Lesson 2 : The Hypothesis in Quantitative Research

Instructional objectives: After studying this lesson, the student will be able to:

1 *Define hypothesis.*

2 *Describe the purposes of the hypothesis(es) in quantitative research.*

3 *List the criteria of a theory useful for a research study.*

4 *Distinguish between an inductive and a deductive hypothesis.*

5 *State the criteria used to evaluate hypotheses for research.*

6 *Define operational definition and give an example.*

7 *Identify a testable hypothesis from given examples.*

8 *Define null hypothesis and explain its purpose in a research study hypothesis testing.*

9 *Write a research hypothesis and a null hypothesis for a research study.*

10 *Distinguish between a directional and a nondirectional hypothesis.*

11 *Describe the steps in testing a hypothesis.*

12 *State the purpose of the research plan and list the elements to be included.*

13 *State the purpose of a pilot study.*

After stating the research question and examining the literature, the quantitative researcher is ready to state a **hypothesis** based on the question.* This should be done before beginning the research project. Recall that the quantitative problem examines the relationship between two (or more) variables. The hypothesis presents the researcher's expectations about the relationship between variables within the question. Hence, it is put forth as a suggested answer to the question, with the understanding that the ensuing investigation may lead to either support or lack of support for the hypothesis. Note that we use the word *support*, not *prove*. Research may find support for a hypothesis, but it does not prove a hypothesis.

A researcher might ask, "What is the effect of preschool training on the first grade achievement of culturally disadvantaged children?" The hypothesis would read "Culturally disadvantaged children who have had preschool training achieve at a higher level in first grade than culturally disadvantaged children who have no preschool training." You can see that the hypothesis related the variables of preschool training and first-grade achievement. The following are additional examples of hypotheses in educational research:

1. Boys in elementary school achieve at a higher level in single-sex classes than in mixed classes.
2. Students who complete a unit on problem-solving strategies will score higher on a standardized mathematics test than those who have completed a control unit.
3. Middle school students who have previously taken music lessons will have higher math aptitude scores.
4. Middle school students who have siblings will be more popular among their peers than students

who have no siblings.
5. Students who do warm-up exercises before an examination will score higher on that examination than those who do not.
6. Math anxiety in young adolescents influences their decision to enroll in math courses and their performance in math.
7. Elementary school children who do not get adequate sleep will perform at a lower level academically than will their peers who have adequate sleep
8. Retaining children in the lower grades increases the likelihood of their dropping out of school in later years.

Although hypotheses serve several important purposes, some research studies may proceed without them. Hypotheses are means in the research process, not ends. Studies are often undertaken in areas in which there is little accumulated background information. A researcher may not know what outcome to predict. For example, surveys that seek to describe the characteristics of particular phenomena, or to ascertain the attitudes and opinions of groups, often proceed without hypotheses. Two reasons for stating a hypothesis before the data-gathering phase of a quantitative study are (1) a well-grounded hypothesis indicates that the researcher has sufficient knowledge in the area to undertake the investigation, and (2) the hypothesis gives direction to the collection and interpretation of the data; it tells the researcher what procedure to follow and what type of data to gather and thus may prevent a great deal of wasted time and effort on the part of the researcher.

Purposes of the hypothesis In Quantitative research

Principal purposes served by the hypothesis include the following:
1. *The hypothesis integrates information to enable the researcher to make a tentative statement about how the variables in the study may be related*. By integrating information based on experience, related research, and theory, the researcher states the hypothesis that provides the most satisfactory prediction or the best solution to a problem.
2. *Because hypotheses propose tentative explanations for phenomena, they stimulate a research endeavor that results in the accumulation of new knowledge*. Hypothesis testing research permits investigators to validate or fail to validate theory through an accumulation of data from many studies, thus extending knowledge.
3. *The hypothesis provides the investigator with a relational statement that is directly testable in a research study*. That is, it is possible to collect and analyze data that will confirm or fail to confirm the hypothesis. Questions cannot be tested directly. An investigation begins with a question, but only the proposed relationship between the variables can be tested. For instance, you do not test the question, "Do teachers' written comments on students' papers result in an improvement in student performance?" Instead, you test the hypothesis that the question implies: "Teachers' written comments on students' papers result in a meaningful improvement in student performance," or, specifically, "The

performance scores of students who have had written teacher comments on previous papers will exceed those of students who have not had written teacher comments on previous papers." You then proceed to gather data about the relationship between the two variables (teachers' written comments and student performance).

