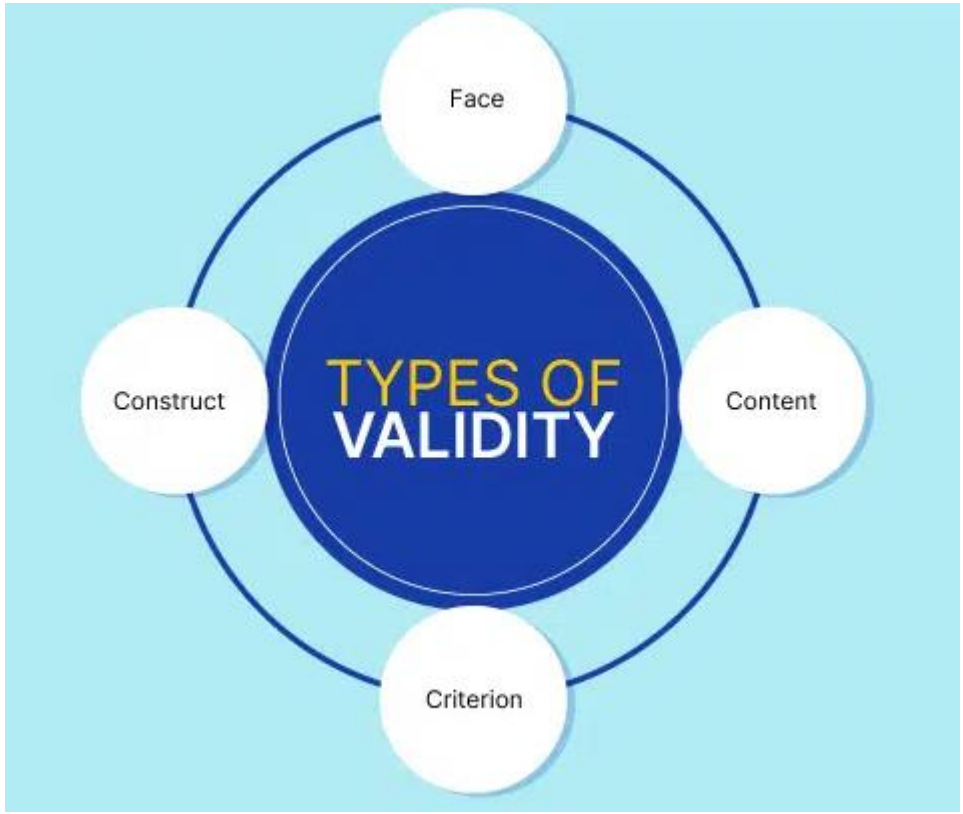
- If you want to measure the temperature, you use a thermometer.

  Which is Valid.

- But you cant use the thermometer to measure air pressure since it does not measure it. It is invalid to measure the air pressure


# Tests of Sound Measurement

There are four types of validity tests



# Tests of Sound Measurement

1. **Content validity (صدق المحتوى):** is the extent to which a measuring instrument provides adequate coverage of the topic under study (يجب ان نقيس كل الجوانب).

Example:

1. The exam would have high content validity if the questions asked cover every possible topic in the course
2. A mobile phone company wants to conduct a customer satisfaction survey about a specific cell phone model they recently launched. The survey should have questions about the product such as – features, quality, performance, color, design, price, etc. This means that to protect the validity of the result, the content of the survey must cover all relevant questions about the product.

# Tests of Sound Measurement

**2. Construct validity (صدق المفهوم):** is about how well a test measures the concept it was designed to evaluate.

Example:

In a test measuring intelligence, if individuals who score higher on the test also perform better academically or are perceived as more intelligent by experts, it indicates good construct validity. In simpler terms, construct validity confirms that a test or measurement tool is indeed capturing what it claims to measure, based on its alignment with other established measures or theoretical frameworks.

# Tests of Sound Measurement

**3. Face validity (الصدق الظاهري):** considers how suitable the content of a test seems to be on the surface. It's similar to content validity, but face validity is a more informal and subjective assessment.

it's often considered the weakest form of validity. However, it can be useful in the initial stages of developing a method.

Example:

1. (مثل تحكيم المحكمين للاستبيان)
2. A questionnaire designed to measure customer satisfaction at a restaurant. If the questions in the questionnaire directly ask about aspects such as food quality, service speed, and overall dining experience, without any complex or ambiguous language. On its surface, the survey seems like a good representation of what you want to test, so you consider it to have high face validity.

