SSE5210

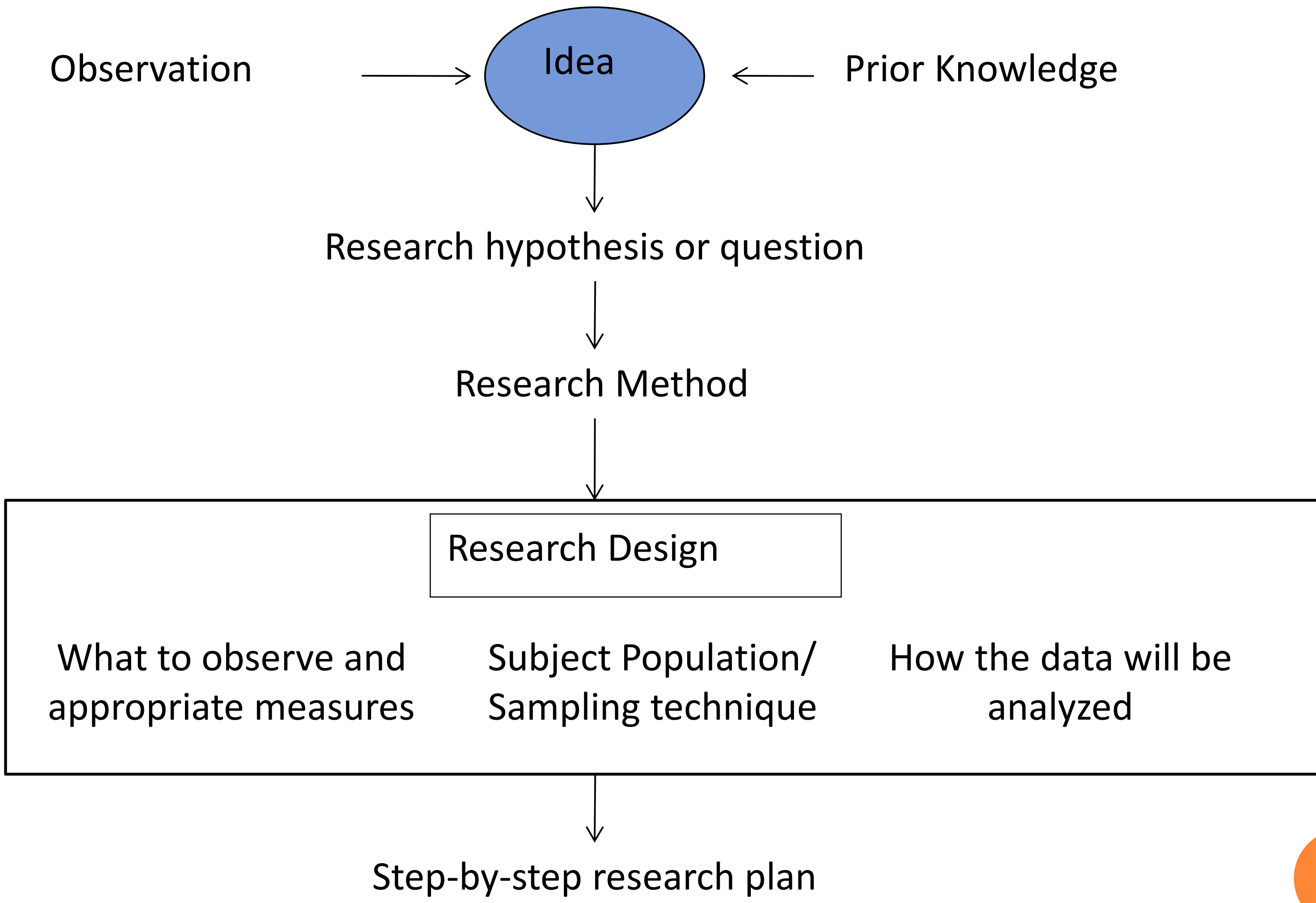
CHAPTER 1

OVERVIEW OF EMPIRICAL METHODS

What is Empirical Research?

- Empirical research is defined as research based on observed and measured phenomena.
- It reports research based on actual observations or experiments using quantitative research methods and it may generate numerical data between two or more variables.

Deploying Empirical Research Methods



Steps of Empirical Research

1. Select a topic or phenomenon to study
2. Perform background investigation/literature review
3. Identify specific research questions or hypotheses
4. Select a research method
5. Develop a detailed research plan/proposal
   a. For identifying or recruiting subjects
   b. For collecting data
      - Define variables or phenomena to be observed and a coding scheme
      - Determine how the data will be obtained
   c. For analyzing data
6. Execute the plan
7. Document the research you performed (ongoing)

Basic Concepts of Measurement-1

"Measurement is a mapping from the empirical world to the formal, relational world. Thus, a measure is the number or symbol assigned to an entity by this mapping in order to characterize an attribute" [Fenton96]

- A measure is a mapping from the attribute of an entity to a measurement value, usually a numerical value.
- Measure is used to characterize an attribute in a formal way.
- The measurement must preserve the empirical observations of the attribute.
- E.g.:
- Object A is longer than object B, the measure of A must be greater than the measure of B.

