THEORETICAL FRAMEWORKS *for* RESEARCH *in* CHEMISTRY/SCIENCE EDUCATION

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Theoretical Frameworks for Research In Chemistry and Science Education

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Prologue

In a typical experiment performed by a practicing chemist, the researcher chooses a particular analytical instrument, or a particular software package, or a particular approach to synthetic chemistry that meets the needs of the experiment being done. The choice of instrument or computational technique obviously influences the kind of experiment that can be done and, thus, the data that can be gathered about the compound being studied. One would not expect to obtain mass data from an HPLC, for example; nor would one expect to obtain retention time information from a mass spectrometer. The choice of instrument affects the type of data the researcher will obtain and later analyze and interpret.

For qualitative research studies in education, the theoretical framework plays a role analogous to the role of the instrument. A theoretical framework is a system of ideas, aims, goals, theories and assumptions about knowledge; about how research should be carried out; and about how research should be reported that influences what kind of experiments can be carried out and the type of data that result from these experiments. Crotty (1998) defined a theoretical framework as "the philosophical stance informing the methodology and thus providing a context for the process and grounding its logic and criteria" (p. 3). Because a theoretical framework has great influence on the design, data collection, and data analysis of qualitative studies, each qualitative researcher must make explicit the framework he or she has chosen for a particular study.

Clearly, qualitative research in chemistry education is strongly influenced by the researcher's choice of theoretical frameworks. For this reason, researchers need to be familiar with the various theoretical frameworks available to guide a study. Investigating and comparing individual theoretical frameworks can be time-consuming, however, because adequate descriptions of these frameworks are distributed across a wide spectrum of journals and research monographs with which chemistry educators are not familiar. Furthermore, few of the descriptions of theoretical frameworks that are readily available are discussed within the context of chemistry education research.

We have therefore tried to create a concise volume in which various theoretical frameworks used in chemistry education/science education research are described and critiqued. In this book, we will also review and discuss the potential applications of each theoretical framework to different types of chemistry education/science education research. Our goal is to help practicing chemists, chemistry instructors, and chemistry educators learn how to do basic educational research within the context of their own instructional laboratories and classrooms.

This book is an outgrowth of a series of discussions with graduate students and faculty from Departments of Chemistry, Schools of Education, and, more recently, Colleges of Engineering, that inevitably seemed to focus on the question: Where can I obtain the information that would enable me to make an intelligent choice about the theoretical perspective or framework upon which I can build the study I want to carry out?

We have asked the author of each chapter to provide the following information:

- A description of the theoretical framework;
- A brief history of the framework (when and why it was developed);
- The ontological assumptions of the framework;
- The methodologies and analysis techniques associated with the framework;
- The advantages and disadvantages of using the framework;
- A description of studies in chemistry education and/or science education that have used the framework;
- A discussion of the types of chemistry/science education studies for which the framework might be appropriate and, equally important, the types of studies for which the framework might not be appropriate.

The first symposium on research in chemical education at an American Chemical Society meeting was held slightly more than twenty years ago. This symposium contained a total of six papers and filled a half-day of the chemical education program. Since then, the number of people who have devoted their careers to doing research on the teaching and learning of chemistry has increased significantly. There have also been significant developments in the methodology for doing research in this area — and in the sophistication of the questions being investigated — in the last two decades. The topics being addressed in this book, however, are not unique to the field of content-based educational research in chemistry nor are they unique to educational research that involves qualitative research techniques or methodologies, although the emphasis of many of the chapters in this book will be on qualitative research.

The goal of this book is to help those who want to learn how to design educational research studies that are consistent with the call for rigorous research issued by the National Research Council Committee on Scientific Principles for Education Research (Shavelson & Towne, 2002). The NRC report argued that scientific research in education poses a *significant* question that can be investigated empirically; that this research is linked to relevant theory; and that it uses methods that permit direct investigation of the question. It called for research that provides a coherent, explicit chain of reasoning; can be replicated/generalized across studies; and is subject to professional scrutiny and critique. Research of this nature should also meet the criteria set forth by Diamond (2002), who calls for research that requires a high level of discipline-related expertise; that is conducted in a scholarly manner with clear goals, adequate preparation, and appropriate methodology; that has significance beyond the setting in which the research is conducted; that is innovative; that can be replicated or elaborated on; that is appropriately and effectively documented, including a thorough description of the research process and detailed summaries of the outcomes and their

significance; and is judged to be meritorious and significant by a rigorous peer review process.

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