Measurement

Y520

Strategies for Educational Inquiry

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How are variables measured?

- First, variables are defined by conceptual definitions (constructs) that explain the concept the variable is attempting to capture.
- Second, variables are defined by operational definitions; that is, definitions of how variables will be measured.

Example: “Study effort” (a)

- The variable “study effort” may be defined conceptually as the amount of effort required to master a body of material, including reading, looking up definitions, note-taking, drill, self-quizzing, and so forth.
- Each of these components must be operationalized in order to be measured.

Example: “Study effort” (b)

- The variable “study effort” may be said to consist of reading, looking up definitions, note-taking, drill, and self-quizzing.
  - Reading (operational definition): How many hours per day do you read course related material?
  - Looking up definitions (operational definition): On average, how many words per textbook page do you look up?

Example: “Study effort” (c)

- The variable “study effort” may be said to consist of reading, looking up definitions, note-taking, drill, and self-quizzing.
  - Note-taking (operational definition): How many pages of notes do you take per textbook page? Do you consolidate your notes by taking notes on your original notes?
  - Drill (operational definition): How many hours per day do you drill on new terms and formulas?

Operational definitions - Constructs

- In any research project it is important to involve key players in the formulation of operational definitions because:
  - Operational definitions should be consistent with constructs.
  - Critiques of poorly constructed operational definitions can be used for improvement.
  - Constructs are often inferred from operational definitions.

What is Measurement?

- Measurement is the assignment of numerals to objects or events according to rules.
  - **Numerals** are labels that have no inherent meaning, for example zip codes, or automobile license plates.
  - **Numbers** are numerals that have quantitative meaning and can be analyzed, for example, age.

What is Measurement?

- The rules for assigning labels to properties of variables are the most important components of measurement, because the result of poor rules is meaningless outcomes.
- Concepts often cannot be measured directly, e.g., “intelligence,” so what is usually measured are indicators of constructs, such as speed, logic, verbal skill, etc.

Levels of Measurement

- Four levels of measurement have been identified. These levels differ in how closely they approach the structure of the number system we use.
- Understanding the level of measurement of variables used in research is important because the level of measurement determines the types of statistical analyses that can be conducted.
- The conclusions that can be drawn from research depend on the statistical analysis used.

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Levels of Measurement: Nominal

- Nominal level measurement uses symbols to classify observations into mutually exclusive and exhaustive categories.
  - Mutually exclusive means the categories must be distinct so that no observation falls into more than one category.
  - Exhaustive means sufficient categories must exist so that all observations fall into some category.

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Levels of Measurement: Nominal

- This is the most basic level of measurement.
- At this level we can determine only whether two observations are alike or different.
- Example: In a survey of teachers, sex was determined by a question. Observations were sorted into two mutually exclusive and exhaustive categories, male and female. Observations could be labeled with the letters M and F, or the numerals 0 and 1.

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Levels of Measurement: Nominal

- In the same survey the variable of martial status could be measured by two categories, married and unmarried.
- But, these categories must each be defined so that all possible observations will fit into one category but no more than one: legally married, common-law marriage, religious marriage, civil marriage, living together, never married, divorced, informally separated, legally separated, widowed, annulled, abandoned, etc

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Levels of Measurement: Nominal

- In nominal measurement, all observations in one category are alike on some property and differ from the members in the other category on that property (e.g., sex, martial status).
- On ordering of categories exists. We cannot say one category is better or worse, or more or less than another.

Levels of Measurement: Nominal — Numbers used as Names

- Basic Empirical Operations
  - Determination of equality
- Permissible Statistics
  - Number of cases
  - Mode
  - Contingency correlation
- Examples
  - Numbers on basketball jerseys
  - Assignment of type or model numbers to classes

Levels of Measurement: Ordinal

- Ordinal level of measurement uses symbols to classify observations into categories that are not only mutually exclusive and exhaustive. In addition, the categories have some explicit relationship among them.
- Observations may be classified into categories such as taller and shorter, greater and lesser, faster and slower, harder and easier, and so forth.
- The categories must be exhaustive and mutually exclusive.

Levels of Measurement: Ordinal

- Most questionnaires use Likert type items. For example, we may ask teachers about their job satisfaction.
- Asking whether a teachers is very satisfied, satisfied, neutral, dissatisfied, or very dissatisfied is using an ordinal scale of measurement.

Levels of Measurement:
Ordinal — Rank order data

- Basic Empirical Operations
  - Determination of “greater” or “less”
- Permissible Statistics
  - Median
  - Percentiles
  - Rank order correlation
- Examples
  - Scores on cognitive & affective measures
  - Hardness of minerals
  - Quality of performance; objects (wool, meals, etc)

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Level of Measurement: Interval

- The interval level of measurement classifies observations into mutually exclusive and exhaustive categories that have some explicit relationship among them, and the relationship between the categories is known and exact. This is the first quantitative application of numbers.

