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Chapter 6

Sections

Quantitative Core Designs: Sampling and Evaluation of Quantitative Research

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Essential Questions

- What types of research problems are suitable for quantitative research?
- How does a researcher select a quantitative design?
- What are the GCU core designs for quantitative research?
- How does one select appropriate measures or instruments for quantitative research?
- What sampling approaches are used in quantitative research?
- What are the most common approaches used in quantitative data analysis?

Introduction and Definition of Quantitative Research

Quantitative research is frequently used in the social sciences because it is quick, relatively inexpensive, and considered a valid method of inquiry by researchers and academicians. The goals of quantitative research are to describe the attributes of a group of people, to measure differences between groups, to determine if a relationship exists between variables, or to predict if one event or factor causes another.

Quantitative studies contain measureable and quantifiable data, a statistically appropriate sample, use of statistical techniques, and a structured data collection plan to ensure that the study can be replicated. Additionally, quantitative studies require the use of valid and reliable instruments, surveys, or databases to quantify variables. The research method is **deductive**, very structured, and inflexible as often the goal of the researcher is to generalize or apply the results to other groups and populations besides those participating in the study. Ultimately, quantitative research offers a systematic and structured process for answering research questions (Balnaves & Caputi, 2001).

Research Problems Suited for Quantitative Research

Doctoral researchers first identify a broad field of interest that they may want to study in the dissertation. Sources used to identify research problems can include literary articles, social, political, or religious issues, practical workplace situations, topics of personal interest and experience, or extensions of prior research studies. The most important aspect of identifying the research problem is to thoroughly read the available research and literature in the field of interest to find out what has not been studied. This leads to the elusive gap that the doctoral study can fill. A topic of interest does not always make a feasible research study. Some problems suited for quantitative research may include:

- Determining if the climate of an organization is impacted by the level of emotional intelligence displayed by the leader.

- Determining if high stakes test scores were improved by student participation in an accelerated math curriculum over a 3-year period.
- Determining if the level of moral reasoning of employees is related to or correlates with the number of years they spent with a company.

The steps for conducting a quantitative study closely resemble the steps of the scientific method:

1. Identify a problem or gap based on prior research that is appropriate for a dissertation study.
2. Establish research objectives.
3. Identify the appropriate methodology and design.
4. Plan for and collect data.
5. Process and analyze data.
6. Report and interpret data.

Overview of Quantitative Core Designs

While there are a number of designs that are appropriate for quantitative studies, GCU has endorsed specific designs that facilitate a smooth dissertation journey for learners. As shown in Table 6.1, these fall into three broad categories: experimental research, quasi-experimental research, and nonexperimental research. Nonexperimental studies can be further classified as descriptive, correlational, and causal-comparative.

GCU Core Quantitative Designs

- Experimental
- Quasi-Experimental
- Descriptive (Survey)
- Correlational
- Causal-Comparative

Table 6.1

Quantitative Designs, Descriptions, and Examples (McMillan, 2012)

Design	Description	Example

Experimental	Used to test an idea, treatment, or program to see if it makes a difference. Determines if there is an effect/outcome of some form of treatment(s) using random assignment of subjects to treatment and control groups. There is a control group and a test group. Individuals are assigned randomly to the two groups. One group gets the treatment (test group) and the other group (control group) does not get the treatment. There is a pretest and posttest for both groups in a traditional experimental design. Standardization of all aspects of research procedures employed to ensure conditions are the same for all participants. Designed to demonstrate unambiguous cause-and-effect relationship between variables.	The effect of a new discipline plan on student incidences of misbehavior. A comparison of the effect of direct instruction vs. cooperative groups on students' ability to compute multistep math equations.

Quasi-Experimental	Designed to demonstrate cause-and-effect relationship between variables. Determines if there is an effect/outcome of some form of treatment(s) using preexisting groups of subjects assigned to treatment and control groups. Does not meet all requirements of an experimental design, thus cannot produce an unambiguous cause-and-effect explanation. It is the same as experiment in that there is a control and test group; however, current groups are used as is rather than randomly assigning people to the two groups. Both groups receive the pretest and posttest in a traditional design. Typically no random assignment—participants are in preexisting groups or groups that are formed naturally. Inclusion of participants in the control or treatment group is determined by conditions beyond the control of the researcher. Conducted with similar rigor and control as experimental studies with clearly defined treatments.		

