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Critical Theory

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Biography

Provi Mayo was born and raised in San Juan, Puerto Rico. She attended the University of Puerto Rico at Rio Piedras and received a B.S. in chemistry. Upon graduation, Provi enrolled in the graduate program at Purdue University, where she completed an M.S. thesis on the problems of bilingual science learners and a Ph.D. dissertation on the learning of abstract three-dimensional concepts by the visually impaired. While at Purdue, Provi served as a teaching assistant for both chemistry and biochemistry courses, as well as a course supervisor and substitute lecturer for chemistry courses. She also worked with various minority programs and the adaptive services program. After completing her Ph.D., she joined the faculty at South Dakota State University, where she teaches a variety of chemistry and education courses and works on research in chemical education. Provi is the proud mother of Elena and Rafael.

Introduction

Critical theory is primarily concerned with issues of power and justice. It has been used to deal with matters of race, economy, class and gender; and it concerns itself with the way education, religion, and other social institutions interact to construct a social system (Denzin & Lincoln, 2000). Within the realm of education, critical theory provides the tools to explore, determine, understand, and eventually address the issues important to each diverse group within the complex social, historical, political and institutional practices used to create the classroom environment in which students and their instructors interact (McLaren, 1995).

Critical theory can be traced back to a group of philosophers at the Institute of Social Research in Frankfurt, Germany, who initiated a conversation in the German tradition of philosophical and social thought. Frustrated by forms of domination emerging from capitalism, critical theorists such as Horkenimer, Adorno and Marcuse, saw in critical theory a method for temporarily freeing academic work from these forms of power. They came to view their academic disciplines as manifestations of the discourses on power relations in the social and historical contexts that produced them. Other critical theorists

such as Poster (1989) and hooks (1994) have argued that critical theory originates in the assumption that we live in a world of pain and that critical theory has a pivotal role in the alleviation of that pain.

Brookfield (2005) described five distinctive characteristics of critical theory. In my description of these characteristics, I will express them within the context of an educational research study. First, critical theory is grounded in a particular political situation that is stable and is likely to remain stable until certain conflicts within that aspect of society are resolved and society is transformed.

The second characteristic of critical theory as applied to educational research is its concern with generating knowledge that can be provided to individuals to help them understand their situation, with the goal of facilitating their freedom from one or more oppressive aspects of the classroom environment in which the study is being carried out. Critical theories seek to generate knowledge that will result in action that leads to a change in the society being analyzed. If change is not part of the process of generating knowledge, critical theorists believe that the process is not complete. Critical theory is transformative; its main goal is to produce social change, enlightenment and emancipation (Brookfield, 2005).

Brookfield's third characteristic of critical theory presumes that it does not distinguish between the participants and the focus of the research. Critical theory's usefulness depends on the participants' recognition that the study in which they are participating represents a search for a better, more authentic way of life. The validity of critical theory is determined by the extent to which the participants believe that the study represents their hopes and dreams (Brookfield, 2005).

According to Brookfield (2005), the fourth defining feature of critical theory is that it is normatively grounded. Critical theory is grounded in the current instructional environment, while, at the same time, envisioning a less alienated, more just, and more democratic world. Critical theory's goal is to create a more ideal alternative to the present situation, rather than merely generating a description of the present situation.

Finally, Brookfield (1995) argues that any verification of critical theory is impossible until the more ideal social vision it seeks to achieve is realized. Horkheimer (1995) captured this aspect of critical theory when he noted, "in regard to the essential kind of change at which critical theory aims, there can be no corresponding concrete prescription of it until it actually comes about" (p 220). Horkheimer also argued that it is a struggle to create the conditions needed to test the vision critical theory has of the society under study.

Goals of Critical Theory

Jensen (1997) argued that critical theory seeks to provide a better understanding of present social conditions, how these conditions evolved, and how they interact with each other. In order to provide this knowledge, critical theory encompasses a multi-disciplinary approach that combines perspectives drawn from many fields of study,

including history, philosophy, economics, politics, psychology and sociology. As we have seen, however, the generation of knowledge is not enough; critical theory's ultimate goal is to transform our present society into a more just, rational, humane and reconciled society.

