

Research Methodology in Computer Science (AI800)

Lecture 5

Research Methods in Computer Science – part 1



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- Types of Methodology
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Learning Outcomes

- To **identify** the **Research Methods** in computer science research
- To **understand** the **Computer Science Research Methodology**
- To **understand** Type of Methods and Methodology .
- To **describe** the **various** quantitative, qualitative, and Mixed Methods Research Design.



Research Methods in Computer Science

The techniques and approaches used to investigate and gather data in the field of computer science

- These *methods* are *crucial* for *conducting experiments*, *analyzing algorithms*, *developing new technologies*, and *evaluating* the *performance* of computer systems.
- They *encompass* a wide range of *techniques*, such as *surveys*, *experiments*, *simulations*, *case studies*, *data mining*, and *statistical analysis*.
- By *employing* these *research methods*, computer scientists can:
 - ☐ Gain insights into complex problems.
 - ☐ Validate hypotheses.
 - ☐ Contribute to advancements in the field.



- *Computer science, computing systems, and computation have produced* a body of knowledge *that includes* the *following* theories for understanding:
- ☐ Computing *techniques* and systems
 - ☐ *The* design *process*
 - ☐ Tools and algorithms
 - ☐ *Techniques* for concept testing
 - ☐ Analysis and verification *techniques*
 - ☐ *The* implementation and representation *of* knowledge.



Exploring the nature of research involves understanding its purpose and various methodologies used across different disciplines

- ☐ *Reading books or magazines to gather information isn't research.*
- ☐ Research *involves* more than just *circulating information*.
- ☐ Research *does not* simply involve *moving data from one source to another*.
- ☐ There is *no contribution* of *knowledge*



The research methodology in computer science is a plan for how information will be gathered and analyzed throughout the study's life cycle.

- Incorporate both qualitative and quantitative approaches to ensure a comprehensive understanding of the subject matter.
- Use of rigorous experimentation and data analysis techniques to validate research findings and enhance the credibility of the results.



Research Methodology





Methodology vs. Methods

Methods cover the technical procedures or steps taken to do the research

- **Describes** the techniques/tools used to collect the data
- Detailed enough for a good researcher to be able to **replicate** a study from reading a method section

Behaviors and instruments used in the selection and construction of the research technique

Methodology provides the underlying reasons why certain methods are used in the process

- **Rationale** for the research approach
- **Justification** of approach to a research problem through logic and assumptions

Science of understanding how research is performed methodically



Types of Methods

Types	Description
Library based Research	1) Analysis of documents- statistical analysis
Field based Research	2) Personal, Focused and Group Interview- open and closed questions 3) Survey- Mail and Telephone 4) Non-participant direct observation 5) Participant observations- Recording, everyday observations
Laboratory based Research	Small group, controlled environment- Use of device to record data



Types of Methodology

Types	Description
Historiography	Writing of history based on critical examination of sources into a narrative
Ethnography	Explores the social world or culture, shared beliefs and behaviors
Phenomenology	Describes the “lived experience’ of a particular phenomenon
Grounded theory	Use an inductive approach to develop new theory
Ethnomethodology	Examine how people use dialogue and body language to construct a world view



Quantitative Research Methods

- *Quantitative Research utilizes* the deductive approach to learning.
- *Quantitative Research aims* to:
 - ☐ Disprove an accepted theory
 - ☐ produce objective, transferable knowledge.
 - ☐ predict and exert control
- *Quantitative Research accepts* that knowledge is objective
- *Quantitative Research utilizes* instruments for standard measurement
- The process of *constructing knowledge* is *independent of the researcher*.



Quantitative Research Methods(cont.)

- *Quantitative research methods* involve the *collection* and *analysis* of numerical data to *draw conclusions* and *make generalizations*.
- *Quantitative research methods* often use *structured surveys*, *experiments*, or *statistical analysis* to *measure variables* and *establish relationships* between them.



Survey Research



Correlation
Research



Causal-Comparative
Research



Experimental
Research



Quantitative Research Methods (cont.)

- *Quantitative research methods* provide a *systematic* approach to *studying phenomena*, allowing researchers to *quantify* and *objectively evaluate* data.
- Employing rigorous *Quantitative research techniques* such as:
 - ☐ Sampling
 - ☐ Randomization
 - ☐ Statistical tests
- *Quantitative research methods* aim to *produce reliable* and *replicable findings* that can be used for *decision-making* and *theory development* in various fields.