# Tests of Sound Measurement

**4. Criterion validity (صدق المعيار):** How well the results of your test approximate the results of another test.

Example:

1. A university professor creates a new test to measure applicants' English writing ability. To assess how well the test really does measure students' writing ability, she finds an existing test that is considered a valid measurement of English writing ability, and compares the results when the same group of students take both tests. If the outcomes are very similar, the new test has high criterion validity. face validity.

# Tests of Sound Measurement

## 2. Reliability

Reliability is the degree to which a scale is able to produce consistent results when repeated measurements are taken under the same situation.

- This simply means that if the results appear similar again and again, provided that the condition is the same, then we refer to the measurement as reliable.

(اي انه لو تم إعادة الدراسة تحت ظروف مشابهة ستعطي نفس النتائج)

# Tests of Sound Measurement

## 2. Reliability

Example:

When you weigh the same quantity of rice on a balance repeatedly with the result remaining the same all through the measurement process, you refer to this weight as reliable. This also means that the quantity neither decrease nor increase on being measured multiple times.


Reliable
Not Valid
Low Validity
Low Reliablity
Not Reliable
Not Valid
Both Reliable
and Valid

# Tests of Sound Measurement

## 3. Practicality

- Practicality means that the test is easy to design, easy to administer and easy to score.
- Practicality is concerned with a wide range of factors of economy, convenience, and interpretability

# Reliability in Experimental Computer Science

Reliability is a critical aspect of any experimental research. Therefore, to ensure reliability, researchers must focus on several key areas.

- **Replication:** Repeating the same experiment under the same conditions verifies consistency and reliability.
- **Consistency in Procedures**: All aspects of the research process should be standardized to ensure equal treatment of all participants.
- **Accurate and Consistent Data Collection**: Valid and reliable measurement tools should be used to ensure consistent data recording and analysis.
- **Statistical Tests:** Test-retest reliability method can be used to assess data reliability.
- **Reliability:** Reliability should be monitored throughout the research process, ensuring consistency and repeatability of results.

# Qualitative research in CS and IS

Focus of Research

**Qualitative**
- Understanding
- Interpretation

**Quantitative**
- Description
- Explanation

- Qualitative research involves the use of qualitative data, such as interviews, documents, and participant observation, to understand and explain a specific phenomena. It focuses on exploring **how** and **why** certain outcomes occur rather than just measuring them.
- Qualitative research techniques include:
  - **Most commonly used**: individual depth interviews (IDIs) and group interviews (focus group), Case studies, and action research. **(breiefly covered covered in this course)**
  - **Less commonly used**: ethnography, phenomenology, hermeneutics, and grounded theory **(Not Covered in this course)**

**Example: In User Experience Research, s**tudying how users interact with a new software application to identify usability issues and improve interface design.

# Qualitative research in CS and IS

## 1. Individual Interviews

**Individual Interviews** are a qualitative research method where a researcher engages one participant at a time to explore their perspectives, experiences, or insights. These interviews are often open-ended or semi-structured, allowing for in-depth discussions and personalized responses.

| Advantages | Disadvantages |
|---|---|
| **In-depth Data:** Interviews allow for detailed exploration of participants' thoughts, providing rich data. | **Time-Consuming:** Conducting, transcribing, and analyzing interviews takes a significant amount of time and effort |
| **Flexibility:** The interviewer can adjust questions or probe deeper based on the participant's responses. | **Limited Generalizability:** Insights are often specific to individual participants |
| **Personalized Insights:** Tailored questions can be asked to suit the specific participant's expertise | **Subjectivity:** Responses are influenced by personal biases or interpretations |
| **Confidentiality:** Participants might feel more comfortable sharing sensitive information | **Interviewer Bias:** The interviewer's own views or manner of questioning may unintentionally influence participants' responses |

**Example:** Conducting interviews with system administrators to learn about their strategies and challenges in maintaining cybersecurity in cloud environments.