Critical theory provides a framework for understanding the environment in which it is being implemented. Denzin and Lincoln (2000) noted that critical theory does not determine how we see the world, but it provides a strategy for its exploration. Critical theory holds that knowledge is socially constructed, contextual, and dependent on interpretation. Held (1980) argued that one of the aims of critical theory is to assess the disparity between ideas and reality. These contradictions need to be disclosed and understood before one can close the gap between theory and practice, between perception and reality.

McLaren and Giarelli (1995) suggest that critical theorists want to understand hierarchies of contexts, types of knowledge, and ways to evaluate them in terms of their possible contribution to information that can be used to achieve critical emancipation. Through research, critical theory seeks to expose the reasons why societies and individuals are prevented from making decisions that affect their lives.

Critical theory has inspired studies in education that have focused on providing a "voice" to groups whose opinions have historically been suppressed (Giroux, 1998). The role of critical theory in education is closely linked with the needs of communities and has been of great importance in the development of new approaches to research that will investigate societies and support their evolution toward freedom. Some of these developments within the area of adult education, for example, were partially responsible for the origins of participatory action research in Latin America (Torres, 1995).

Methods Used in Critical Theory

Critical theory tries to understand societies, their hierarchies, and the reasons why decisions are made that positively affect one group while suppressing another. Because of the quantity of information needed to obtain the insight required to achieve this goal, qualitative methods are typically used in studies inspired by critical theory

The goals of critical theory are also consistent with the choice of narrative as a research tool (Agger, 1998; Held, 1980), even though the knowledge expressed in narrative or stories (Chapter 13) is often fragmented. Critical theory is often paired with other methodological frameworks, such as ethnography (Chapter 10), case study, Action Research (Chapter 9), and critical race theory. Critical theory often serves as the inspiration, guide or theoretical base for a study while the second framework with which it is coupled provides the method for data collection and analysis (Agger, 1998).

The term *critical ethnography* is often used by researchers when critical theory is paired with ethnographic methods (Chapter 10). This approach has also been called *critical research* (Carspecken, 1996). Madison (2005) noted that the "critical" in critical

ethnography defines the types of questions, field notes, narratives, journals and case studies to be used during the research. The “ethnographic” part of critical ethnography describes the interaction between the interviewer and the interviewee, who are partners in this research as they construct memories, meanings and experiences together (Madison, 2005).

Lorsbach and Tobin (1995) used a critical theory perspective for a study of learning environments in a science classroom in order to have a transformative effect on these classrooms. The authors’ goal was to use a critical approach to assist students and teachers to develop a learning environment that leads to emancipation. The methodology these authors coupled to the critical theory framework was that of a case study in which the data were gathered primarily by performing interviews with students and a teacher as well as by doing observations of the students working on lessons on optics and static electricity.

Hanrahan (1999) used a theoretical framework based on a mixture of psychological, sociological, and critical theory to study scientific literacy. Her study combined the points of view of a science education researcher and a science teacher by using methods such as Action Research (Chapter 9) and ethnographic case studies (Chapter 10). The data collection techniques used in her study were based on recorded information from action planning and review meetings, in-depth and short interviews, as well as informal conversations with the teachers, staff and students that were audio taped and transcribed.

Data Analysis

As we have seen, critical theory as a theoretical framework is often paired with a methodological framework that contributes its research methods and data analysis techniques. As a result, there is no specific way in which critical theory data are analyzed because analysis depends on the methodological approach and the data sources used in the project. Denzin and Lincoln (2000) referred to data interpretation within critical theory as an ”often neglected domain” and pair critical theory with hermeneutics as the basis for discussions of the analysis of interpretation of data obtained in critical theory research.

Carspecken (1996) described the process of extracting meaning from data collected during a critical theory study as a hermeneutic process for which there is not a definite procedure. The meanings extracted from the data must always come from the participants. The researcher’s role is to gather, interpret without polluting, and deliver the message derived from the data. For more information on hermeneutics refer to Chapter 6 of this text.

Benefits of Critical Theory

The main goal of critical theory is to help people create an environment in which they are free to make their own choices regarding the way they decide to think, learn and

live. Critical theory resembles many of the other theoretical frameworks described in this text because the choice of critical theory as the paradigm on which a study is based has a significant effect on the choice of methodology by which data will be collected and the nature of the research questions that can be addressed in the study.