Qualitative Research Methods

- **Qualitative research methods** are used to *gather* in-depth insights and *understanding* of *human behavior*, *attitudes*, and *experiences*.
- **Qualitative research methods** involve *collecting* data through *interviews*, *observations*, and *focus* groups to explore the *richness* and *complexity* of a particular phenomenon.
- **Qualitative research methods** allow researchers to uncover *underlying motivations*, *cultural influences*, and *social contexts* that shape individuals' perspectives and actions.



Qualitative Research Methods (cont.)

- The inductive method of knowledge construction is used in *qualitative research methods*. Inductive method involves generating theories and understanding from data, rather than starting with predetermined hypotheses or theories. It is often contrasted with the deductive method, which starts with a specific hypothesis or theory and then tests it using data.
- According to qualitative research techniques, *there is as much knowledge as there are people*, which means that knowledge is as diverse and varied as the individuals who contribute to its creation and development.



Qualitative Research Methods (cont.)

- Instead of relying on *mechanistic objective knowledge*, qualitative research methods accept *justified true belief*.
- **Mechanistic Objective Knowledge:** In many traditional or quantitative research methods, the emphasis is on obtaining objective, measurable data that can be analyzed statistically.



Qualitative Research Methods (cont.)

- **Justified True Belief in Qualitative Research:** Qualitative researchers do not aim to establish universal truths or objective facts. Instead, they seek to generate knowledge that is grounded in the experiences and perspectives of individuals. This knowledge is considered "justified true belief" because it is based on the careful analysis of data, meaningful interpretations, and the researcher's belief that it accurately represents the reality as understood by the participants.