	Design contains a confounding variable or factor that prevents the research from obtaining an absolute cause-and-effect answer.		
	Descriptive (Survey)	Describes the opinions, attitudes, or trends of a population numerically.	A description of how parents participate in school activities.
		Provides a description of individual variables but is not concerned with the relationship between variables.	A description of the extent to which high school teachers integrate technology into math instruction.
		Uses a process of surveying a sample to generalize to the population.	
		Determines if there is a relationship between two or more variables on a single group of participants with the intent	The relationship between employee perceptions of servant leadership and job satisfaction.

Nonexperimental	**Correlational**	of predicting or defining a relationship. Observes relationships between variables in a naturally occurring setting. Valid approaches to data collection such as validated surveys or databases. There is a theoretical or logical explanation that can be used to predict a correlation. Variables should not or cannot be manipulated. The intent is to determine if and to what degree the variables are related.	The relationship between teacher collaboration and student achievement.

		It does not imply one causes the other.	
	Causal Comparative	Compare two groups with the intent of understanding the reasons or causes for the two groups being different.	The effect of preschool attendance on reading ability at the end of the third grade.
		Determines the causes of differences that already exist between or within two or more groups on two or more variables.	The effect of gender on math achievement.
		Identify one or more groups that serve as the independent variable.	The effect of single-gender schools and student achievement.
		Define the dependent variable on which the groups will be compared.	

		Select sample groups that are as homogeneous as possible.	

Process for Selecting a Quantitative Design

Selecting a method and design for a research study depends on what one wants to accomplish. The focus of the research must be considered as well as the desired outcomes. Quantitative research is sometimes based on worldviews of realism or positivism, attempting to disclose an existing reality in a world that functions based on predictable patterns of cause and effect. The researcher knows a certain truth exists and attempts to uncover facts in a systematic, objective manner (Balnaves & Caputi, 2001). Thus, quantitative research is not in opposition to the Christian worldview which asserts that truth can be known. Ultimately, the researcher will select a method and design based on the problem of the study and the stated research questions.

If the goal of the researcher is to address research questions with a quantitative answer, to be able to generalize the results of a study to a larger population, or to test a theory numerically, the researcher will select a quantitative method and design. Suppose a GCU doctoral learner works in a hospital and wants to determine if there is a relationship between registered nurses' (RN) perceptions of their nursing manager's leadership style and RN job satisfaction. This study is an attempt to determine if a relationship exists between variables; therefore, a quantitative method and correlational design can be used. The researcher would include hypotheses that serve as a possible explanation for a factual situation that merits investigation Thus, quantitative research is appropriate for research questions that need to be answered quantitatively, when numerical changes are studied, when one wants to describe the current state of a situation, or wants to explain a phenomenon, or when a hypothesis is tested (Balnaves & Caputi, 2001).

Variables and Subvariables

Variables are the building blocks or foundation of quantitative research. Variables represent the characteristics of an individual, an event, a group, or an organization that can assume different values or amounts and can be numerically measured through instruments, surveys, or observations. Variables can vary in degree or amount (income level, temperature) or by type or kind (gender, marital status). Some variables differ by degree, amount, or level of measurement. Other variables take on a specific role such as explaining how the world functions or those use in the design and conduct of research.

Variables That Differ by Degree, Amount, or Level of Measurement

Nominal variables are considered the most rudimentary level of measurement, and are categorical in nature, meaning that they are made up of different categories. They cannot be ordered in any specific manner; they are just different. Nominal variables simply name the characteristic being measured, with no ranking. Gender, religion, marital status and political party are other types of nominal variables. The attribute is simply named, but one is not ranked over the other (Trochim, 2006).

Ordinal measures represent variables that can be rank ordered, such as socioeconomic status, education levels, or grades received in classes. However, the distance between the groups or levels has no meaning. For example, there is no specific or defined difference between levels of education. If a researcher were to ask customers how satisfied they were with their service, they could offer a survey in which the customers selected answers on a scale of 1 to 5 with 1 being very satisfied to 5 being very dissatisfied. The researcher could not say that the difference between satisfied to somewhat satisfied is the same as being very dissatisfied. All he or she could say is that some customers were more satisfied than others (Trochim, 2006).

Interval variables can be rank ordered, but the distance between the levels or categories has a specific meaning. For instance, temperature has specific distance between degrees, or numbers on the Richter scale that measure the intensity of an earthquake can be interpreted, as they are a specified distance apart. Temperature is another example of interval variables (Trochim, 2006).

Finally, ratio variables are similar to interval data, but the ratio data has an absolute zero, or has no numbers below zero. Height and weight are examples of ratio data. If one wants to measure an individual's weight in pounds, there are specific quantities that can be measured in equal units and that measurement cannot go below zero (Trochim, 2006).