When applied to research in education, critical theory allows participants in the study to ask questions about their own situation so they can make positive and informed choices about their learning. Brookfield (2005) argued that one of the benefits of applying critical theory to education is the ability "to investigate how dominant ideologies educate people to believe certain ways of organizing society are in their best interest when the opposite is true" (p. 30). Critical theory also provides insight into how people identify and oppose the ideological forces that shape the classroom environment in which they find themselves. It helps students learn how to challenge structures and beliefs that serve the interests of a more powerful group instead of the well-being of society as a whole.

Criticisms of Critical Theory

Critical theory has often been criticized and misunderstood. Many of the critics automatically equate critical theory with "leftist" or Marxist attitudes (Brookfield, 2005). Within the context of science classrooms, many instructors might object to a theoretical framework that uses terms such as "oppression" and "emancipation." I will try to justify the use of these terms in the next section of this chapter.

Agger (1998) described what he called "friendly" critiques of critical theory, which include "obscurantism" and "groundedness." The critique of *obscurantism* reflects the stylistic difficulty and inaccessibility of the language used by some critical theorists. Agger (1998) acknowledged that this criticism is ironic since critical theory values democracy and equality, but the language of critical theory is often difficult to understand and, therefore, frustrating. Marcuse was singled out by Agger as the only member of the Frankfurt school who noticed this difficulty and avoided complicated prose without compromising the message and depth of his social and cultural criticism. Agger answers the criticism of obscurantism by asserting that "many critical theorists need to write more clearly, taking the time to explain their complicated concepts without feeling compromised or diverted from their intellectual project" (p. 164).

The criticism of *groundedness* results from the tendency of many critical theorists to be too close to the issues, everyday life, culture, and politics that influence their work. This makes their theoretical work appear as if it obeys the demands of organized political movements instead of serving as a guide and conscience for society (Agger, 1998). Critical theory is therefore fundamentally different from ethnography, which has been criticized for being too neutral (Chapter 10).

Agger (1998) argues that critical theorists must make concessions to the disciplinary grounding of many scholars involved with critical theory. To achieve this, critical theorists need to develop empirical implications of critical theory for writing and teaching critical theory to the rest of the population. Critical theorists need to use examples and

common language to avoid confusion and make their work accessible to researchers trying to learn and use critical theory. Held (1980) also noted that although the central thought for critical theory advocated by Horkheimer, Adorno and Marcuse was the process of liberation and self-emancipation, the theorists failed to conceive a proper relationship between their theory and the application of those ideas.

Kincheloe (1995) noted that some have criticized his research as a type of politicization. He argued that these critics incorrectly see the dialogue needed between the critical theorist and the teacher as a means for the theorist to impose his views and opinions, which it is not. Critical theory goes farther than politics; it provides a vehicle for groups that historically have been neglected to teach others about their situation through research studies.

Published Examples of Critical Theory Influenced Studies

The goal of this chapter is to introduce critical theory, to provide examples of research that has been influenced by critical theory, and to give advice to those who are new to critical theory on how to use this theoretical framework in educational research. Often, researchers use critical theory to provide a guiding force for a study and couple it with other research frameworks that provide the methodology for the project. When used correctly, this combination is a powerful and useful tool for getting the information needed to empower a given population.

Because of the complexity of critical theory, I have created two separate tables to describe examples of the use of critical theory in science education. The first table contains papers about critical theory and its development. The second table contains studies in which critical theory was combined with a second theoretical framework.

The literature cited in Table 1 includes studies of the link between teacher education and issues of race, socio-cultural theories, pedagogy, and law.

Table 1. Literature about critical theory and its development.