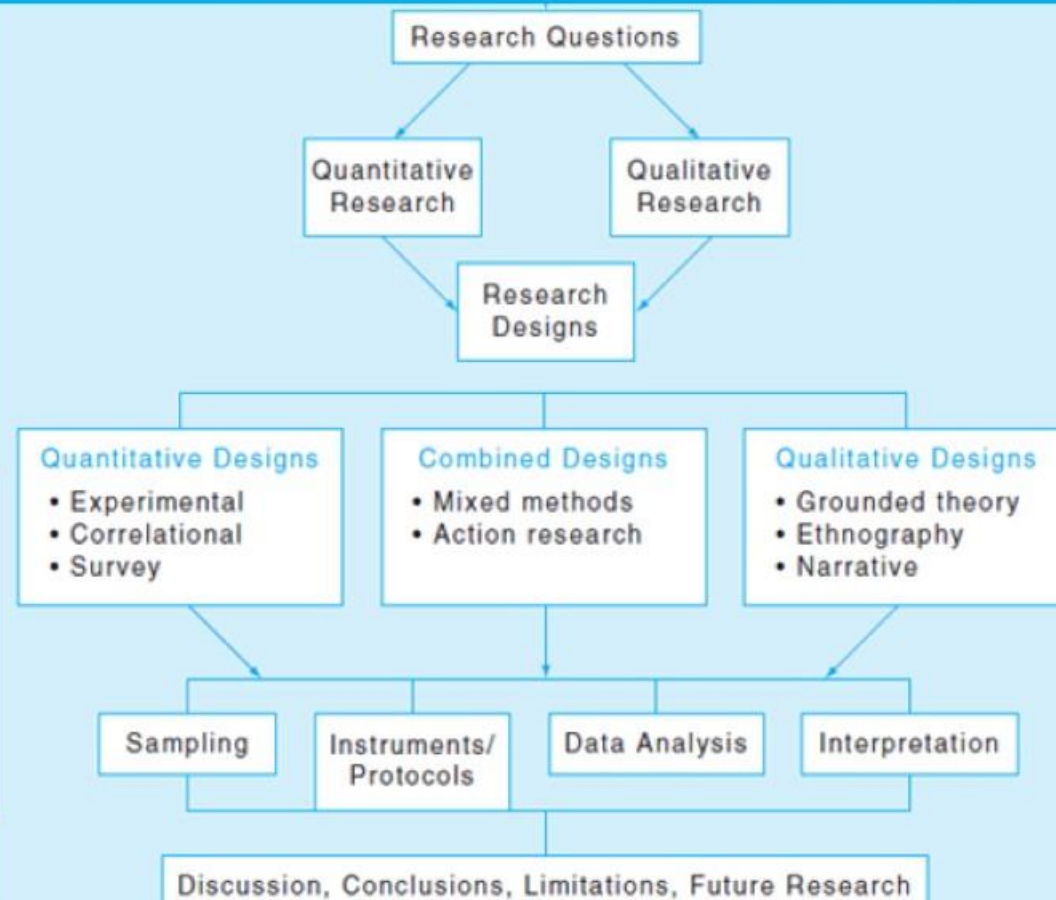


Research Process: Quantitative vs Qualitative

The research process for both starts with research problem identification and a literature review.

Combined design refers to
“Mixed Methods Research”

Combines qualitative and quantitative methods to collect and analyze data from both sources and to use the two methods concurrently.





Research Design

- The **systematic** *planning* and *execution* of **experiments** or **studies** to **investigate** a specific problem or question in the field of computer science.
- It **encompasses** various methodologies, such as *quantitative*, *qualitative*, or *mixed methods* approaches, **depending on** the **nature** of the research **objectives**.
- A well-designed research design **includes** considerations for *data collection*, *analysis techniques*, and *ethical considerations* to **ensure** the **validity** and **reliability** of the **findings**.



Design a Study Quantitative and Qualitative

Qualitative Research



- ✓ Explore
- ✓ Go Deep
- ✓ Seek to Understand

Qualitative

- Answer "Why?" question
- Observation, Symbol, Word etc.
- Observe and interpret
- Grouping of common data /non-statistical analysis

Purpose

Data type

Approach

Analysis

Quantitative



- Answer "How many/much?" question
- Number/Statistical result
- Measure and test
- Statistical analysis

Quantitative Research



- ✓ Quantify
- ✓ Validate
- ✓ Make Decisions



Quantitative Research Designs : Experimental Designs

- **Experimental design** (also known as **intervention** studies or group **comparison** studies) are techniques used to **ascertain** whether a particular **activity** or set of materials **affects** participants' **outcomes**.
- **Experimental quantitative researchers designs** **involve** the **manipulation** of **independent variables** to **determine** their effects on **dependent variables**.
- These designs typically **include** **random assignment** of participants to different conditions or groups, allowing for **comparisons** between the groups.
- Researchers often **use** control groups to compare the effects of the independent variable to a baseline condition.



Quantitative Research Designs : Correlational Designs

- **Correlational research designs** are used to **examine** the **relationship** between two or more **variables**.
- These designs allow **researchers** to **determine** if there is a **statistical association** between variables, but they do not **establish causation**.
- By measuring the extent to which **changes** in one variable are related to changes in another, **correlational research** can **provide** valuable insights into patterns and trends within a given population.
- **Correlational research designs** can be useful for generating **hypotheses** and identifying potential areas for further **investigation**.



Quantitative Research Designs : Survey Designs

- **Survey research designs** are a type of research method that **involve** collecting data from a sample of individuals using **questionnaires** or **interviews**.
- **Survey research designs** are often **used** to gather information about people's attitudes, opinions, behaviors, or characteristics:
 - **Conducted in various settings, such as in-person, over the phone, or online.**
- **Survey research designs allow** researchers to **collect** large amounts of **data quickly** and **efficiently**, making them a popular choice for studying a wide range of topics in social sciences and market research.



Qualitative Research Designs : Grounded Theory Designs

- **Grounded Theory Designs** refer to a **qualitative** research methodology that **aims** to develop theories from **data collected** during the research process.
- **Grounded Theory Designs** systematically **analyzing** and **coding** the data to **identify patterns, categories, and themes** that emerge.
- **Grounded Theory Designs** **generate** new insights and **theories** that are grounded in the data rather than being based on pre-existing hypotheses or theories.
- Researchers using this approach often engage in **constant comparison** and **theoretical sampling** to **refine** their **theories** until saturation is reached.



Qualitative Research Designs : Ethnographic Designs

- **Ethnographic designs** aims to **understand** and **describe** the cultural beliefs, practices, and behaviors of a specific group or community.
- **Ethnographic designs** **involve** immersive fieldwork, where researchers spend extended periods of time in the natural setting of the group they are studying.
- **Ethnographic designs** **provide** rich and detailed insights into the social dynamics and lived experiences of the studied population:
 - **Observing and participating in daily activities, conducting interviews, and analyzing artifacts,.**
- **It provide** a setting description, examines themes or problems that emerge over time as the group interacts, and provides a detailed account of the group.