Table 6.2

Nature of Numerical Data Variables

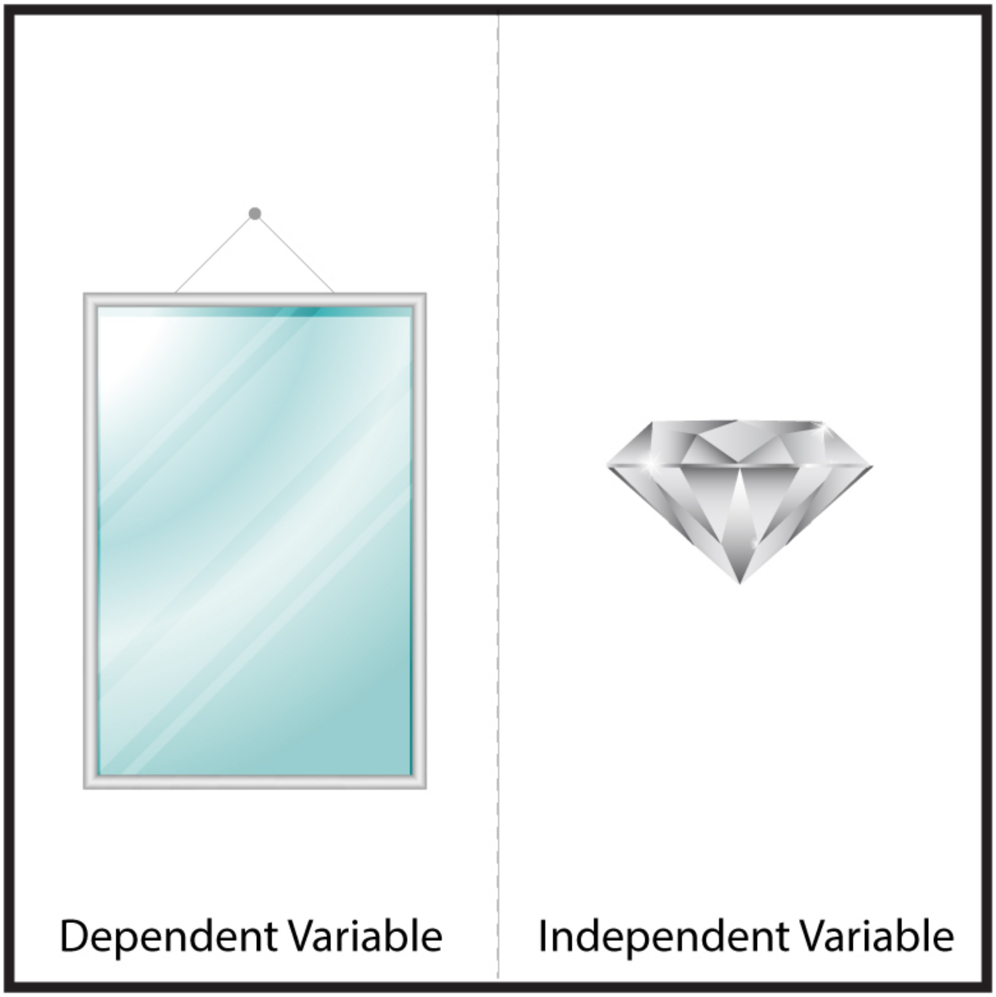
Nature Table

Binary Variable	Variables that often are listed as zero and one. These are variables that exist in two different states—yes/no, completed/not completed, effective/not effective, exists/doesn't exist.
Categorical Variable	Categorical data. Examples—gender (male/female), married status (married/single/divorced/widowed), employment status (employed/self-employed/not employed), etc. Variables are assigned numerical values, e.g. male=0, female=1. AKA: Nominal Variable.

Continuous Variable	A variable that demonstrates continuous movement of time, range and space (e.g. age range, time, size intervals, IQ ranges). AKA: Interval Variable
Dichotomous Variable	See Binary Variable
Discrete Variable	Variables that can take on a finite number of values (e.g. responses on a five-point rating scale, specific number of integers, finite values). All qualitative variables are discrete.
Interval Variable	See Continuous Variable
Nominal Variable	See Categorical Variable
Ordinal Variable	A variable for which order matters (e.g. scales of measurements, Likert scales)

Variables That Take on a Specific Role

There are two main types of variables that describe the way phenomena work or that researchers use when conducting quantitative studies: independent and dependent. **Independent variables** can stand alone, but they can also *cause* changes in other variables. On the other hand, a **dependent variable** depends on, relates to, or is caused by other factors. It changes as the independent variable changes. Therefore, independent variables are the cause of other variables, whereas dependent variables represent the outcome or effect. The dependent variable is a phenomenon one is attempting to explain or predict. In experimental studies the independent variable is the treatment or intervention, or the manipulated variable. In nonexperimental studies, no variables are manipulated, so the independent variable explains or predicts the dependent variable.