Reference	Theme concerning critical theory
Breunig, 2005	How critical pedagogy theory can be combined with experiental education
Calabrese Barton, 2001	Interview with McLaren concerning the application of critical pedagogy
Cooke, 2005	Contemporary critical social theory and authoritarianism
Dixson & Rosseau, 2005	Review of critical race theory framework literature

Jordan & Yeomans, 1995	Theory and practice in critical ethnography
Kompridis, 2005a	Determining the contemporary identity of critical theory
Kompridis, 2005b	Past and future of critical theory: alternate conceptions for critical theory
Ladson-Billings & Tate, 1995	The development of a critical theory with a race perspective to address the limitations of the multicultural paradigm
Lynn & Adams, 2002	Recent developments of critical race theory in legal theory and how it can contribute to education
Mariage, Paxton-Buursuma & Bouck, 2004	Discussion of new educational justice discursive practices through the use of critical theory and socio-cultural theories
Masschelein, 2004	Relationship between contemporary critical educational theory and the “self reflective” life
Mezirow, 1981	Ideas of Habermas applied to adult learning and education
Olivos,& Quintana de Valladolid, 2005	Discussion of bilingual education reform from the perspective of critical theory and pedagogy
Pinar, 2003	Discussion of queer theory, its roots and relationship to critical theory
Price & Reus-Smit, 1998	The relationship and contributions that critical theory can make to international theory
Solorzano, 1997	Discusses the emerging critical race theory as a framework in the law field and its relationship to race, stereotypes and teacher education
Solorzano & Yosso, 2001a	Links between critical race theory and its relationship with race and racial stereotyping in teacher education
Solorzano & Yosso, 2001b	Discusses how critical race theory can offer a methodology to conduct and present research grounded in the experiences and knowledge of people of color
Walton, 2005	Application of Foucault’s analysis combined with critical theory to improve research on bullying in schools

Critical theory is often combined with other theoretical frameworks to create a concrete research design and method (Breunig, 2005; Calabrese Barton, 2001). The literature cited in Table 2 provides examples of studies in which critical theory was used as one of the research frameworks to provide a more solid research design. These examples combine critical theory with adult learning theory, ethnography, case-study methodology, race theory, constructivism, Action Research, and queer theory to address the research questions and interests. The wide variety of frameworks combined with critical theory demonstrates that, used properly, critical theory can be the inspiration for many research projects that aim to understand, teach, empower and make a difference in a population.

Table 2. Examples of Critical Theory Studies in Science Education

Reference	Methodological frameworks	Research purposes or question(s)
Brown, 2004	Adult learning theory; Transformative learning theory; Critical social theory	Create a process-oriented model responsive to the challenges education faces in order to keep justice and equity
Calabrese Barton, 2000	Critical ethnography	Should political research methodologies be considered to improve urban education?
Chapman, 2005	Case study; Critical race theory; Portraiture	Describes how matters of voice are placed within contextual issues such as method, framework, analysis and relationships between the participant and researcher
Fuzessy, 2003	Critical race theory; Cummins sociology model	Examination of Inuit students' perceptions of the teacher's role in Nunavic
Hammond, 2001	Critical ethnography	Emergence of a new multiscience as the participants' "funds of knowledge" are used to complement and guide a new kind of science curriculum
Hanrahan, 1999	Sociological, psychological, and critical literacy theory	Effect of the use of affirmation dialogue journal writing in science learning for high school low socioeconomic adolescent science students

Hoffman & Burrello, 2004	Case study	How superintendents of a regional education agency shifted the focus of schooling from utility to teaching and learning
Jofili & Geraldo, 1999	Critical constructivism; Action research; Case study	Case study of a teacher who changed the induction process of biology concepts for her students
Lorsbach & Tobin, 1995	Case study	How learning settings can play a transformative role in creating a more emancipatory learning atmosphere in the classroom
Lynn, 2002	Critical race theory; Qualitative methods	Understanding the motivations and perspectives of male black teachers in public schools with a high African American population
Preston, 1992	Social, ethical, and critical approach	What are the social and ethical implications of computer education in secondary schools in Queensland, Australia?
Snyder & Broadway, 2004	Critical and queer theory	How eight biology textbooks address sexuality outside the heterosexual norm.

By combining critical theory with adult learning theory, Brown (2004) developed a strategy to help future educational leaders develop proper skills, such as reflection on values and beliefs, as well as content and experience in order to equip them with the proper tools to support and address equity issues in education.

Through a combination of critical theory and ethnography, Calabrese Barton (2000) used critical ethnography to combine the experiences of the participants and the researcher to incorporate the students' language, beliefs, and experiences into urban school practices. Hammond (2001) used critical ethnography to design a new type of science (multiscience) created by incorporating the teacher's, the students' and the community's knowledge in order to improve education by addressing the similarities and differences in beliefs and knowledge of these three groups who contribute to the classroom environment.