4. *The hypothesis provides direction to the research*. The hypothesis posits a specific relationship between variables and thus determines the nature of the data needed to test the proposition. Very simply, the hypothesis tells the researcher what to do. Facts must be selected and observations made because they have relevance to a particular question, and the hypothesis determines the relevance of these facts. The hypothesis provides a basis for selecting sampling, measurement, and research procedures, as well as the appropriate statistical analysis. Furthermore, the hypothesis helps keep the study restricted in scope, preventing it from becoming too broad or unwieldy. For example, consider again the hypothesis concerning preschool experience of culturally disadvantaged children and their achievement in first grade. This hypothesis indicates the research method required and the sample; it even directs the researcher to the extended statistical test for analyzing the data. It is clear from the statement of the hypothesis that the researcher will conduct an ex post facto study that compares the first-grade achievement of a sample of culturally disadvantaged children who went through a preschool program and a similar group of disadvantaged children who did not have preschool experience. Any difference in the mean achievement of the two groups could be analyzed for statistical significance by the test or analysis of variance technique.

5. *The hypothesis provides a framework for reporting the findings and conclusions of the study*. The researcher will find it very convenient to take each hypothesis separately and state the conclusions that are relevant to it; that is, the researcher can organize this section of the written report around the provision of answers to the original hypotheses, thereby making a more meaningful and readable presentation.

Suggestions for Deriving hypotheses

A study might originate in a practical problem, in some observed behavioral situation in need of explanation, in previous research, or even more profitably in some educational, psychological, or sociological theory. Thus, researchers derive hypotheses inductively from observations of behavior or deductively from theory or previous research. Induction and deduction are complementary processes. In induction, you start with specific observations and reach general conclusions; in deduction, you begin with generalizations and make specific predictions.

Deriving hypotheses inductively

In the inductive procedure, the researcher formulates an **inductive hypothesis** as a generalization from apparent observed relationships; that is, the researcher observes behavior, notices trends or probable relationships, and then hypothesizes an explanation for this observed behavior. This reasoning process should be accompanied by an examination of previous research to determine what findings other investigators have reported on the question. The inductive procedure is a particularly fruitful source of hypotheses for classroom teachers. Teachers observe learning and other student behavior every day and try to relate it to their own behavior, to the behavior of other students, to the teaching methods used, to changes in the school environment, and so on. Teachers might observe, for example, that when they present particularly challenging activities in the classroom, some students get motivated and really blossom, whereas others withdraw from the challenge.

Some students learn complex concepts best from primarily verbal presentations (lectures), whereas others learn best from discussions and hands-on activities. After reflecting on such experiences, teachers may inductively formulate generalizations that seek to explain the observed relationship between their methods and materials and students' learning. These tentative explanations of why things happen as they do can become the hypotheses in empirical investigations. Perhaps a teacher has observed that classroom tests arouse a high degree of anxiety and believes this adversely affects student performance. Furthermore, the teacher has noted that when students have an opportunity to write comments about objective questions, their test performance seems to improve. The teacher reasons that this freedom to make comments must somehow reduce anxiety and, as a result, the students score better. This observation suggests a hypothesis: Students who are encouraged to write comments about test items on their answer sheets will achieve higher test scores than students who have no opportunity to make comments. The teacher could then design an experiment to test this hypothesis. Note that the hypothesis expresses the teacher's belief concerning the relationship between the two variables (writing or not writing comments about test items and performance on the test). Note also that the variable *anxiety*, which was part of the reasoning chain leading to the hypothesis, is not part of the final hypothesis. Therefore, the results of the investigation would provide information concerning only the relationship between writing comments and test performance.

