*Strategies for Educational Inquiry*

# *Inquiry & Scientific Method*

## *A Definition of Inquiry*

King, Keohane, and Verba (1994, p. 3) state that the main goal of their book on social inquiry is

> ... to connect the traditions of what are conventionally denoted "quantitative" and "qualitative" research by applying a unified logic of inference to both. The two traditions appear quite different; indeed they sometimes seem to be at war. Our view is that these differences are mainly ones of style and specific technique. The same underlying logic provides the framework for each research approach. This logic tends to be explicated and formalized clearly in discussions of quantitative research methods. But the same logic of inference underlies the best qualitative research, and all qualitative and quantitative researchers would benefit by more explicit attention to this logic in the course of designing research.

In this course we will pursue the laudable goal epoused by King et al. (1994) and attempt to apply a unified logic of inference to quantitative and qualitative research. This goal is easier stated than achieved. The qualitative researchers Miller and Fredericks (1996) point to the fundamental problem: "[H]ow can we make a case that qualitative data (findings) establish warranted inferences about the topics we are studying?... In essence, how do (should) we go about 'weighing' our evidence so that at some point we can say a justified inference has been made from the evidence to the question at hand?" (p. 1). You can read more about their concerns at http://olam.ed.asu.edu/epaa/v5n13/.

King et al. (1994, pp. 7-9) list four characteristics of good (aka, scientific) research. These characteristics apply equally to quantitative and qualitative investigations.

> **1. The goal is inference.** Scientific research is designed to make descriptive or explanatory *inferences* on the basis of empirical information about the world. Careful descriptions of specific phenomena are often indispensible to scientific research, but the accumulation of facts alone is not sufficient. Facts can be collected (by qualitative or quantitative researchers) more or less systematically, and the former is obviously better than the latter, but our particular definition of science requires the additional step of attempting to infer beyond the immediate data to something broader that is not directly observed. That something may involve *descriptive inference* — using observations from the world to learn about other unobserved facts. Or that something may involve causal inference — learning about causal effects from the data observed. The domain of inference can be restricted in space and time — voting behavior in American elections since 1960, social movements in Eastern Europe since 1989 — or it can be extensive — human behavior since the invention of agriculture. In either case, the key distinguishing mark of scientific research is the goal of making inferences that go beyond the particular observations collected.

> **2. The procedures are public.** Scientific research uses explicit, codified, and public methods to generate and analyze data whose reliability can therefore be assessed. Much social research in the qualitative style follows fewer precise rules of research or procedure or of inference. As Robert K. Merton ([1949] 1968:71-72) put it, "The sociological analysis of qualitative data often resides in a private world of penetrating but unfathomable insights and ineffable understandings... [However,] science ... is public, not private." Merton's statement is not true of all qualitative researchers (and it is unfortunately still true of some quantitative analysts), but many proceed as if they had no method — sometimes as if the use of explicit methods would diminish their creativity. Nevertheless they cannot help but use some method. Somehow they observe phenomena, ask questions, infer information about the world from these observations, and make inferences about cause and effect. If the method and logic of a researcher's observations and inferences are left implicit, the scholarly community has no way of judging the validity of what was done. We cannot evaluate the principles of selection that were used to record observations, the ways in which observations were processed, and the logic by which their conclusions were drawn. We cannot learn from their methods or replicate their results. Such research is not a *public* act. Whether or not it makes good reading, it is not a contribution to social science.
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> All methods — whether explicit or not — have limitations. The advantage of explicitness is that those limitations can be understood and, if possible, addressed. In addition, the methods can be taught and shared. This process allows research results to be compared across separate researchers and research projects studies to be replicated, and scholars to learn.
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> **3. The conclusions are uncertain.** By definition, inference is an imperfect process. Its goal is to use quantitative or qualitative data to learn about the world that produced them. Reaching perfectly certain conclusions from uncertain data is obviously impossible. Indeed, uncertainty is a central aspect of all research and all knowledge about the world. Without a reasonable estimate of uncertainty, a description of the real world or an inference about a causal effect in the real world is uninterpretable. A researcher who fails to face the issue of uncertainty directly is either asserting that he or she knows everything perfectly or that he or she has no idea how certain or uncertain the results are. Either way, inferences without uncertainty estimates are not science as we define it.
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> **4. The content is the method.** Finally, scientific research adheres to a set of rules of inference on which its validity depends. Explicating the most important rules is a major task of this book.... The content of "science" is primarily the methods and rules, not the subject matter, since we can use these methods to study virtually anything. This point was recognized over a century ago when Karl Pearson (1892:16) explained that "the field of science is unlimited; its material is endless; every group of natural phenomena, every phase of social life, every stage of past or present development is material for science. The unity of all sciences consists alone in its method, not in its material."

The end result of these procedures is to minimize the influence of experimenter bias and/or prejudice as he or she tests a theory or hypothesis. No one seriously questions the assertion that personal and cultural beliefs can, and do, influence not only our perceptions but also our interpretations of natural and social phenomena. Thus, we use standard procedures and criteria (aka, the scientific method) to minimize those influences. By adhering as strictly as is humanly possible to this method, investigators endeavor, through replicated studies, to construct a reliable, consistent, non-arbitrary (i.e., accu-

rate) representation of the world. These characteristics are discussed within a traditional description of the scientific method.

## *Scientific Method*

Descriptions of the scientific method can be found in virtually any introductory "hard" science textbook (physics, chemistry, astronomy) as well as texts in the life (e.g., biology) and social sciences (particularly experimental psychology). The following description borrows heavily from Frank Wolfs, a physicist at University of Rochester.