Case-study methodology has been combined with critical theory by several authors (Chapman, 2005; Hoffman & Burrello, 2004; Lorsbach & Tobin, 1995). Case study provides the tools necessary to study the participants' life experiences in order to understand their particular situation. Case-study methodologies provide a good design for special populations since they concentrate on the way particular groups of people

confront specific problems, taking a holistic view of the situation. Patton (1990) argues that case study offers a method for investigating and understanding complex social units. This method was used in conjunction with critical theory as a theoretical framework to better answer the research questions raised in the studies described in this paragraph.

Critical race theory was used by Lynn (2002) to understand the motivation of male black teachers who choose to work in the public school system in areas where most of the students are of African American descent. Fuzessy (2003) used critical theory to examine Inuit students' perceptions of the non-Inuit teacher's role in the course and how cross-cultural training might help these teachers cope with cultural dissonance.

Sociological, ethical and constructivist approaches were combined with critical theory in studies by various authors. Hanrahran (1999) studied how having students write a reflective journal affects their sense of empowerment toward a particular course. Preston (1992) studied the ethical and social implications that must be taken into consideration when offering computer education in secondary schools.

Queer theory, derived from critical theory, was used by Snyder and Broadway (2004) in applying qualitative methods to study how eight different high-school biology textbooks approached the issue of homosexuality.

Detailed Example of a Critical Theory-Influenced Study

As an example of a project for which critical theory was viewed as an appropriate theoretical framework, I will describe some of the work we have done to try to understand how blind students visualize abstract chemistry concepts such as the three-dimensional representations of molecules. Critical theory is appropriate for these students because we are trying to change an "oppressive" environment in which blind students struggle to complete introductory chemistry courses that are necessary for them to enter many academic fields. The research has the potential to be "emancipatory" if we can help blind and visually impaired students develop the skills and knowledge they will need to succeed in fields that have traditionally been closed to them. Although chemistry texts can be translated into Braille and figures from these texts can be transposed onto tactile paper for blind students, the documentation of blind students' perceptions, imageries, and visualizations of the instructional materials provided for them can play a pivotal role in understanding how these students learn and what they need to help them learn better.

This project began as an idea when blind students I was tutoring in work with the adaptive services program at Purdue mentioned that they often disregarded figures in their textbook because they either took too much time to understand or they did not correlate properly with the images they derived from reading the text. The students also noted how hard it was for them to understand abstract three-dimensional material from the text and the figures provided for the class. After reading the literature on studies of learning by blind students (Herman, Herman, & Chatman, 1983; Hollins, 1986; Millar,

1977, 1994; Pring, 1989), I designed a critical-theory-laden study based on the following research questions:

- How do blind students translate abstract chemistry ideas in their textbooks into a two-dimensional image or drawing? What symbols do they use to represent the translated ideas? How do blind students decide to use certain symbols to represent the abstract material given to them in the text?

- What discrepancies arise when blind students compare their perceptions of abstract concepts from the text and their haptic perception of raised-line drawings of those figures? How do they reconcile these differences?

- What are visually impaired students' mental images when they are given words used in chemistry such as precipitation and crystallization?

By understanding how the mental images of these students diverge from the figures used to introduce abstract ideas, this study sought to generate the knowledge needed to enable programs for visually impaired students to better meet their needs. Critical theory provided this study with the focus needed to eventually develop appropriate educational material that would provide non-sighted students with the emancipatory knowledge to develop as independent and successful students in the sciences.

Critical theory served as the inspiration for this study because it focused on learning about and empowering visually impaired science students. This theoretical framework was combined with symbolic interactionism (Chapter 3), which seeks to understand the meanings and interpretations given to symbols by participants in a community. These theoretical frameworks were then augmented by the use of a case-study methodology.

Symbolic interactionism was used in this study to identify and decipher the common symbols that visually handicapped participants develop through their learning experiences in order to cope with their difficulty with abstract material. The visualizations and symbols gathered were used to understand the students' thought processes while reading a text versus "looking" at a figure prepared for them by the adaptive services group at Purdue.

In the course of this study, I tried to understand what symbols the visually handicapped participants used, where these symbols were extracted from, and what the symbols meant for them. The meanings attached to these symbols could be either verbal or visual, in the form of an image.