The relationships between anxiety and comments, and anxiety and test performance, could be subjects for subsequent hypotheses to investigate. Frequently, an original idea involves a series of relationships that you cannot directly observe. You then reformulate the question to focus on relationships that are amenable to direct observation and measurement. The following additional examples of hypotheses might be arrived at inductively from a teacher's observations:

- Students' learning of computer programming in the middle grades increases their development of logical thinking skills.
- Using advance organizers increases high school students' learning from computer-assisted instruction in chemistry.
- Students trained to write summaries of a lecture will perform better on an immediate posttest on lecture comprehension than will students who simply take notes.
- Students score higher on final measures of first-grade reading achievement when they are taught in small groups rather than large groups.

• The cognitive and affective development of first-graders is influenced by the amount of prior preschool experience.

• After-school tutoring programs increase the achievement of at-risk students. In the inductive process, the researcher makes observations, thinks about the problem, turns to the literature for clues, makes additional observations, and then formulates a hypothesis that seeks to account for the observed behavior. The researcher (or teacher) then tests the hypothesis under controlled conditions to examine scientifically the assumption concerning the relationship between the specified variables.

Deriving hypotheses deductively

In contrast to hypotheses formulated as generalizations from observed relationships, some are derived by deduction from **theory**. These hypotheses have the advantage of leading to a more general system of knowledge because the framework for incorporating them meaningfully into the body of knowledge already exists within the theory. A science cannot develop efficiently if each study results in an isolated bit of data. It becomes cumulative by building on the existing body of facts and theories. A hypothesis derived from a theory is known as a **deductive hypothesis**. After choosing a theory of interest, you use deductive reasoning to arrive at the logical consequences of the theory. If A is true, then you would expect B to follow. These deductions then become the hypotheses in the research study. For example, social comparison theory suggests that students form academic self-concepts by comparing their self-perceived academic accomplishments to some standard or frame of reference. The frame of reference for most students would be the perceived academic abilities of their classmates. If this is true, you might hypothesize that gifted students would have lower academic self concepts if they were placed in selective homogeneous groups than if they were in heterogeneous or mixed-ability groups in which they compare themselves to less able students. You could investigate this hypothesis by examining the change over time in the academic self-concept of gifted students in homogeneous classes compared to that of matched gifted students placed in regular heterogeneous classes. The evidence gathered will support, contradict, or possibly lead to a revision of social comparison theory.

Another useful theory from which an educational researcher might make deductions is Piaget’s classic theory on the development of logical thinking in children. Piaget (1968) suggested that children pass through various stages in their mental development, including the stage of concrete operations, which begins at age 7 or 8 and marks the transition from dependence on perception to an ability to use some logical operations. These operations are on a concrete level, but involve symbolic reasoning. Using this theory as a starting point, you might therefore hypothesize that the proportion of 9-year-old children who will be able to answer correctly the transitive inference problem, “Frank is taller than George; George is taller than Robert; who is the tallest?” will be greater than the proportion of 6-year-olds who are able to answer it correctly. Such research has implications for the importance of determining students’ cognitive capabilities and structuring educational tasks that are compatible with their developmental level. Piaget's cognitive theory also emphasizes that learning is a highly active process in which learners must construct knowledge. This tenet—that knowledge must be constructed by learners rather than simply being ingested from teachers—is the basis for much of the research on discovery-oriented and cooperative learning. In a study designed to test a deduction from a theory, it is extremely important to check for any logical gaps between theory and hypothesis. The researcher must ask, "Does the hypothesis logically follow from the theory?" If the hypothesis does not really follow from the theory, the researcher cannot reach valid conclusions about the adequacy of the theory. If the hypothesis is supported but was not rigorously deduced from the theory, the researcher cannot say that the findings furnish credibility to the theory.

Characteristics of a usable hypothesis

After tentatively formulating the hypothesis, but before attempting actual empirical testing, you must evaluate the hypothesis. The final worth of a hypothesis cannot be judged prior to empirical testing, but there are certain useful criteria for evaluating hypotheses.

A hypothesis states the expected relationship between variables

A hypothesis should conjecture the relationship between two or more variables. For example, suppose you attempt to start your car and nothing happens. It would be unprofitable to state, "The car will not start and it has a wiring system," because no relationship between variables is specified, and so there is no proposed relationship to test. A fruitful hypothesis would be "The car will not start because of a fault in the wiring system." This criterion may seem patently obvious, but consider the following statement: "If children differ from one another in self-concept, they will differ from one another in social studies achievement." The statement appears to be a hypothesis until you note that there is no statement of an expected relationship. An expected relationship could be described as "Higher self-concept is a likely antecedent to higher social studies achievement." This hypothesis would then be stated as "There will be a positive relationship between self-concept and social studies achievement." If the opposite is predicted—that is, higher self-concept leads to lower social studies achievement—then the hypothesis would be "There will be a negative relationship between self-concept and social studies achievement." Either statement would meet this first criterion.