Qualitative Research Designs : Narrative Designs

- **Narrative research designs** aim to understand and interpret individuals' experiences and stories.
- **Narrative research designs involve collecting and analyzing rich, detailed narratives from participants to uncover themes, patterns, and meanings within their lived experiences.**
- **Narrative research designs** are particularly useful when studying complex phenomena or exploring subjective perspectives, as they allow researchers to delve deeply into the unique narratives of individuals and gain a holistic understanding of their lives.



Mixed Methods Research Design: Conceptual Framework

- *Theoretical* structure that *provides* a foundation for *understanding* and *analyzing* various aspects of a *particular problem* or *phenomenon*.
- *Helps* researchers *organize* their thoughts, *define key concepts*, and *establish relationships* between *variables* or *components*.
- Using a conceptual framework, researchers can *develop hypotheses*, *design experiments*, and *interpret* their findings in a *systematic* and *coherent manner*.
- This framework *serves* as a *roadmap* for *conducting* research and *contributes* to the advancement of knowledge in the field of computer science.



Mixed Methods Research Design: Embedded Design

- **Embedded Design** allows researchers to *gather* a *comprehensive understanding* of the *research topic* by *collecting* and *analyzing* both *subjective experiences* and *numerical data*.
- By using a mixed methods design, researchers can *gain* a more *holistic perspective* and *validate* their *findings* through multiple *sources of evidence*.
- This design also *offers flexibility* in adapting the **conceptual framework** to accommodate the unique needs of the study, ensuring that both *qualitative* and *quantitative* components are *effectively integrated*.



Research Model

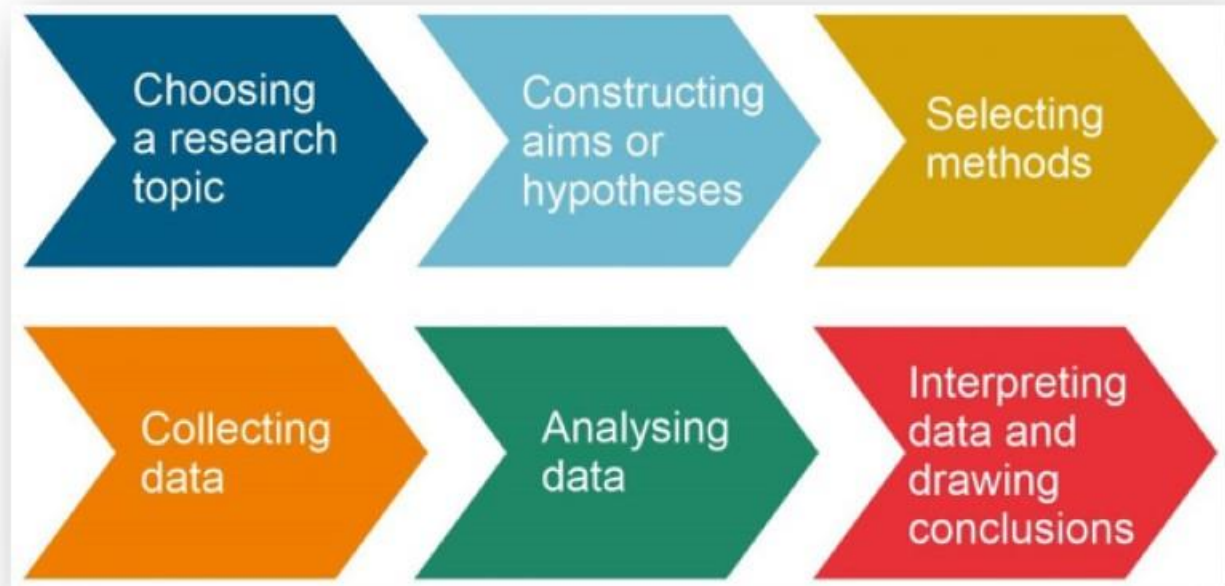
- **Research model** *refers* to a *framework* or *structure* that researchers use to *guide* their study and *analyze* data.
- **Research model** *helps* to *organize* the research process and *ensure* that all relevant factors *are considered*.
- By following this *systematic* process, researchers can *ensure* that their study is *rigorous* and *reliable*.