Yin (1994) defined case-study methodology as "an empirical inquiry that investigates a contemporary phenomenon within its real life context especially when the boundaries between the phenomenon and the context are not clearly evident" (p. 13). Merriam (1998) noted that a case study is descriptive in nature and that it contains a complete literal description of the phenomenon being investigated. Case studies include as many variables as possible and portray interactions among these variables over a long period

of time. Usually the case's description has qualitative characteristics since it uses prose and literary techniques to describe, elicit images, and analyze the situations under study. The use of case study as a methodological framework gave me the opportunity to discover and interpret the factors that played a significant role in the way visually impaired students visualize abstract, three-dimensional concepts they encounter in text and figures in their science courses.

In order to answer my guiding research questions, I conducted interviews with blind and visually impaired students that were both audio- and videotaped. The video component was used to capture the participant's gestures and drawing style. One-on-one interviews with visually impaired students gave me the opportunity to gather data and interact with the participants in a way that provided access to their mental images, symbols, and drawings.

Each of the undergraduate students who participated in this study was interviewed for two hours on two separate occasions. Another source of data for this study was an interview with one of the faculty at Purdue who had taught a biochemistry course in which one of these participants in this study had been enrolled. This interview, which also lasted two hours, provided a more complete picture of the reality of having a visually handicapped student in a science classroom. The last source of data for this study was a three-hour interview with a blind chemistry professor at a predominantly undergraduate university.

The interview questions, shown in Table 3, were chosen to help me understand the visually impaired participants' mental images and visualizations of three-dimensional material. I chose molecular geometry as the theme for this study because it required the participants to construct mental images and visualize abstract material. Once the topic for the interviews was chosen, I asked the adaptive services program at Purdue to provide examples of the material on molecular geometry they gave to visually impaired students when they enrolled in a general chemistry course at Purdue. These materials were provided in Braille and focused on trigonal planar, tetrahedral and trigonal bipyramidal geometries.

Table 3. Sample of the questions asked to the different participants during the study.

Participants	**Questions**
Blind Undergraduate Students	1. The participants were asked to draw different shapes such as a triangle, square, xyz coordinate system, square, square based pyramid and cube. 2. The participants were given a Braille text describing different molecular shapes and were asked to explain using words or drawings what they understood and visualized. 3. The participants were given models and were asked to use them to describe their mental images of certain molecular shapes such as "trigonal bipyramidal."

	4. The participants were asked to describe mental images evoked by visually-charged terms that are used in chemistry such as “melting,” “precipitation,” “soluble,” “bonding” and “combustion.”
Blind Chemistry Professor	1. Describe the geometry around the boron atom for B_2H_6. 2. Borazine has a similar structure to benzene, with alternate B-N bonds. Draw and describe the structure. 3. Describe the shape of $Fe(CO)_5$. 4. The professor was given the text and figures which were used with the other participants. He was asked to explain how his mental images of the text correlated to the figures that were prepared for the students.
Biochemistry Professor	1. The professor was asked what tools and techniques he used to explain abstract concepts to the blind student in his class. 2. The professor was asked if he noticed a difference in his teaching in the classroom and if he noticed a difference in the sighted students’ performance

My role in the interview was to observe the individuals being interviewed in a manner that would enable me to describe the setting, the activities that took place, the people who participated, and the meaning of what was observed from the perspective of the participants. Like other forms of qualitative research, descriptions of what was observed during the interviews conducted using a critical theory perspective should be factual and accurate, without being cluttered by irrelevant details. The quality of the observations is judged by the extent to which the descriptions of these observations permit the reader to enter and understand the situation being described.

Observations can be made and documented from two different perspectives: emic and etic (Patton, 2002). The *emic* perspective focuses on an insider’s perspective in which the researcher shares as intimately as possible the life and activities of the participants in order to develop an insider’s point of view. The *etic* approach involves observing the particular phenomenon or culture from outside to see its separate events in relation to similarities and differences as compared to events in other cultures (Patton, 2002). This study was done through an etic perspective; I was an outsider to the participant’s world and they provided me with glimpses into their reality during the interviews.

I observed the participants’ body language and use of symbols as they either drew and/or modeled during the interview. As an observer, I was able to ask the participants about their mental images, learning and course materials. The observational data gathered from the students and the professors’ interviews were used to supplement the audiotapes from the interviews.