A hypothesis Must be testable

The most important characteristic of a "good" hypothesis is testability. A **testable hypothesis** is verifiable; that is, deductions, conclusions, or inferences can be drawn from the hypothesis in such a way that empirical observations either support or do not support the hypothesis. If the hypothesis is on target, then certain predictable results should be manifest. A testable hypothesis enables the researcher to determine by observation and data collection whether consequences that are deductively implied actually occur. Otherwise, it would be impossible either to confirm or not to confirm the hypothesis. In the preceding example, the hypothesis "The car's failure to start is a punishment for my sins" is obviously untestable in this world. Many hypotheses—or propositions, as they may initially be stated—are essentially untestable. For instance, the hypothesis "Preschool experience promotes the all-around adjustment of the preschool child" would be difficult to test because of the difficulty of operationalizing and measuring "all-around adjustment." To be testable, a hypothesis must relate variables that can be measured. If no means are available for measuring the variables, no one can gather the data necessary to test the validity of the hypothesis. We cannot emphasize this point too strongly: Unless you can specifically define the indicators of each variable and subsequently measure these variables, you cannot test the hypothesis.

The indicators of the variables are referred to as **operational definitions**. Remember that variables are operationally defined by specifying the steps the investigator takes to measure the variable. Consider the hypothesis "High-stressed nursing students will perform less well on a nursing test than will low-stressed students." The operational definition of stress is: One group of students is told that their performance on the nursing test will be a major determinant of whether they will remain in the nursing program (high stress), and the other group is told that they need to do as well as they can but that their scores will not be reported to the faculty or have any influence on their grades (low stress). The operational definition of test performance would be scores from a rating scale that assessed how well the students performed on the various tasks making up the test. Or consider the following hypothesis: "There is a positive relationship between a child's self-esteem and his or her reading achievement in first grade." For this hypothesis to be testable, you must define the variables operationally. You might define *self-esteem* as the scores obtained on the Self-Image Profile for Children (Butler, 2001) and reading achievement as scores on the California Reading Test, or as first-grade teachers' ratings of reading achievement.

Make sure the variables can be given operational definitions. Avoid the use of constructs for which it would be difficult or impossible to find adequate measures. Constructs such as *creativity*, *authoritarianism*, and *democracy* have acquired such diverse meanings that reaching agreement on operational definitions of such concepts would be difficult, if not impossible. Remember that the variables must be defined in terms of identifiable and observable behavior.

It is important to avoid value statements in hypotheses. The statement "A counseling program in the elementary school is desirable" cannot be investigated in an empirical study because "desirable" is too vague to be measured. However, you could test the hypothesis "Elementary pupils who have had counseling will have higher scores on a measure of expressed satisfaction with school than will those who have not had counseling." You can measure verbal expressions of satisfaction, but whether they are desirable is a value judgment.

A hypothesis should be Consistent with the existing body of knowledge

Hypotheses should not contradict previously well-established knowledge. The hypothesis "My car will not start because the fluid in the battery has changed to gold" satisfies the first two criteria but is so contrary to what is known about the nature of matter that you would not pursue it. The hypothesis "The car will not start because the fluid in the battery has evaporated to a low level" is consistent with previous knowledge and therefore is worth pursuing. It would probably be unprofitable to hypothesize an *absence* of relationship between the self-concept of adolescent boys and girls and their rate of physical growth because the preponderance of evidence supports the *presence* of such a relationship. Historians of science find that notables such as Einstein, Newton, Darwin, and Copernicus developed truly revolutionary hypotheses that conflicted with accepted knowledge in their time. However, remember that the work of such pioneers was not really so much a denial of previous knowledge as a reorganization of existing knowledge into more satisfactory theory. In most cases, and especially for the beginning researcher, it is safe to suggest that the hypothesis should agree with knowledge already well established in the field. Again, this highlights the necessity for a thorough review of the literature so that hypotheses are formulated on the basis of previously reported research in the area.

