

Doctoral Dissertation Boot Camp

Quantitative Methods

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The Scientific Method of Problem Solving

The conceptual phase – Reviewing the literature, stating the problem, identifying a theoretical framework, formulating research questions and/or hypotheses.

The methods phase - Design, subject selection, instrumentation, data collection methods, and data analysis plan.

The empirical/analytic phase – Analysis and interpretation of the data to answer the research questions and/or test the hypotheses.

The dissemination phase – Publishing and/or presenting the study.

According to Kerlinger, scientific research is a **systematic**, **controlled**, **empirical**, and **critical** investigation of hypothetical propositions about the presumed relations among natural phenomena. Systematic so that the study may be replicated: 1) Direct replication – to confirm, 2) Systematic replication – to generalize. Extraneous/confounding variables must be controlled. The outcome variable must be measured. The study must be evaluated by experts.

<https://home.ubalt.edu/tmitch/632/kerlinder%20definitions.htm>

Typical sources of the research problem are experience, literature, theory, external sources, and social issues. *Applied* research is done to solve a problem and/or improve practice. *Basic* research is done for the sake of knowledge to understand processes and structures that underlie observed behaviors.

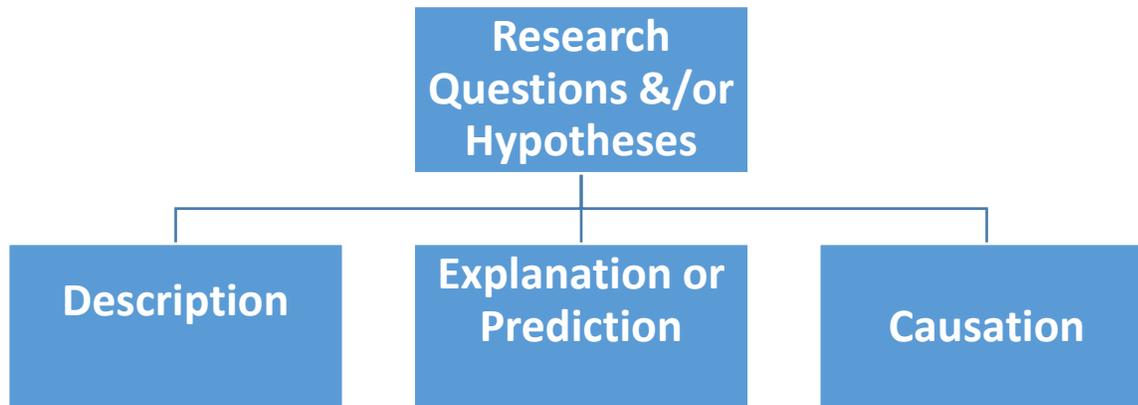
Research Quality: Schoenfeld's Framework: Generalizability, Trustworthiness, Importance

https://gse.berkeley.edu/sites/default/files/users/alan-h.-schoenfeld/Schoenfeld_2008%202nd%20edn%20intl%20HBK.pdf

MaxMinCon Principle (Kerlinger)

- **Max** – Maximizing explained/true variance.
- **Min** – Minimizing unexplained/error variance.
- **Con** – Controlling for extraneous/confounding variables.

Statement of the Problem → Specific Objectives →



Research Design

Experimental versus Non-Experimental Studies

Causal inferences may be drawn in experimental research but not in non-experimental studies. **Manipulation, control, and observation** are the three major ingredients of experimental research.

- **True experiment** employs random assignment.
- **Quasi experiment** employs intact groups.

Do not confuse **random assignment** with **random selection**. Random assignment is done in experimental research to tend to internal validity so that we may conclude that, for example, the independent variable (e.g., teaching method) did indeed affect the outcome measure (e.g., achievement in mathematics). Random selection is related to external validity (generalizability of the results)

Experimental versus Causal-Comparative Studies

Also called ex post facto (after the fact), causal-comparative studies are conducted to **predict** or **explain**. Causal inferences cannot be drawn because the independent variable is not manipulated by the researcher. A comparison group is selected from a population which is similar to the "characteristic present" group except for the variable(s)/characteristic(s) that are being investigated. For example, comparing school dropouts with school completers if the purpose of the study is to predict school dropout.

Correlational Research – To examine the degree of the relationship among two or more quantitative variables for the purpose of prediction or explanation. Note that correlation does not necessarily indicate causation.