The purpose and the methods for data gathering in this study were directly guided by critical theory, the theoretical framework in this project. The data analysis was done

following the guidelines for case study and symbolic interactionism, the methodological frameworks. The data gathered for each participant was organized in separate case files. During the analysis, I discussed what methods the participants used to answer the questions, what images they described throughout the interview, and how the participants worked with the molecular models. Each participant was discussed in a separate section and examples to support any statement in the conclusion were extracted from the case records. Also at the end of each participant section I provided a summary which compared and contrasted each of the main points made in the analysis of the participant's data. The data and the participants' ideas and feedback on the materials used during the project were given to the adaptive service program staff at Purdue. In accordance with critical theory, the participants, as well as I, the researcher, had the opportunity to learn how they visualize, explore and understand the materials prepared for them by the adaptive services program. Also, the adaptive services program staff got feedback from the students how their services can be improved so they can better fulfill their needs. The students felt empowered because they had an opportunity to learn and participate in the development of scientific materials for other blind students who utilize the adaptive service program.

Conclusions

As noted previously, the goal of critical theory is to address issues important to diverse populations by generating knowledge that would help the individuals further understand and eventually change their situation. This knowledge will ideally empower these individuals to make the changes they feel are needed to improve their position within society as a whole. Critical theory helps the researcher accurately represent the participants' goals. It also provides the tools to help the participants devise a plan to achieve these goals.

Usually, critical theory is used to study a population that has been ignored or forgotten by society. These populations are not in a position of power and are not able to change their situation on their own. Critical theory provides the guidelines and tools to give these populations the power to induce a favorable change. Critical theory was useful as a theoretical framework for my research project inasmuch as visually impaired students represent a very small fraction of the total student population and the instructional materials were designed by and made for sighted people. The subjects of this study had no input into either the development of the instructional materials or their adaptation for use with visually impaired students. This project provided the blind students who participated in the interviews with a "voice" to improve the materials that will be given to students who enroll in chemistry courses in the future.

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15

Feminism

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Biography

Brenda Capobianco is an Assistant Professor of Science Education in the Department of Curriculum and Instruction and Affiliated Faculty in Women's Studies at Purdue University. She also holds a courtesy appointment as an Assistant Professor in Engineering Education. She is the coordinator of Purdue's elementary science teacher education program. Before entering academia, she was an award-winning middle science teacher for over ten years in Connecticut and an adjunct instructor of university science elementary and secondary methods courses. Brenda writes and teaches in the field of science education with interests in action research and issues of gender and culture in science education. Her research and publications focus on teachers' development of practice through collaborative action research; teachers' attempts at integrating feminist pedagogies using action research; and the construct of identity among young women in science and engineering.

Introduction

The goal of this chapter is to inform researchers of how feminism can be used as a theoretical framework for research in science education. To accomplish this goal I will review briefly how feminism is defined. Then I will describe the historical roots of feminism in science education. Lastly, I will describe feminist research methods practiced by science education researchers and provide compelling examples of feminist studies in science education. This chapter is designed to demystify feminism as a theoretical framework by examining what researchers and practitioners alike can actually do and furthermore, offer models to emulate or to modify. In this sense, I hope to take readers beyond a fundamental understanding of feminism as "fighting patriarchy" to a more progressive perspective of feminism as "producing knowledge" (Reinharz, 1992) and "generating a discourse" necessary for establishing and sustaining equity and diversity in science education and society at large (Barton, 1998a).

Defining Feminism

In its simplest form, feminism is defined as “the advocacy of women’s rights on the grounds of political, social, and economic equality to men” (Jewell & Abate, 2001, p. 622). Feminism is premised on the recognition that gender is a phenomenon which helps to shape our society. Feminist researchers believe that women are located unequally in the social formation, often devalued, exploited, and oppressed (hooks, 1984; Kenway & Modra, 1992; Luke & Gore, 1992; Reinharz, 1992; Tong, 1998). Education systems, the knowledge which they offer, and the practices which constitute them, are seen to be complicit in this. Feminist researchers share the commitment to a form of politics directed towards ending the social arrangements which lead women to be “other than,” less than, put down, and put upon (hooks, 1984; Maher & Tetreault, 2001; Reinharz, 1992). Feminism, then, is a social theory and social movement, but it is also personal political practice.