# Qualitative research in CS and IS

## 2. Group Interviews

**Group Interviews**, also known as **focus groups**, are a qualitative method where multiple participants engage in a structured or semi-structured discussion led by a facilitator. The goal is to gather collective insights, ideas, or experiences from a group of individuals on a particular topic.

| Advantages | Disadvantages |
|---|---|
| **Interaction and Synergy:** Participants build on each other's ideas, leading to richer data and diverse perspectives. | **Dominant Voices:** Some participants may dominate the conversation, leading to a skewed dataset and the suppression of quieter voices. |
| **Efficient Data Collection:** Multiple participants are interviewed at once, making it more time-efficient | **Limited Depth:** May not allow for the same level of in-depth exploration as IDIs, as time is divided among participants. |
| **Observing Group Dynamics:** Allows researchers to observe how individuals interact and discuss topics in a group setting, which can reveal important dynamics. | **Groupthink:** Participants may conform to the group's opinion rather than share their true thoughts, leading to less authentic responses. |
| **Emerging Ideas:** New ideas or issues may emerge during the group discussion that individual participants might not have considered on their own. | **Complexity in Analysis:** Analyzing data from group discussions can be challenging due to overlapping conversations and multiple perspectives. |

**Example:** Conducting a focus group with a team of developers to identify issues with communication tools and processes during a sprint in Agile software development.

# Qualitative research in CS and IS

## 3. Case Study

**A case study** is a qualitative research method that involves an in-depth investigation of a single case or multiple cases within their real-world context. The case can be an individual, organization, project, or system.

| Advantages | Disadvantages |
|---|---|
| **In-Depth Understanding:** Provides comprehensive insights into a specific instance | **Limited Generalizability:** Findings from a single case or a small number of cases may not be generalizable to broader populations |
| **Real-World Context:** Captures phenomena as they occur in practice, offering valuable practical implications | **Time-Consuming:** Collecting and analyzing detailed data over an extended period can be labor-intensive. |
| **Flexibility:** Allows for a variety of data collection methods (e.g., interviews, observations, documents), making it adaptable to different research needs | **Subjectivity:** The interpretation of case study data may be influenced by the researcher's biases or perspectives. |
| **Generates Rich Data:** Case studies yield detailed qualitative data, helping to understand not just the "what" but also the "how" and "why" behind a phenomenon | **Analysis:** Due to the volume of data and multiple variables involved, analyzing case study findings can be difficult and may require a systematic approach. |

**Example:** A case study of a banking system failure due to a server crash, examining the technical and organizational factors that contributed to the event and the solutions implemented.

# Qualitative research in CS and IS

## 4. Action Research

**Action Research** is a participatory and iterative research method that involves researchers working closely with participants to address a problem or improve a process in a real-world setting. The focus is on generating practical solutions while simultaneously studying the process. c.

| Advantages | Disadvantages |
|---|---|
| **Practical Solutions:** It is aimed at solving real-world problems while contributing to academic knowledge. | **Time-Intensive:** The iterative cycles require continuous engagement and time investment, which can slow down the research process. |
| **Collaborative Approach:** Researchers work alongside participants (e.g., developers, users, managers) to develop solutions, promoting buy-in and relevance. | **Researcher Bias:** Close collaboration with participants may introduce subjectivity or bias in the interpretation of data |
| **Iterative Process:** The cyclical nature (plan, act, observe, reflect) allows continuous improvement and adaptation based on real-time feedback. | **Complex Data Collection:** Balancing the dual goals of solving a practical issue and generating research findings can make data collection and analysis more complex. |
| **Immediate Impact:** The outcomes can have immediate benefits for the participants involved. | **Limited Generalizability:** Findings are often context-specific, making it difficult to generalize results beyond the immediate setting. |

**Example:** Action research could be applied to develop and continuously improve a cybersecurity awareness program within an organization.

# Qualitative research in CS and IS

- The collected data is analyzed using the following **Commonly used Qualitative Analysis Techniques**:
  - **Coding:** A widely used method to analyze and reduce qualitative data. It organizes raw data into conceptual categories or "bins" by assigning labels to pieces of data (words, phrases, or documents).
  - **Memoing:** Involves writing reflective notes or commentaries during or after data collection. Memos can capture observations, ideas, or initial interpretations of the data.
  - **Content Analysis:** Examines text for the presence and frequency of dominant concepts (e.g., words or constructs).

# Qualitative research in CS and IS- Data analysis Software tools

- **Qualitative data analysis tools** help you make sense of customer feedback so you can focus on improving the user and product experience and creating customer delight.
- Some of the most commonly used tools are:

  - NVivo is one of the most popular qualitative data analysis tools and probably the most expensive. NVivo's Transcription tool transcribes and analyzes audio and video files from recorded calls—like interviews, and product demos—and lets you automatically transfer text files into NVivo for further analysis to:
    - ✓ Find recurring themes in customer feedback
    - ✓ Analyze different types of qualitative data, like text, audio, and video
    - ✓ Code and visualize customer input
    - ✓ Identify market gaps based on qualitative and consumer-focused research

  - MAXQDA: It is a data analysis software that can analyze and organize a wide range of data, from handwritten texts, to video recordings, to Tweets.