In some quantitative studies there are extra variables that are not a primary focus, but may be related to the independent or dependent variables. These are called **extraneous variables**. For example, a researcher wants to study the relationship between pay and job satisfaction. However, he or she also believes that the workers' motivation may impact their job satisfaction. The extraneous variable would be motivation. In other studies moderator variables may impact the strength of relationship between the independent and dependent variable. An example of a moderator variable in the above example may be organizational climate.

Sometimes a researcher wants to investigate how one variable affects or impacts the other. An intervening, mediating, or mediator variable is a causal link between two variables. For example, excessive food consumption may cause obesity, but another effect can be that the individual becomes diabetic (which is an intervening variable) (Frankfort-Nachmias & Leon-Guerrero, 2006; Trochim, 2006).

Table 6.3

Role of Relative Position Variables

Role Table

Confounding Variable	An extraneous variable, the presence of which in the study could damage the validity of the research if the researcher fails to control or eliminate it.
Control Variable	A variable that the researcher does not want to examine in the study. The variable is controlled.
Criterion Variable	The predicted outcome variable in correlational research or a nonexperimental study.
Dependent Variable	The predicted outcome variable (attribute or characteristic) of a study. The dependent variable is influenced by independent variables.
Dummy Variable	A bucket of binary variables with more than two variables in two categories of variables. For example, marital status—married, single, divorced, widowed—can be bucketed into married or not married.
Endogenous Variable	Used in a causal model. It is a variable that is changed by one of the functional relationships within the study or model. For example, changing the income demand curve using quantity and price (variables within the model).
Exogenous Variable	A variable that is not within the study or model. The variable is either endogenous (from within the study/model) or exogenous (outside of the study/model).
Independent Variable	A variable that affects the outcome of a dependent variable or an outcome. For example, in a study examining the effects of sleep on test scores, sleep is the independent variable.

Intervening Variable	A variable that provides a link (causal) between other variables.
Latent Variable	A variable that cannot be observed. They exist to define/explain other variables. For example, patterns that underlie specific behaviors related to voting for a president—Republican/Democratic.
Manifest Variable	This variable is the opposite of a latent variable. Variables that can be directly observed.
Manipulated Variable	An independent variable that is manipulated to determine a particular effect. For example, the amount of helium in a balloon would be the manipulated variable.
Mediating Variable	A variable that creates a link between two variables that is causally associated.
Moderating Variable	A variable that increases or decreases the proven effect of the independent variable on the dependent variable.
Outcome Variable	A variable that is the result the researcher compares in a study or experiment. AKA: Dependent Variable, Response Variable
Polychotomous Variable	Variables with more than two possible values. Includes binary variables and categorical variables with multiple categories.
Predictor Variable	Predicted cause on a nonexperimental study. Typically used in correlational studies. For example, if studying whether GPA predicts intent to go to college, GPA is the predictor variable.

Treatment Variable	See Independent Variable

Standardized Measurements and Instruments

After a researcher has defined the variables present in a situation, he or she must decide how to measure them. Therefore, measures and indicators must be considered. Measures are instruments that directly assess quantities. For example, if one wanted to ask participants about their level of income, weight, or age, responses to a survey would measure these variables. Other questions are considered indicators, as they are not direct numeric measurements.

Selecting a valid and reliable instrument is required for a quantitative study as one goal of the researcher is to be able to generalize the results of the study to a larger population. First, the researcher needs to determine the type of data to be collected by reviewing the stated research questions, determining the scope or parameters of the study, reviewing the methods that were used in prior research on the topic, and the nature of the data to be collected (qualitative, quantitative, or both).

At GCU, learners as researchers should become familiar with the instruments used in studies on their dissertation topic through a thorough review of literature on the topic. This occurs as they develop Chapter 2 of the dissertation, the Literature Review. As a doctoral learner considers the proper selection of instruments for his or her dissertation study, he or she should consider how data on the topic was gathered in prior research studies, whether or not the identified instrument is appropriate for the nature or type of data needed, if the instrument will collect data to answer all research questions, and if the instrument is valid and reliable.