A hypothesis should be stated as simply and Concisely as possible

A hypothesis should be presented in the form of a concise declarative statement. A complete and concisely stated hypothesis makes clear what the researcher needs to do to test it. It also provides the framework for presenting the findings of the study. If a researcher is exploring more than one relationship, he or she will need to state more than one hypothesis. The general rule is to state only one relationship in any one hypothesis. For example, if you were investigating the effect of a new teaching method on student achievement and student satisfaction, you would state two hypotheses—one for effect on achievement and one for effect on satisfaction. You need not worry about the verbal redundancy inevitable in stating multiple hypotheses. Remember that the goals of testability and clarity will be served better by more specific hypotheses.

The terms used in the hypothesis should be the simplest acceptable for conveying the intended meaning; avoid ambiguous or vague constructs. Use terms in the way that is generally accepted for referring to the phenomenon. When two hypotheses are of equal explanatory power, prefer the simpler one because it will provide the necessary explanation with fewer assumptions and variables to be defined. Remember that this principle of parsimony is important in evaluating hypotheses.

Types of hypotheses

There are three types of hypotheses in a research study: the research hypothesis and two statistical hypotheses null and alternative.

The research hypothesis

The hypotheses we have discussed thus far are **research hypotheses**. They are the hypotheses developed from observation, the related literature, and/ or the theory described in the study. A research hypothesis states the relationship you expect to find as a result of the research, and it is called the heart of the study. It may be a statement about the expected relationship or the expected *difference* between the variables in the study. A hypothesis about children's IQs and anxiety in the classroom could be stated “There is a positive relationship between IQ and anxiety in elementary schoolchildren” or “Children classified as having high IQs will exhibit more anxiety in the classroom than children classified as having low IQs.” Research hypotheses may be stated in a **directional** or **nondirectional** form. A directional hypothesis states the direction of the predicted relationship or difference between the variables. The preceding two hypotheses about IQ and anxiety are directional. A directional hypothesis is stated when you have some basis for predicting the direction of the relationship or whether a “greater than” or “less than” result is expected. A nondirectional hypothesis, in contrast, states that a relationship or difference exists but without specifying the direction or nature of the expected finding—for example, “There is a relationship between IQ and anxiety in children.” The literature review generally provides the basis for stating a research hypothesis as being directional or nondirectional.

The null hypothesis

It is impossible to test research hypotheses directly. For reasons founded in statistical theory, it is a statistical hypothesis that we assess in the process of hypothesis testing. The statistical hypothesis is called a **null hypothesis** (symbolized H 0). You must first state and assess the probability that the null hypothesis is true. It is called a null hypothesis because it states that there is *no* relationship between the variables in the population. A null hypothesis states a negation (not the reverse) of what the researcher expects or predicts. Remember that researchers gather data from a sample. If they find a relationship between two variables in a sample, can they infer that the relationship would be found in the entire population from which the sample was drawn? That is the question they must answer. A researcher begins with a null hypothesis that states the variables are not related in the population, and then proceeds to try to reject this hypothesis. The researcher may hope to show that after an experimental treatment, two populations will have different means, but the null hypothesis would state that after the treatment the populations’ means will *not* be different. What is the point of the null hypothesis? If we’re interested in one hypothesis (the two variables are related), why do we start with one that says they are not related? A null hypothesis lets researchers assess whether apparent observed relationships in a sample are genuine or are likely to be a function of chance alone. It states, “There is no relationship between the variables in the population” or “There is no difference in the means of the groups in the population” or “The results of this study could easily have happened by chance.”

In fact, the null hypothesis of no relationship between two variables is either true in the population, or it is not true. We use statistical tests to determine the probability that the null hypothesis is true. If the tests indicate that observed relationships had only a slight probability (, 1 %) of occurring by chance, the null hypothesis becomes an unlikely explanation, and the researcher rejects it. The decision to reject or not reject the null hypothesis has direct relevance to the status of the original research hypothesis. If researchers reject the null hypothesis , they conclude that there *is* a relationship between the variables of the study in the population, just as the research hypothesis predicted. Testing a null hypothesis is analogous to the prosecutor's work in a criminal trial. To establish guilt, the prosecutor (in the U.S. legal system) must provide sufficient evidence to enable a jury to reject the presumption of innocence beyond reasonable doubt. It is not possible for a prosecutor to prove guilt conclusively, nor can a researcher obtain unequivocal support for a research hypothesis. The defendant is presumed innocent until sufficient evidence indicates that he or she is not, and the null hypothesis of no relationship is presumed true until sufficient evidence indicates otherwise.