Several other tools are available.

# Mixed Method research in CS and IS

**Mixed Methods Research** in Computer Science (CS) and Information Systems (IS) refers to a research approach that combines both **qualitative** and **quantitative** methods within a single study. This approach is valuable because it allows researchers to draw from the strengths of both methods, addressing complex research questions that require multiple types of data and analysis.

**Key Characteristics:**

- **Integration of Data:** The qualitative and quantitative data are combined, often by comparing, validating, or expanding the findings from one method with the other.
- **Complementarity:** Qualitative data can provide a deeper understanding of quantitative results, while quantitative data can offer generalizability to qualitative insights.
- **Sequential or Concurrent Design:** Mixed methods can take one of the three following forms:

# Mixed Method research in CS and IS

| Sequential Explanatory Strategy | Sequential Exploratory Strategy | Concurrent Triangulation Strategy |
|---|---|---|
|  |  |  |
| • Collection and analysis of quantitative data followed by collection and analysis of qualitative data.<br>• Use qualitative results to assist in explaining and interpreting the findings of a quantitative study<br><br>**Example: Evaluation the effectiveness of a new educational app**<br>The researchers first gather quantitative data through surveys to assess user satisfaction and learning outcomes among students. They then explore these results further through qualitative methods like interviews and focus groups, delving into the reasons behind the statistics, guiding more targeted improvements in app design and functionality. | • Collection and analysis of qualitative data followed by collection and analysis of quantitative data.<br>• Use quantitative data and results to assist in the interpretation of qualitative findings.<br><br>**Example: Development of a New Feature for Programming IDEs**<br>The researchers first conduct qualitative research through interviews and observations with novice programmers to identify their challenges and needs. Insights gained guide the development of a quantitative survey aimed at a broader audience to validate the demand for new features. | • Uses different methods concurrently -- Why?<br>▸ "What people say" could be different than "what people do." S, Collecting data from multiple sources helps improve validity.<br>**Example: Assessing a new algorithm's efficiency**<br>The researchers might conduct experiments to gather quantitative performance metrics (like execution time and resource usage) while also interviewing expert users to gain qualitative insights into the algorithm's practical usability and effectiveness |

**All methods have limitations. The strengths of one method can compensate the weaknesses of other methods.**

- In Software development in particular, there are lots of different methodologies, and each of them has its own advantages and disadvantages. The most commonly used are:
    1. Waterfall Methodology
    2. Agile Methodology. It has different types, the most common are:
        - 2.1 Scrum
        - 2.2 Kanpan
        - 2.3 Lean Software Development (LSD)

# 1.Waterfall Methodology (Traditional Approach) ( 1 of 3)

- Waterfall methodology is a structured approach to project management, guiding through clear stages.
- **Phases** are initiation – design – implementation – verification - deployment.
- Each phase is clear and concise, making it ideal for projects with clear goals.
- However, it may not be flexible for sudden changes.
- Waterfall is a guide for thoroughness and keeping focus on the goal.
- Early software development projects often used a waterfall approach

**When to use it:**

- The waterfall approach is great for manufacturing and construction projects, which are highly structured, and when it's too expensive to pivot or change anything after the fact. The waterfall method makes use of Gantt charts for planning and scheduling.

**Examples:**

- CS Example: Developing a desktop software application with rigid specifications.
- IT Example: Implementing a network infrastructure upgrade with predetermined steps and deliverables.