Research Model (cont.)

➤ The model **provides** a *systematic approach* to research by **outlining** the steps **involved**, such as:

- ☐ *Defining* the research question
- ☐ *Conducting* a literature review
- ☐ *Collecting* and *analyzing* data
- ☐ *Drawing* conclusions.





Research Model (cont.)

A research model can be used in both **quantitative** and **qualitative** research methods. The choice of whether to use a research model in a quantitative or qualitative study depends on the research objectives, the nature of the research questions, and the type of data being collected:

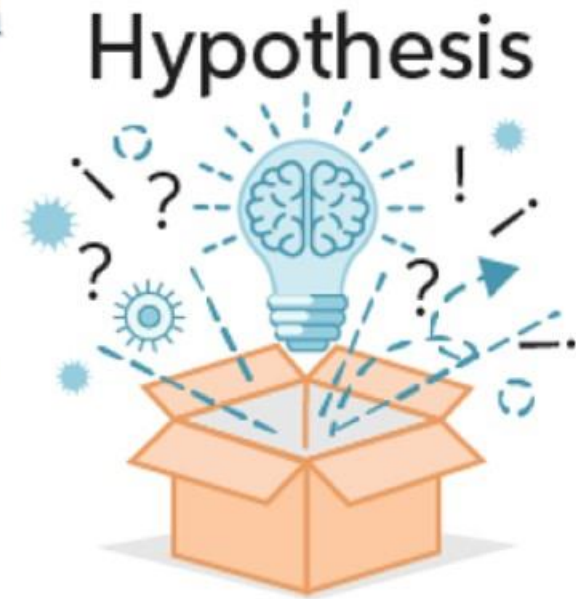
1. Quantitative Research: In quantitative research, research models are often used to test hypotheses, examine relationships between variables, and collect numerical data. Statistical models and experimental designs are common in quantitative research to quantify and analyze data.

2. Qualitative Research: In qualitative research, research models can be used to provide structure and guidance for data collection and analysis. These models may involve conceptual frameworks, theoretical frameworks, or coding schemes to help researchers make sense of qualitative data such as interviews, observations, and textual materials.



Research Hypothesis

- A *proposed explanation* or *prediction* about the research *problem* that can be tested through *experimentation* or *analysis* and *proved* through the empirical data.
- *Hypothesis* serves as a starting point for *investigations* and *guides* researchers in their quest to *find evidence* or *support* for their proposed idea.





Research Hypothesis (cont.)

- By formulating *hypotheses*, researchers aim to *advance knowledge* and *understanding* in various domains of computer science.
- *Hypothesis* is the *relationship* between *two variables* in the *conceptual framework*
- Different types of *hypotheses* in computer science research:
 - ☐ Null hypotheses
 - ☐ Alternative hypotheses
 - ☐ Directional
 - ☐ Non-directional hypotheses.



NULL HYPOTHESIS

means insignificant or no relationship between two variables.



ALTERNATIVE HYPOTHESIS

means rejection of null hypothesis.