The alternative hypothesis

The other statistical hypothesis, the **alternative hypothesis**, is designated as H1. As the name indicates, an alternative hypothesis is an alternative to the null hypothesis and specifies other possible ways the population means can differ. Note that the alternative hypothesis in the previous example, "Children taught by individual computer-assisted instruction will exhibit less mastery of mathematical concepts word problem-solving skills than those taught by group instruction," posits a relationship between variables and therefore is *not* a null hypothesis. Whereas the null hypothesis specifies no relationship between the variables of the study or no difference in the means, the alternative hypothesis specifies a relationship between the variables or a difference in the means. In the example, if the sample mean of the measure of mastery of mathematical concepts word problem-solving skills is higher for the individual instruction students than for the group instruction students, and a statistical analysis indicates that the null hypothesis is unlikely to be true, you reject the null hypothesis and tentatively conclude that individual instruction results in greater mastery of mathematical concepts problem-solving skills than does group instruction. The research hypothesis is supported. If, in contrast, the mean for the group instruction students is higher than the mean for the individual instruction students, and an inferential statistics test indicates that this difference is not likely to be a function of chance, then you tentatively conclude that group instruction is superior. The alternative hypothesis is supported. If the statistical test indicates that observed differences between the means of the two instructional groups could easily be a function of chance, the null hypothesis is retained, and you decide that insufficient evidence exists for concluding there is a relationship between the dependent and independent variables. The retention of a null hypothesis is *not* positive evidence that the null hypothesis is true. It indicates that the evidence is insufficient and that the null hypothesis, the research hypothesis, and the alternative hypothesis are all possible.

Testing the Hypothesis

A quantitative study begins with a research hypothesis, which should be a simple clear statement of the expected relationship between the variables. Previously, we explained that hypotheses must be testable—that is, amenable to empirical verification. When researchers speak of testing a hypothesis, however, they are referring to the null hypothesis. Only the null hypothesis can be directly tested by statistical procedures. **Hypothesis testing** involves the following steps:

1. State, in operational terms, the relationship that should be observed if the research hypothesis is

true.

2. State the null hypothesis.

3. Select a research method that will enable the hypothesized relationship to be observed if it exists.

4. Gather the empirical data and select and calculate appropriate descriptive statistics for these data.

5. Calculate inferential statistics to determine the probability that your obtained results could have occurred by chance when the null hypothesis is true.

6. If the probability of the observed findings being due to chance is very small (e.g., only 1 in 100 chances), you would have sufficient evidence to reject the null hypothesis.

Many hypotheses that are formulated are rejected after empirical testing. Their predictions are not supported by the data. Many beginning researchers believe that if the data they collect do not support their hypothesis, then their study is a failure. This is not the case. In the history of scientific research, hypotheses that failed to be supported have greatly outnumbered those that have been supported. Experienced researchers realize that unconfirmed hypotheses are an expected and useful part of the scientific experience. They can lead to reconsideration or revision of theory and the generation of new hypotheses, which often brings science closer to a correct explanation of the state of affairs. Darwin (1887/2007) wrote, I have steadily endeavored to keep my mind free so as to give up any hypothesis, however much beloved (and I cannot resist forming one on every subject), as soon as facts are shown to be opposed to it. Indeed, I have had no choice but to act in this manner, for with the exception of the Coral Reefs, I cannot remember a single first-formed hypothesis which had not after a time to be given up or greatly modified (p. 293). Although you may find support for a hypothesis, the hypothesis is not *proved* to be true. A hypothesis is never proved or disproved; it is only supported or not supported. Hypotheses are essentially probabilistic in nature. Empirical evidence can lead you to conclude that the explanation is probably true, or that it is reasonable to accept the hypothesis, but it never proves the hypothesis.