Basic Concepts of Measurement-2

- When we use a measure in empirical studies, we must certain that the measure is valid.
- The measure must not violate any necessary properties of the attribute it measures – must be a proper mathematical characterization of the attribute.
- The mapping from an attribute to a measurement value can be made in many different ways-each different mapping –a scale
- Admissible transformation (rescaling)- able to transfer one measure to another and preserve the relationships-
- Meaningful vs. meaningless relate with the scale types.

Scale Types

- The most common scale types:

1. Nominal
2. Ordinal
3. Interval
4. Ratio

NOMINAL SCALE

- Least powerful
- Only maps the attribute of entity into a name or symbol.
- Classification of entities according to the attribute.
- Possible transformation: one-to-one
- Example: classification, labeling and defect typing

Ordinal Scale

- Consists of classes that are ordered with respect to the attribute – more powerful than nominal scale.
- Example of ordering criteria: “greater than”, “better than” , “more complex”
- The numbers represent ranking only, so addition, subtraction, other arithmetic operations have no meaning.
- Any mapping that preserves the ordering (any monotonic function) is acceptable.
- Example: grades, software complexity

Interval Scale

- Preserve order same as the ordinal scale but there is notion of “relative distance” between two entities.

- Possible transformation $M' = aM + b$, where M′ and M are different measures on the same attribute.

- Example: temperature measure in Celsius and Fahrenheit.

  Fahrenheit = 9/5 Celsius + 32

Ratio Scale

- Preserves ordering, size of intervals between entities, and ratio between entities.
- Start at zero and increase at equal intervals, known as units.
- Possible transformation, $M' = aM$ where M′ and M are different measures on the same attribute.
- Example: length; convert feet to inches: $I = 12\ F$
- Other example: Length of software code, duration of the development phase.

Meaningful vs. meaningless

- Meaningful- if the statements are true even if the measures are rescaled, otherwise they are meaningless.

1. Fred is <u>twice</u> as tall as Jane - at least on ratio scale and meaningful no matter what unit is used

2. The temperature in Tokyo today is <u>twice</u> than in London.

   - Twice-> implies ratio scale but not meaningful because we measure temperature on two scales, Fahrenheit and Celsius.
   - If Tokyo 40° C and London is 20° C then the statement is true, however on Fahrenheit, Tokyo is 104° F while London is 68 ° F.

Objective Measure

- There is no judgment in the measurement value-only dependent on the object that is being measured.
- Ensure consistency in measurement.
- Different people produce the same measures- can be measured several times and the same value can be obtained within the measurement error.
- E.g. Lines of code, delivery date

Subjective Measure

- The measure depends on both the object and the viewpoint from which they are taken.
- Subjective measures depend on the environment, vary with the person measuring.
- Can be different if the object is measured again.
- E.g. personal skill, usability

  - mostly nominal or ordinal scale type

DIRECT AND INDIRECT MEASUREMENT

- Direct measurement of an attribute of an entity involves no other attribute or entity.
- E.g. lines of code, number of defects found in test
- Indirect measurement – involves the measurement of other attributes – derived from the other measures
- E.g. defect density (number of defect /LOC), programmers productivity (LOC/effort)

MEASUREMENT IN SE

Can be classified into 3 classes:

1. Processes (collections of software-related activities)

2. Products (any artifacts, deliverables or documents that result from a process activity)

3. Resources (entities required by a process activity)

Within each class, can distinguish between

1. Internal attributes (can be measured purely in terms of the objects itself)

2. External attributes (can only be measured with respect to how the product, process or resource relates to other objects)

Example of Measures in SE

Class	Examples of objects	Type of attribute	Example of measures
Product	Code	Internal	Size
		External	Reliability
Process	Testing	Internal	Effort
		External	Cost
Resource	Personnel	Internal	Age
		External	Productivity

Summary of measurement scales and statistics relevant to each

Scale Type	Defining relations	Example of appropriate statistics	Appropriate statistical tests
Nominal	Equivalence	Mode Frequency	Non-Parametric
Ordinal	Equivalence Greater than	Median Percentile Spearman *r* Kendall ζ Kendall *W*	Non-Parametric
Interval	Equivalence Greater than Known ratio of any intervals	Mean Standard deviation Pearson product-moment correlation Multiple product-moment correlation	Non-Parametric and parametric
Ratio	Equivalence Greater than Known ratio of any intervals Known ratio of any two scale values	Geometric mean Coefficient of variation	Non-Parametric and parametric