### Four steps

The scientific method may be described as consisting of four steps:

1. Observation and description of a phenomenon or a group of related phenomena. When an investigator has little prior information, the first step is description, or as Steiner characterizes it, "natural history." This is the stage when qualitative methods may provide considerable information about what-is.
2. Formulation of a hypothesis to explain the phenomena. Based on qualitative and/or descriptive studies, investigators begin to speculate about which variables might be related to other variables and in what manner (directly or indirectly). In educational research, the hypothesis is often a question about the relationship between or among variables that may influence learning. The hypothesis may be one that merely asks whether a relationship exists (correlational research), or the hypothesis may state a cause-and-effect relationship.
3. Predict the existence of other phenomena using the hypothesis, or predict the results of new observations. Consider the Rosenthal & Jacobson study as an example.
4. Conduct experimental tests of the predictions by several independent experimenters who use proper experimental methods.

If experiments by independent investigators replicate the results, then the hypothesis may be regardes as a theory or law of nature. If the experiments fail to support the hypothesis, then it must be rejected or modified. Central to this description of the scientific method, and to the definition of inquiry quoted from King et al. (1994), is the predictive power of the theory, as tested by experimental methods. Keep in mind that theories and hypotheses can never be proved, only disproved, for it is impossible to conduct all the observations across all time and space to provide all possible replications. The next observation (aka, experiment) may disprove a widely accepted theory.

### Hypothesis testing

Observations made under experimental conditions may confirm a hypothesis or fail to confirm the hypothesis. If the predictions stemming from a hypothesis are time and again not confirmed by experimental tests, the hypothesis has to be ruled out (for example, recall "cold fusion") or modified. No matter how elegant a theory or hypothesis may be, its predictions must agree with experimental results (aka, "observations,") before we are willing to believe that it is a valid description. Note that the experiment is the "gold standard" among the methods for testing hypotheses. Experimental verification of hypothetical predictions is absolutely necessary. Clearly, a theory must be testable. If a

theory is not testable, because its constructs are not operationalized, it does not qualify as a scientific theory (e.g., Freud's theory of psycho-sexual development).

### Error in experiments

Errors in investigations can be classified as "random" or "systematic." Random error is intrinsic to all measurement performed by humans. Early astronomers, who were timing the movement of heavenly bodies, noticed that different individuals recorded different times. Some times were shorter; others, longer. Because there is equal probablity of producing measurements that are higher or lower that the "true" value, this type of error is said to be random. Random error is also present when we measure achievement, attitudue, and personality. The second type of error is systematic or non-random error. This kind of error is due to factors that bias the result in one direction. Several sources of systematic error have been identified and we will examine these later in the course.

No measurement, and thus no experiment, is perfectly precise (i.e., without error). Therefore, standard methods exist to estimate the amount of error present. It is important to determine the accuracy of a particular measurement and to state the measurement error. A Comparisons between treatment conditions is made in the context of experimental errors. How large (or small) are the standard deviations for each? Have all sources of systematic and random errors been estimated?

## *Objectivity*

We assume that empirical research yields more reliable and valid information about all complex natural phenomena, including individuals and social organizations. Empirical research is used to describe, explain, and predict natural phenomena. Our understanding of phenomena will, nonetheless, always be partial, incomplete, and changing.

Empirical research is based on evidence obtained via systematic and controlled observations. Social sciences attempt to use the same methods as the natural sciences. Social sciences studies often do not achieve the same level of objectivity.

Objectivity may be thought of as agreement among expert judges on what is observed. *Objectivity is a procedure or a method. It does not refer to qualities or characteristics of a person doing research.* An objective test does not mean that the test itself is unbiased; rather, it means only that any investigator could arrive at the same score using the test as a measuring device. Objectivity also refers to the controlled experimental conditions that produces replicable results.

Our human limitations and characteristics make the achievement of objectivity difficult. Nonetheless, this insistence on objectivity is what gives research its special character — it provides more trustworthy explanations of natural phenomena than do other ways of knowing. Objectivity is a matter of degree, but we always strive for the highest levels. It protects research from personal biases of researchers by allowing replication and generally producing the same or similar results.

Criticisms of empirical research include the humanistic critique against the practice of objectivity, which, some say, makes the research practice abstract, remote, and cold. It is said by some that research ignores human values, needs, intuition, and spiritual values. Research yields knowledge that is only partial and reductionistic.

The phenomenologists and interpretivists argue that humans cannot be objective because we are ruled by our values, motives, history, and cultural context. The postmodernists, feminists, and advocacy researchers say research is merely a tool for those in power to push their own agenda.

Phenomenologists claim that humans, groups, and organizations cannot be measured, for each of these entities is a whole that cannot be reduced to quantitative parts. Another claim is that anything that can be quantified is trivial.

Investigators who value the empirical research tradition recognize that humans are not able to construct or discover "absolute truths." Instead, we generate knowledge that is more or less reliable and valid. Objective procedures increase the probability of obtaining more reliable and more valid knowledge. Although objectivity is an ideal we pursue but never obtain, research can become more objective by maintaining:

- an open atmosphere of open inquiry and a self-critical attitude
- only testable statements can be considered
- findings must be replicated
- faith in the scientific method, tempered by a healthy dose of skepticism
- belief that most natural phenomena can be understood, at least to a limited degree
- complete honesty in the research process; what contrary evidence exist for your favorite hypothesis.

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