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Level of Measurement: Interval

- In the interval level of measurement, a common and constant unit of measurement is established between the categories. For example, measures of temperature are interval scales.
- A temperature of 75° is one degree cooler than a temperature of 76°; likewise, a temperature of 32° is one degree warmer than a temperature of 31°.

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Level of Measurement: Interval

- Numbers may be assigned to observations because the relationship between any two categories is assumed to be the same as the relationship between numbers in the number system. For example, 76-1=75 and 31+1=32.
- Intervals between categories are equal but they originate from some arbitrary point of origin. No meaningful zero point exists.

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Levels of Measurement: Interval — Equal intervals

- Basic Empirical Operations
  - Determination of equality of intervals / differences
- Permissible Statistics
  - Mean
  - Standard deviation
  - Product-moment correlation
- Examples
  - “Standard scores” on cognitive & affective scales
  - Temperature: Fahrenheit & centigrade scales
  - Calendar dates

Levels of Measurement: Ratio

- The ratio level is the same as the interval level with the addition of a meaningful and non-arbitrary zero point.
- Examples: Weight, area, speed, velocity. In education, budgets and number of students are measured on ratio scales.

Levels of Measurement: Ratio

- Variables measured at a higher level can always be converted to a lower level but not vice versa.
- Observations of actual age (ratio scale) can be collapsed to categories of younger and older (ordinal scale), but age measured simply as younger or older cannot be converted to measures of actual age.

Levels of Measurement: Ratio — Equal intervals & Absolute zero

- Basic Empirical Operations
  - Determination of equality of ratios
- Permissible Statistics
  - Same as for interval
  - Coefficient of variation
  - Logarithmic transformations
- Examples
  - Temperature: Kelvin scale
  - Length, weight, force, etc.
  - Money

Levels of Measurement:

Review —

- What level of measurement is each of the following, and what is your reasoning?
  - Numbers in street addresses.
  - Order of finish in 100 yard dash.
  - Social Security Numbers.
  - Number correct on classroom spelling quiz.
  - Number correct on SAT.

Inferences in Measurement

- **The following slide contains a list of nine items.**
- **For each item:**
  - **Describe how we measure,**
  - **Identify the level of measurement,**
  - **Describe the inference we make, and**
  - **Describe the construct.**

Inferences in Measurement

1. Length of table
2. Weight of person
3. Speed of car
4. Temperature
5. Humidity
6. Wind chill index
7. Discomfort Index (Smog Index / Pollen Index)
8. Intelligence
9. Anxiety

Inventing Constructs

- How would you describe the relationship(s) among the following:
  - Operational definitions
  - Variables
  - Measurement
  - Scales of measurement
  - Inferences from measurements
  - Constructs
- Discuss each for the items on the following slide

Inventing Constructs

1. Temperature
2. Wind Chill
3. Discomfort Index
4. Intelligence
5. Extroversion

Example:

Intelligence and its Measurement

- Intelligence is one construct that continues to generate discussion, and divergent opinions.
- The *Journal of Educational Psychology* held a symposium in 1921 entitled “Intelligence and its Measurement.”
- Definitions of the constructed were offered by researchers. As you read, how would you operationalize each definition? What would items on a scale look like?

Definitions:

Intelligence and its Measurement (a)

1. The ability to give responses that are true or factual. — E. L. Thorndike
2. The ability to carry on abstract thinking. — L. M. Terman
3. The ability to learn to adjust oneself to the environment. — S. S. Colvin
4. The ability to adapt oneself to relatively new situations in life. — R. Pinter

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Definitions:

Intelligence and its Measurement (b)

5. The capacity for knowledge and knowledge possessed. — V. A. C. Henmon
6. A biological mechanism by which the effect of a complexity of stimuli are brought together and given a somewhat unified effect in behavior. — J. Peteson

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Definitions:

Intelligence and its Measurement (c)

7. The ability to inhibit an instinctive adjustment, to redefine the inhibited instinctive adjustment in the light of imaginally experienced trial and error, and to realize the modified instinctive adjustment into overt behavior to the advantage of the individual as a social animal. — L. L. Thurstone

Definitions:

Intelligence and its Measurement (d)

8. The ability to acquire abilities. — H. Woodrow
9. The ability to learn or profit by experience. — W. F. Dearborn

"Intelligence is what intelligence tests test."
— E. G. Boring (1923)

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