Challenges arise when the learner or researcher does not conduct a robust review of prior studies on the topic and is unaware of the existing critiques of instruments. At times, though better or more robust instruments may exist, a researcher attempts to use an instrument that has not been tested for reliability and validity, or the researcher uses an instrument for a population or sample for which the instrument is not intended. At GCU, learners are discouraged from designing their own quantitative instruments as calibrating the instrument, field testing the questions, and establishing validity and reliability is a study in and of itself, and outside of the scope of the GCU program timeframe.

Table 6.4

Types of Variables Categorized by Level of Measurement

Type of Variable	Characteristics	Example

	Level of Measurement	
Nominal/Categorical	• Most rudimentary level of measurement • Categorical in nature • Cannot be ordered in any specific manner	• Gender • Religion • Marital status • Political party
Ordinal	• Can be rank ordered • Distance between the groups or levels has no meaning	• Socioeconomic status • Education levels • Grades received in classes
Interval	• Can be rank ordered • Distance between the levels or categories has a specific meaning	• Temperature • Richter scale
Ratio	• Can be rank ordered • Has an absolute zero or no numbers below zero	• Height • Weight
	Role Taken by Variable	
Independent	• Can stand alone • Can cause changes in other variables • In experimental studies, the independent variable is the treatment or intervention, or the manipulated variable. • In nonexperimental studies, the independent variable explains or predicts the dependent variable.	

Dependent	• Depends on, relates to, or is caused by other factors • Changes as the independent variable changes • Represents the outcome or effect • The variable is a phenomenon one is attempting to explain or predict.	
Mediating/Intervening	• Causal link between two variables	
Moderator	• Impacts the strength of relationship between the independent and dependent variable	

Quantitative data can be gathered from a variety of sources. However, they must be collected systematically, from a predefined protocol. Additionally, the instrument used to gather data must be valid and reliable in order to ensure the study can be replicated and that the results can be generalized to other populations or settings (Golafshani, 2003). As shown in Table 6.5, data collection instruments can be categorized into two groups: those the researcher completes and those participants complete.

Table 6.5

Quantitative Data Collection Instruments

Researcher-Completed Instruments	Subject-Completed Instruments
Rating scales, archival databases, media sources	Questionnaires, tests, surveys
Interview or focus-group guides	Self-checklists

Tally sheets	Attitude scales
Flowcharts	Personality inventories
Performance checklists	Achievement or aptitude tests
Time-and-motion logs	Projective devices
Observation forms	Stoichiometric devices

Note. Adapted from Research Rundowns > Quantitative Methods > Instrumentation, Validity, Reliability" by Research Rundowns, 2009. Retrieved from https://researchrundowns.files.wordpress.com/2009/07/rrinstrumentvalidityreliability_72009.pdf

Sampling Approaches for Quantitative Research

When the researcher is ready to apply the selected data collection instruments, he or she needs to consider who is going to participate in the study and who will complete those instruments. First, the researcher needs to always consider the purpose of the study and the practicality as well as strengths and weaknesses of different sampling methods.

Probability and Nonprobability Sampling

- Probability sampling – in this strategy, the sample is specifically selected and directly reflects the characteristics of this population. Probability sampling provides the most credible (valid) results because it directly represents the population. Examples of probability sampling include simple random sampling, stratified sampling, and multistage cluster sampling.
- Nonprobability sampling – this strategy is less desirable than probability sampling as the sample may not represent the population. This strategy is used when the researcher does not care about the direct representation or they are

not able to obtain a sample sufficient for the research or it is too expensive to obtain a random sample. Examples of nonprobability sampling include convenience, purposive, quota, or snowball sampling.

Every researcher has to select a sample or participants from a larger population. For the dissertation study, the population includes the people or units that will be addressed by the research problem and research questions. For example, the population of interest to the researcher may include teenage males in K-12 schools in the United States, if the goal of a study is to determine if a relationship exists between socioeconomic status and academic achievement. In quantitative studies, the researcher should strive to select a representative sample from the population, meaning that the group of individuals selected will produce results that can be generalized to that larger population.

The sampling frame includes the group of people who can be realistically selected for the sample, or to be recruited to participate in the study. For instance, in the previous example about teenage males in K-12 schools, the researcher may only have access to students in one school district located in Georgia. Therefore, only students in those schools will be recruited to participate in the study. This sample represents some bias as the researcher wants to be able to generalize the results of the study but the demographics of the student sample from one district in Georgia may be different than other schools in the United States. The researcher will therefore acknowledge the bias, which is relatively common in dissertation studies. Ultimately, the sample includes the actual individuals who consent to participate in the study. Figure 6.1 includes a graphic of the population, target population, sample, and data collection.