- Simple correlation, r_{xy} . One independent variable (e.g., test anxiety) and one dependent variable (e.g., test performance)
- Multiple correlation, $R_{x_1x_2x_3.y}$. More than one independent variable (e.g., test anxiety, test preparation, & IQ) and one dependent variable (e.g., test performance)

Survey Research is done to *explore*. To obtain information concerning the current status of phenomena. There are no independent or dependent variables and hypotheses may not be tested.

Census – Studying all members of a population.

Longitudinal (prospective) Research - To study the same sample of subjects over an extended period of time.

Retrospective Research – It relies on recollection of past events. It may be called cross-sectional research.

Subject Selection

- Frame
- Population
 - Target population
 - Accessible population
- Sample
- Population validity is achieved if it is shown that the sample is representative of the population.

Non-random/Non-probability Samples

- These samples are not representative of the population. Therefore, results may not be generalized from the sample to the population. Examples of such samples:
 - **Convenience sampling** - Selecting cases based on their availability for the study.
 - **Quota sampling** - Selecting cases based on required, exact number, or quotas, of persons of varying characteristics.
 - **Purposive/judgmental sampling** - Selecting cases which are believed to be representative of a given population.
 - **Network/snowball sampling** – Recruiting a few subjects and then asking them to refer friends and acquaintances.
 - **Self-selected sampling** – Selecting subjects via the use of an invitation to which some may respond and agree to participate in the study.

Random/Probability samples

- These samples are representative of the population. Therefore, results may be generalized from the sample to the population. Examples of such samples:
 - **Simple random sampling** - Each member of the study population has an equal chance/probability of being selected.
 - **Systematic random sampling** - Each member of the study population is listed, a random start is designed, and then every k^{th} (N/n) case from the list is selected. For example, $N = 2,000$ and we would like to select a sample of 200. Then, $k = 2,000/200 = 10$. A random number between 1 and k is selected for the starting point of the sampling, say 7. From there on, every k th element is chosen until the desired sample size is reached, that is, 7, 17, 27, etc.
 - **Stratified random sampling** - Each member of the study population is assigned to a group or **stratum**, and then a simple random sample is selected from each stratum.

❖ Proportionate stratified sampling

Population, $N = 20,000$, is divided into the following strata:

stratum 1=6,000 stratum 2=4,000 stratum 3=4,500 stratum 4=5,500

To obtain a sample, n , of 1,000: $n/N = 1,000/20,000 = 0.05$

$6,000 \times 0.05 = 300$ from stratum 1, $4,000 \times 0.05 = 200$ from stratum 2

$4,500 \times 0.05 = 225$ from stratum 3, $5,500 \times 0.05 = 275$ from stratum 4

❖ Disproportionate stratified sampling

- **Single-stage cluster sampling** - Intact groups, not individuals, are randomly selected. For example, suppose a sample of 1000 nurses is sought to examine nurses' job satisfaction in a city. Let's say, on the average, there are 100 nurses in the city's hospitals. Then 10 hospitals can be randomly selected and within each of these hospitals, all nurses would be included in the study.
- **Multi-stage cluster sampling** - Involves selecting clusters at random (e.g., from states to universities to faculty members).
- **Multi-stage random sampling** – For example, select the clusters at random first, followed by random selection of the subjects in the clusters.

Instrumentation

Instrument is the generic term for any type of measurement.

Validity - The extent to which an instrument measures what one thinks it is measuring.

Types of validity

Face/Logical Validity - What the test appears superficially to measure?

Content Validity - How adequately does the test content sample the larger domain of situations it represents.

Criterion-Related Validity - Refers to the relationship between the scores on a measuring instrument and an independent external variable (criterion) believed to measure directly the behavior or characteristic in question. Obtaining a satisfactory criterion for success is a major problem. For example, what criterion can be used to validate a measure of teacher effectiveness? Who is to judge teacher effectiveness? What criterion can be used to test the predictive validity of a musical aptitude test? Validity Coefficient is the correlation between the test score and the criterion measure.

- **Concurrent Validity** – To estimate present standing. Appropriate for tests developed for *diagnosis*. Johnny is neurotic.
- **Predictive Validity** – To predict future performance. Appropriate for tests developed for *selection* and/or *classification*. Johnny is likely to become neurotic.

Construct Validity - The extent to which the test may be said to measure a theoretical construct or trait.