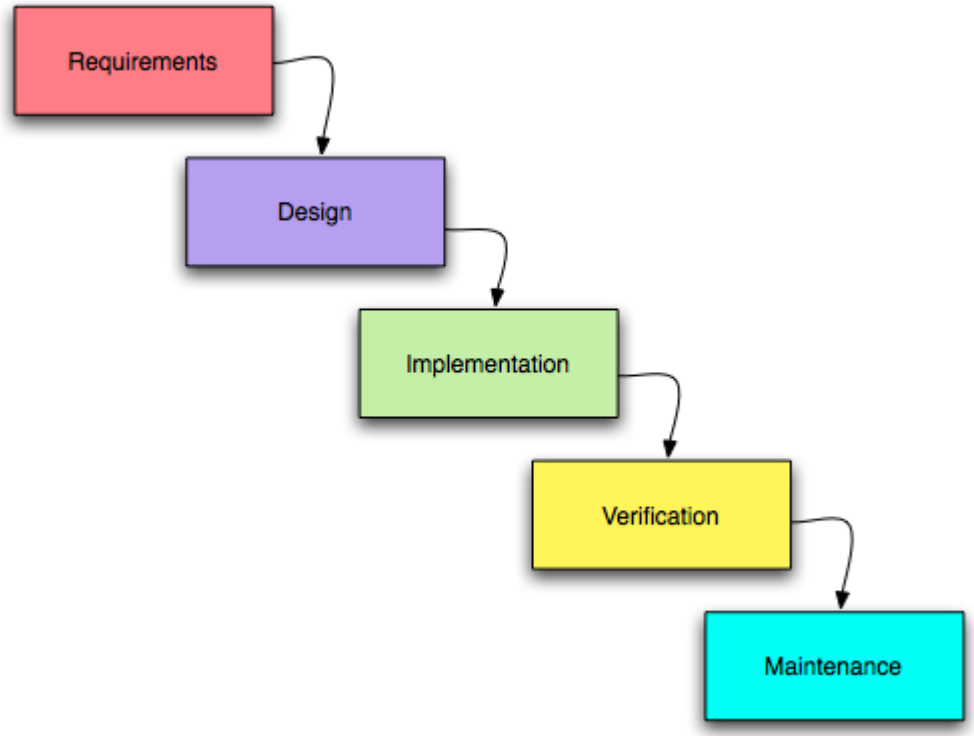
# 1.Waterfall Methodology (Traditional Approach) ( 2 of 2)

## Some of the advantages of Waterfall are:

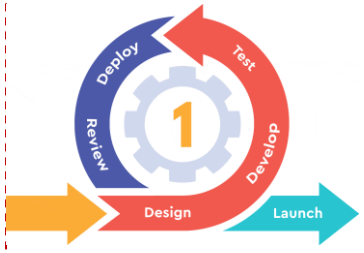
2. Waterfall Model is very simple and easy to understand.
3. Waterfall Model works well for smaller projects and projects where requirements are well understood.
4. In each phase detailed documentation is required.
5. Phases in the Waterfall model are processed one at a time.

## Some of the disadvantages of Waterfall are:

2. It is not well-suited where requirement are continuously changing and updating.
3. Also there is no error detection or feedback present in each stage.
4. Waterfall Model is not well-suited for complex projects.
5. Waterfall Model can result in a lengthy development cycle, as each phase must be completed before moving on to the next. This can result in delays and increased costs if requirements change or new issues arise.
6. There is no collaboration and innovation among different team members



# 2. Agile Methodology (1 of 5)




• Agile is a collaborative, evolving approach to self-organization across teams.
•Characteristics: Flexible, fast, user feedback-driven , unlike waterfall project management.
•Its project planning and work management are adaptive, evolutionary, and seek early delivery.
•Originated in 2001 with the publication of the "Manifesto for Agile Software Development.“

**When to use it:**

•Originated from software development culture.
• Applicable to non-software products with innovation and uncertainty.
• Used in projects requiring responsive, fast-paced production schedules.
• Suitable for projects like computers, motor vehicles, medical devices, food, clothing, music, and marketing.

**Examples:**

- CS Example: Developing a machine learning model iteratively based on user feedback and testing at each sprint.
- IT Example: Building a customer-facing web application with regular user feedback to modify features.

Visit: https://www.youtube.com/watch?v=eVDZJ60c_7c

## 2. Agile Methodology (2 of 5)

- Different Agile frameworks are available.
- What all agile frameworks have in common is that they continuously iterate on the work process itself and aim to deliver value to customers quickly and frequently.
- But there are now countless frameworks and each one offers its own flavor of agile.
- The most common Agile framework that will be discussed are:

  **2.1 Scrum (https://www.youtube.com/watch?v=pl9l4YS9AT0))**

  **2.2 Kanpan (https://www.youtube.com/watch?v=eBXsr7wdWH4)**

  **2.3 Lean Software Development (LSD) (https://www.youtube.com/watch?v=LKL41cC5pxA))**

## 2. Agile Methodology (3 of 5)

### How to Pick an Agile Framework?

It’s crucial to evaluate several key dimensions before choosing:

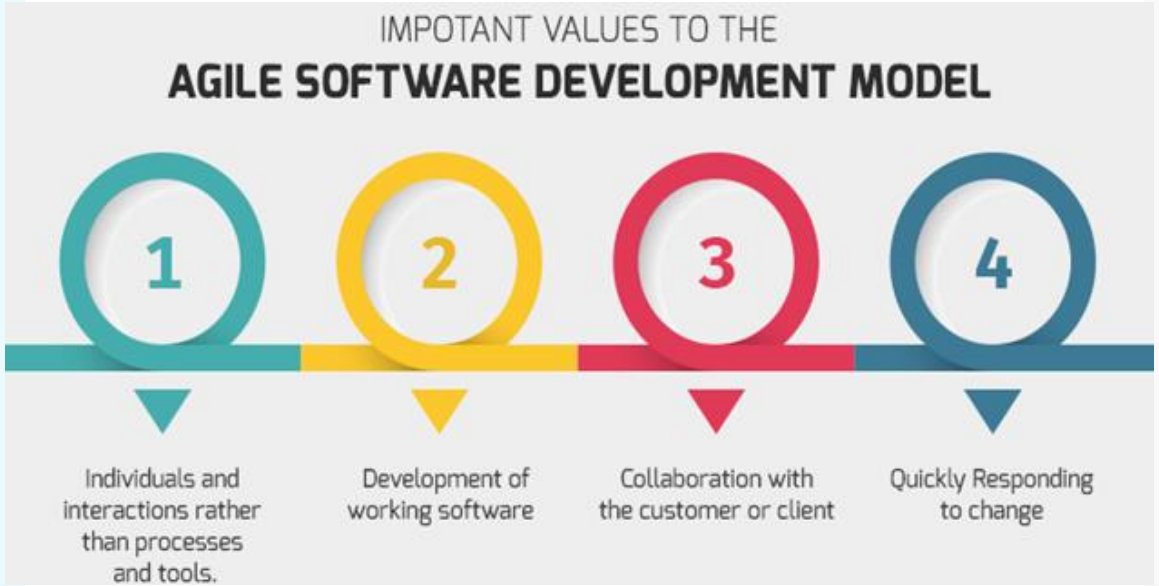
- **Team Size:** The framework you choose should match your team's size. Large frameworks can overwhelm small teams, making them inefficient, while lightweight frameworks might not provide enough structure for larger groups, leading to disorganization..
- **Project Complexity:** When handling projects with multiple complex layers, it’s important to select a framework that helps manage this complexity effectively without halting progress. The framework should simplify project management without removing necessary flexibility.
- **Company Culture:** What’s your company vibe? Your chosen framework must fit into how things run around your office.
- **Customer Engagement:** If customer feedback is crucial to your operations, choose a framework that incorporates this feedback consistently into the development process. Opt for models that facilitate regular inclusion of customer insights in sprint reviews or planning sessions.
- **Adaptability:** Given the rapid pace of change in today’s business environments, it’s essential to adopt a framework that can swiftly adapt to new conditions. Ensure that the framework can support quick decision-making and adjustments without falling apart, especially when immediate shifts are necessary.

# 2. Agile Methodology (4 of 5) The Agile Manifesto

The Agile Manifesto is a document that identifies four key values and 12 principles that its authors believe software developers should use to guide their work. Formally called the *Manifesto for Agile Software Development*,

## The Authors

Kent Beck
Mike Beedle
Arie van Bennekum
Alistair Cockburn
Ward Cunningham
Martin Fowler
Robert C. Martin
Steve Mellor
Dave Thomas
James Grenning
Jim Highsmith
Andrew Hunt
Ron Jeffries
Jon Kern
Brian Marick
Ken Schwaber
Jeff Sutherland




## The Agile Manifesto

We are uncovering better ways of developing software by doing it and helping others do it. Through this work we have come to value:

**Individuals and interactions** over processes and tools

**Working software** over comprehensive documentation

**Customer collaboration** over contract negotiation

**Responding to change** over following a plan

That is, while there is value in the items on the right, we value the items on the left more.

# 2. Agile Methodology (5 of 5) The Agile Manifesto

## Some of the advantages of Agile are:

2. It provides faster delivery of software products and features.
3. Agile methodologies prioritize customer satisfaction.
4. In Agile methodology the daily interactions are required between the business people and the developers.
5. Changes in the requirements are accepted even in the later stages of the development.
6. Better adaption to rapidly changing requirements and respond faster.

## Some of the disadvantages of Agile are:

2. Agile development models require a high degree of expertise from team members.
3. Agile model not suitable for larger, and complex project.
4. For complex projects, the resource requirement and effort are difficult to estimate.
5. Sometimes in Agile methodology the requirement is not very clear hence it's difficult to predict the expected result.