Questions to Consider When Selecting an Instrument

- Consider the following questions as you make your decision:
- Will you use an existing instrument?
    - What permissions do you need if you are using an existing instrument?
    - Are you considering creating your own instrument?
- Will you access data from a database?
    - Do you have permission to use existing database information or does the database contain public information?
- Are you using pretests and posttests (for experiment or quasi-experiment designs)?

  - Do you need permission to use the tests for research?
  - Are the tests valid?
  - Are the tests suitable for retesting at different time points?
- Is there another source for data other than an instrument, database or tests?
  - What is the source of data?

Sample Size

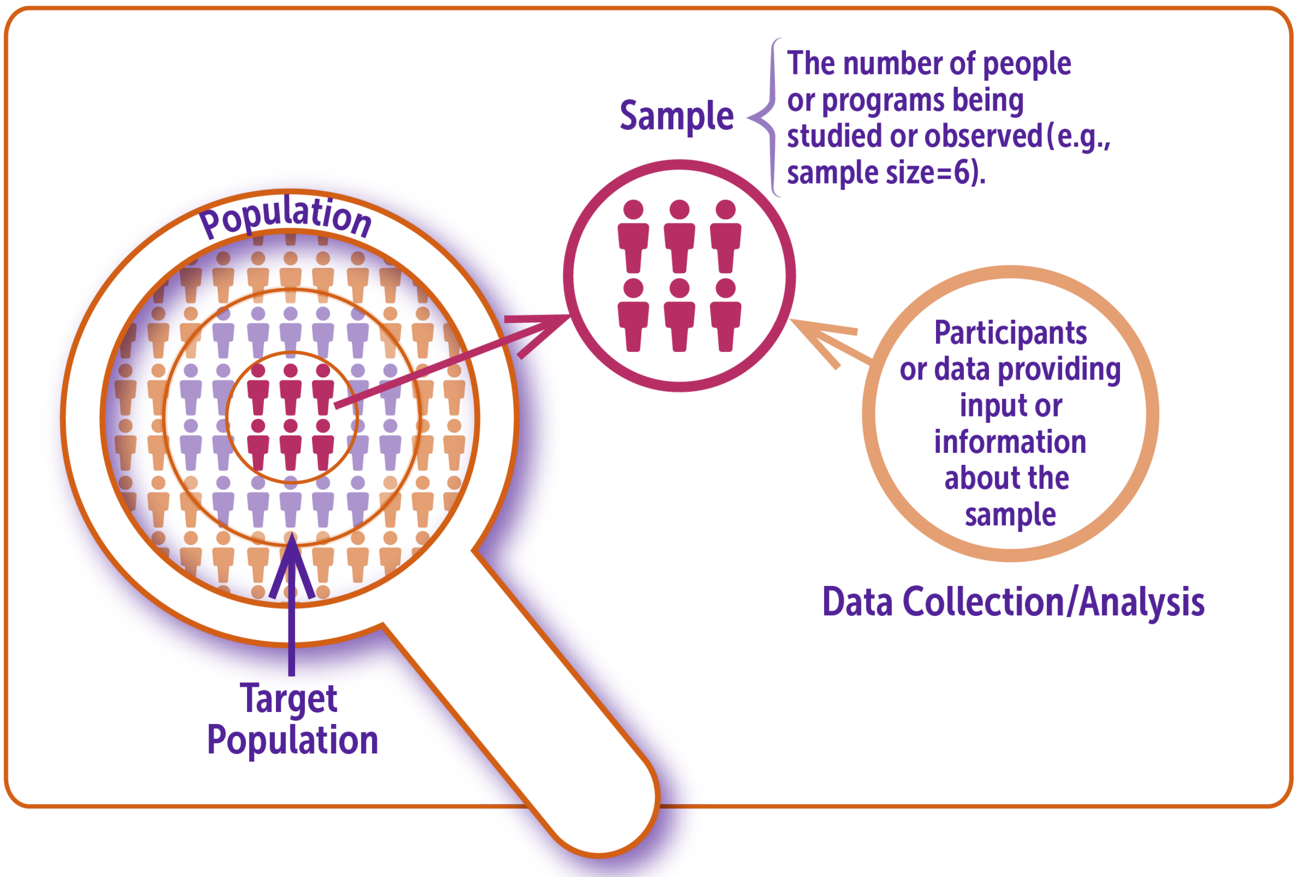


Figure 6.1. Population, Target Population, and Sample

The sample size of a study is determined by the required or desired level of statistical significance. Larger samples reduce the risk of statistical errors and improve the statistical power and confidence of the data. In the most simplistic form, a sample should be equivalent to $\sqrt{N}$ where N is the size of the population. For example, if the population is the 150 5th grade students at ABC Elementary School, a reasonable sample would be 150≈12.24 students. Since the measure of number of students is a discrete measure, the minimum sample size required is 13 students. Advanced data analysis techniques require more advanced calculations of sample size.