- **Convergent Validity** – Convergence among different methods designed to measure the same construct; for example, high correlation between two measures of anxiety. Or showing that the test correlates highly with other variables with which it should theoretically correlate. For example, correlation between scholastic aptitude test scores and school grades, or correlation between scholastic aptitude test scores and achievement test scores.
- **Discriminant Validity** – It refers to distinctiveness of constructs, that is, showing that the test does not correlate highly with variables from which it should differ. For example, low correlation between scholastic aptitude test scores and musical aptitude test scores, or low correlation between measures of anxiety and introversion.
- **Factor Analysis**
- **Experimental Intervention**

Reliability - The degree of consistency of a measuring instrument in measuring whatever it is designed to measure.

A. Errors of Measurement

1. Systematic Errors - They lean in one direction; scores tend to be all positive or all negative, or all high or all low. Error in this case is constant or biased.
2. Random Errors - They are self-compensating; scores tend now to lean this way, then the other way. Error in this case is random. There are several cues for this (e.g., chance, fatigue, mood, and the like).

Procedures for Estimating Reliability

A. Test-Retest Reliability - Coefficient of Stability.

B. Equivalent-Forms (Parallel-Form) Reliability

1. Coefficient of Equivalence
2. Coefficient of Equivalence & Stability

C. Measures of Internal Consistency

1. Split-Half Reliability – Reliability if a function of the length of the instrument.
2. Cronbach's Coefficient Alpha - It ranges from 0 to 1.0 (0% to 100%).

		Test Form	
		1	2
Test Session	1	Internal Consistency Reliability	Coefficient of Equivalence (Immediate Administration of Test Forms)
	2	Coefficient of Stability	Coefficient of Equivalence & Stability (Delayed Administration of Test Forms)

Data Collection

- Existing Data/Information
- Mail Survey/On-line Survey
- Telephone Survey
- Group Administered Survey
- Personal Interview
- Group Interview/Focus Group
- Observation
- Mass Media/Public Hearings
- Bio-physiologic Measures

Likert Scale – It is the most widely used scale in survey research. Levels of agreement, for example:

- 4 = Strongly Agree
- 3 = Agree
- 2 = Disagree
- 1 = Strongly Disagree

Commonly Used Tests

- Intelligence Test – To predict achievement in general.
- Aptitude Test – To estimate future performance.
- Achievement Test – To assess status upon the completion of the task.
- Diagnostic Test – To identify a student's strengths and weaknesses in a subject matter.
- Personality Tests – To assess personality traits.

Data Analysis

- I. Continuous (measurement) data - Use parametric statistical techniques:
 - A. Differences
 1. Two independent groups: t test for independent samples.
 2. Two dependent groups: t test for correlated samples.
 3. One grouping variable with multiple independent levels, and only one outcome measure: One-way ANOVA. Use ANCOVA if there are also extraneous (concomitant) variables.
 4. More than one grouping variable with multiple independent levels, and only one outcome measure: Factorial ANOVA.
 5. Multiple dependent means: Repeated-measures ANOVA.
 6. One grouping variable with multiple independent levels, and more than one outcome measure: MANOVA, Discriminant analysis.
 - B. Relationships
 1. Two continuous variables: Pearson r
 2. Several predictors, one criterion: Multiple correlation & multiple regression. Use Logistic regression if the criterion is a dichotomous (binary) variable. If the criterion variable has more than 2 levels, use discriminant analysis.
 3. Several independent variables (predictors) and several dependent variables (criteria): Canonical correlation.
- II. Categorical (frequency) data - Use non-parametric statistical techniques:
 - A. Differences
 1. Two independent groups: Ordinal data: The Mann-Whitney-Wilcoxon U test. Nominal/count data: Chi-square goodness-of-fit test.
 2. Two dependent groups: Ordinal data: The Wilcoxon Matched-Pairs Signed-Ranks test. Use McNemar test when analyzing dichotomous nominal data.
 3. One grouping variable with multiple independent levels: Ordinal data: The Kruskal-Wallis test. Nominal/count data: Chi-square goodness-of-fit test.
 4. Multiple dependent groups: The Friedman test.
 - B. Relationships
 1. Two ordinal variables: Spearman rho or Kendall tau. Employ Kappa coefficient if you wish to examine inter-judge agreement (reliability of ratings).
 2. Two binary variables: Chi-square test of independence, followed by Phi coefficient. If there are cells with expected frequency < 5 , use Fisher's Exact Test (note that this test does not use the chi-square approximation and should not be called a chi-square test).
 3. Row by Column contingency table: Chi-square test of independence, followed by Cramer's statistic.
 4. Several related samples: Kendall Coefficient of Concordance.

Human Subject Research, CITI Online Course

<http://research.tamucc.edu/compliance/citi.html>

IRB

<http://research.tamucc.edu/compliance/forms.html#irb>

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