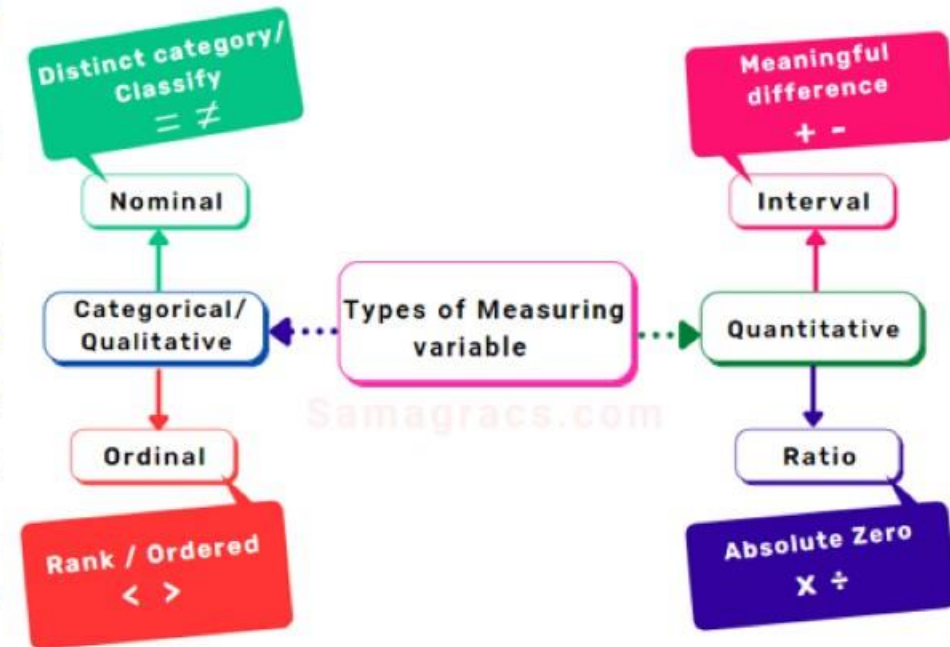
Metrics in Research

- *Metrics* in computer science research are used to *evaluate* the *performance*, *efficiency*, and *effectiveness* of *algorithms*, *systems*, and *methodologies*.
- *Metrics* help researchers *compare different approaches* and *make informed decisions* about their work.
- They can include *measures* such as *runtime analysis*, *memory usage*, *accuracy*, *precision*, *recall*, and *score*.
- *Metrics* play a crucial role in *benchmarking* and *establishing standards* within the field.



Scales of variable measurement

- **Nominal scales:** categorize data into *distinct groups* or *categories* without any inherent order.
- **Ordinal scales:** *ranking* or *ordering* of data based on some *criteria*.
- **Interval scales** provide a measurement with *equal intervals* between values but *do not* have a *true zero point*. Common examples of interval scales include temperature measured in degrees Celsius or Fahrenheit. The zero point in these scales (e.g., 0°C or 0°F) does not mean the complete absence of temperature; it's just a reference point.

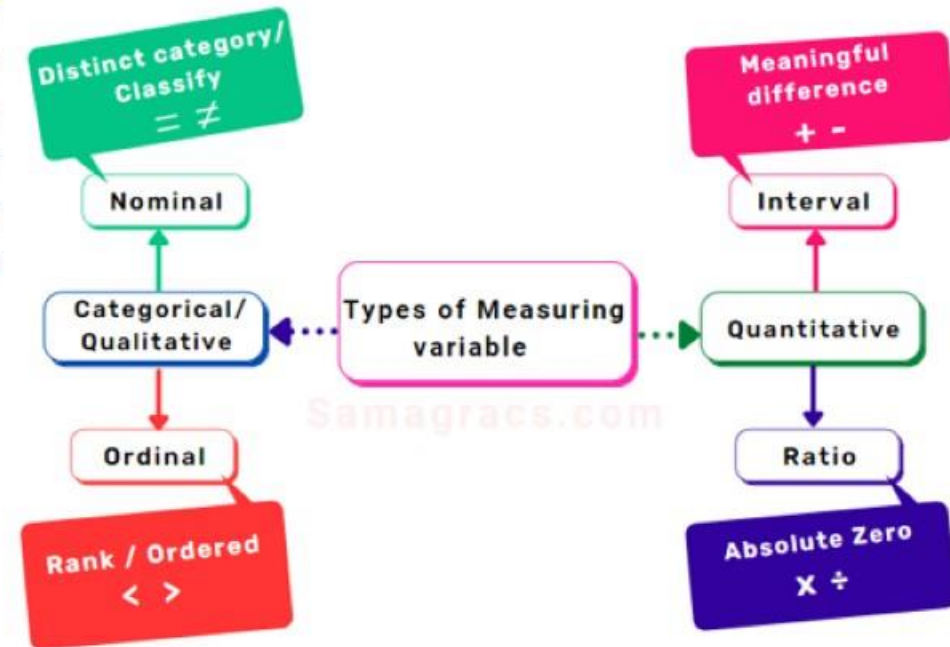




Scales of variable measurement (cont.)

- *Ratio scales provide* a measurement with *equal intervals* between values and a true zero point, allowing for precise mathematical operations. Common examples of ratio scales include measurements like height, weight, age, and income. For example, when measuring weight, a value of 0 kilograms (or pounds) represents the complete absence of weight, as it's not possible to have a negative weight.

A true zero point is a critical feature in measurement scales, as it defines the point where the measured attribute is completely absent.





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Thank You