Sampling Strategies

There are two basic kinds of sampling: random and nonrandom. Random sampling means that every unit in the established sampling frame has an equal chance of being selected. This should result in the sample representing the larger population from which it is drawn. There are four types of random sampling: stratified, systematic, cluster, and multi-stage. Stratified random samples occur when the population is divided into strata or levels, and the sample is randomly selected from each level. In systematic sampling, the researcher systematically selected every nth individual from a list of people. Cluster sampling occurs when the population is divided into groups and then individuals are randomly selected from each group. Multi-stage sampling occurs when the researcher wants to hierarchically combine different random sampling strategies from this group.

When a researcher employs the use nonprobability sampling, he or she does not use random techniques. This sampling strategy is not as reliable or powerful as random sampling as the results cannot always be generalized to a larger population. Therefore, the researcher relies on more haphazard methods of recruiting people to participate in the study. There are several different types of nonprobability sampling. At GCU these usually include convenience, purposive or snowball samples. When applying a convenience sampling strategy, the research selects units or individuals from a group that is readily available. A purposive sample is comprised of a pre-specified group of individuals the researcher specifically seeks out to recruit for participation in a study. Usually these individuals have specific characteristics, such as males age 18 and over attending alternative schools in Georgia. Finally, snowball sampling is used when the researcher recruits initial individuals who participate in a study, and then those individuals may provide names of other people who could be contacted to complete data collection instruments. Table 6.6 contains the most common sampling strategies used at GCU.

Table 6.6

Quantitative Sampling Strategies

Type of Sampling Strategy	Definition
Random sample	• Every participant has an equal chance of being selected.

Accidental, haphazard, or convenience sampling	• Participants are sampled according to what is conveniently, accidentally, or haphazardly available. • Researcher selects participants who are readily available.
Purposive sample	• Participants from a prespecified group are purposively sought out and sampled • Researcher selects participants based on predefined criteria.
Snowball sample	• Initial participants are sampled, and then they identify more people to sample, and so on.

Reliability and Validity in Quantitative Studies

Reliability in quantitative research focuses on the degree to which the variable is consistently measured. Since we use instruments such as surveys to measure variables, then a reliable instrument is one that will gather reasonable and plausible data and produce similar results consistently over time. Test-retest reliability and inter-rater reliability are two types of reliability that researchers address in quantitative studies. In order to establish test-retest reliability, the researcher administers the same instrument at two given times, and one person scores the instrument. In order to establish inter-rater reliability, one version of the instrument is administered at one time, and two people score it. Then, their scores are compared (Golafshani, 2003).

Validity, in essence, refers to the degree the findings of the research can be applied or trusted. Whereas reliability is concerned with consistency of which a variable is measured, validity focuses on whether a variable measures what it is intended to measure. Therefore, a valid instrument allows the researcher to draw meaningful and useful inferences from the scores on the instrument. In general, quantitative researchers must consider three types of validity. **Content validity** refers to whether or not the questions are representative of all questions on the topic. **Criterion related validity** refers to how well the scores on an instrument relate to and predict an outcome. The “criterion” is the condition or standard by which people differ. **Construct validity** refers to what the scores mean (Golafshani, 2003).

Validity assumes reliability. If a researcher has an unreliable or unstable variable, it is not valid. An unreliable variable changes over time and cannot provide a true indication of what it is supposed to measure. If variables are internally unreliable, then they measure more than one concept and then do not accurately measure the concept under study (Golafshani, 2003).

Common Approaches to Quantitative Data Analysis

Researchers collect quantitative data and then analyze that data to discover and describe patterns.

Table 6.7

Three Kinds of Analysis

Univariate Analysis	Descriptive statistics describe the distribution of variables
Bivariate Analysis	Analysis of the relationship between two variables
Multivariate Analysis	Analysis of the relationship between more than two variables

Types of Variables

- When determining what statistical tests to run on a variable it will be important to know both the nature of the numerical data provided by the variable, and, the specific variable type identified by your data source for the variable.

- There are specific terms that describe variables used in research studies. There are two different sets of terminology for variables. The first set of terminology describes the Nature of the Numerical Data that you collect and is defined by the data source you use. These variables include binary/dichotomous variables, categorical/nominal variables, continuous/interval variables, discrete variables, or ordinal variables. For example, in a two-way ANOVA analysis of student test score, you may group the students into two different instructional methods and two gender groups within each instructional method, so instructional method and gender are the "categorical" (or "binary/dichotomous if there are only two levels within each category) variables for the study while test score is the "continuous/interval" (or "scale" in SPSS language).
- The second set of terminology describes the Role of/or Relative Position of the variable(s) in your study. These variables include Confounding, Control, Criterion, Dependent, Dummy, Exogenous, Independent, Intervening, Latent, Manifest, Manipulated, Mediating, Moderating, Outcome, Polychotomous, Predictor, and Treatment variables. Depending on the research design, you will use the relevant terms to describe the variables in your study. For example, in a multiple regression analysis of student test scores, you could use hours of study, instructional method, gender as "predictor" variables and the test score as "outcome" or "criterion" variable.

Univariate Analysis

In Chapter 4 of the dissertation at GCU, the researcher will use descriptive statistics to describe the sample and some of the data collected. Often, tables and graphs are used for this purpose. The sample, for example, may be described in a table displaying the age, gender, job role, and years of experience of the sample. Other graphics such as histograms are used to show the distribution of data along a continuum with no gaps. The researcher may use a histogram to show the years of education for the sample. Frequency distributions are often used to demonstrate how often a particular score or range of scores appears in the data set.

Measures of central tendency are used to summarize the mean, median, and mode of a data set. The mode is the most frequently occurring value, the median is the middle value (divides the distribution in half), and the mean represents the average value. Other summary statistics can include the range and distribution of data. The range includes the entire possible set of data from the lowest to highest point. The standard deviation, or distance from the mean is often calculated.

- **Parametric vs. nonparametric tests.** Based on the way data are distributed, the researcher will conduct parametric or nonparametric tests. Parametric tests are used when the data assume a normal distribution, meaning that half the points fall equally on either side of the mean. Nonparametric tests are used when the data are not normally distributed. Therefore, no assumptions can be made about the form or boundaries of the population distribution from which the study sample was recruited. When data are normally distributed and parametric tests are used, then tests of assumptions must be calculated including normality tests to see if the data is normally distributed, (approximating a normal or "bell-shaped" curve) and possibly homoscedasticity (required for some statistical analyses such as ANOVA) tests to see if the data values are spread out to about the same degree. If the assumptions are not met, the researcher may need nonparametric tests instead of typical inferential statistical tests. The researcher may need to normalize the data if using different tests to allow for the comparison of the raw scores on different tests; in this case, the researcher would calculate the z-scores to normalize or standardize the data from the two tests.

Bivariate and Multivariate Analysis

Bivariate and multivariate analyses are used to determine if a relationship exists between two or more variables, respectively. Inferential statistics estimate the degree of confidence that can be placed in generalizations from a sample to the population from which the sample was selected.

Steps for Conducting Quantitative Data Analysis

The following steps are followed for conducting quantitative analysis of data:

1. Clean and Prepare Data
2. Compute Descriptive Statistics
3. Conduct Assumptions Testing (not used with descriptive/survey design)
   a. Normality
   b. Homoscedasticity
   c. Nonparametric tests
4. Calculate z or t scores
5. Perform inferential statistics if assumptions are met
6. Use nonparametric techniques if assumptions are not met

Table 6.8

Parametric and Nonparametric Tests

Bivariate, Multivariate	Type	Example	Parametric test	Nonparametric test

Bivariate	Compare the difference between two distinctively different groups.	Is there a difference in the mean math scores of students who participate in a technology-rich math class versus those who do not?	Two sample t-test	Wilcoxon rank-sum test
Bivariate	Compare two quantitative measures completed or taken from the same person.	Is there a significant change in the mean math scores of students who participate in a technology-rich math class for a 16-week semester?	Paired t-test	Wilcoxon signed-rank test

Multivariate	Compare means between three or more distinctively different groups.	If the math class has three groups (those who experience traditional instruction, those who have access to technology in the classroom on a daily basis, and those who go to the computer lab once a week), how will their mean scores differ over time?	Analysis of variance	Kruskal-Wallis test
Bivariate	Estimate the degree of association between two variables.	Is student math achievement associated with gender?	Pearson coefficient of correlation	Spearman's rank correlation

Table 6.9 shows the inferential statistical tests most commonly performed. For example, the t -test is used to see whether there is a significant difference for the means between two samples or groups.

Table 6.9

Parametric vs. Nonparametric Tests

Parametric Tests	Nonparametric Tests
t-test (independent means)	Mann-Whitney U test