For feminist researchers, feminism is a primary lens through which the world is interpreted and acted upon. Of course, feminism is not a monolithic discourse. There are, in fact, many feminisms informed by various social theories and research traditions and motivated by somewhat different social, political, and educational projects, each experiencing their own theoretical and practical problems (see Tong, 1998). For instance, liberal feminists might aspire to a world in which women have equal access to current social benefits and so develop an educational agenda premised on notions of “access and success” and equality with men. Liberal feminists have informed major legislation guaranteeing women equal education, pay, and opportunity (the Equal Pay Act of 1963; Title IX of the Education Act Amendments of 1972; the Equal Opportunity Employment Act of 1972). Socialist feminists, on the other hand, are concerned with the exploitative practices by which such benefits are products and their effects for women are gendered and classed social beings (Tong, 1998). Socialist feminists believe women’s oppression is not the result of individuals’ intentional actions but is the product of the political, social, and economic structures within which individuals live. Thus their educational project is directed towards ending education’s involvement in reproducing the complex, intersecting social relationships that are class and gender (Reinharz, 1992). Sometimes race and ethnicity are also encompassed in their agenda (Collins, 1990; hooks, 1984).

The fact that there are multiple definitions of feminism means that there are multiple feminist perspectives on research methods (Olesen, 1994; Reinharz, 1992; Rosser, 1997; Tong, 1998). One shared radical tenet underlying feminist research is that women’s lives are important. Feminist researchers do not cynically “put” women in their scholarship so as to avoid appearing sexist (Reinharz, 1992). Rather, for feminist researchers, females are worth examining as individuals and as people whose experience is interwoven with other women. In other words, feminists are interested in women as individuals and as a social category.

Historical Roots of Feminism in Science Education

There are two unique approaches to examining the construct of feminism in science education. The first approach was introduced by Brickhouse (1998) in her chapter on "Feminism(s) and Science Education" in the International Handbook on Research in Science Teaching. In this chapter Brickhouse outlines four major feminist traditions, including liberal feminism, radical feminism, socialist feminism, and poststructural feminism, and their respective influences on the development of the critiques of science. Her goal was to demonstrate how various feminist theories on science can enhance science curriculum and instruction and furthermore, offer an alternative framework for examining the nature of the discipline. The second approach has been introduced by Barton (1998a) in her book entitled, Feminist Science Education. Drawing from traditions carved out by scholars in women's studies, Barton traces three progressive political and intellectual movements or "waves" in feminism and their impact on science education. In doing so, Barton has placed emphasis on significant reform movements in feminism and how these efforts initiated, if not provoked, major science education reform efforts that generated new and innovative curricular projects, programs, and lines of research that promoted conceptual understandings and scientific literacy for all students in science.

In the following section, I use Barton's approach to describe the three important waves in feminism in science education and, in addition, highlight the effect these efforts made in changing the direction of curriculum, instruction, extra-curricular programs, and scholarship in science education.

First-wave feminism in science education

Feminism is rooted in the Women's Liberation Movement (late 1960s to early 1970s) and is dedicated to changing those institutions and social practices such as science education that subordinate the interests of women to the interests of men (Brickhouse, 1998). Some of the earliest feminist reform movements in science education were linked primarily to debates about equity in science education (Baker & Leary, 1995; Brickhouse, 1994; Kahle & Meece, 1994). The reemergence of the women's movement in the 1960s, along with the civil rights movement, led the science education community to take a critical look at the kinds of opportunities being granted to girls and minorities (Barton, 1998a). This wave of critiques of practices, referred to in women's studies as "first-wave feminism" or "liberal feminism," (Luke & Gore, 1992; Maher & Tetreault, 2001), focused on inferior treatment received by girls and minorities in schools and in other informal science education programs (Barton, 1998a). The liberal feminist perspective played an important role in the development of science education programs because it shifted emphasis from the ways in which girls and minorities were positioned as "inferior" and placed it on the kinds of structural and institutional constraints that posed barriers to successful participation in science by girls and minorities (Barton, 1998a; Brickhouse, 1994, 1998).

According to Barton (1998a), liberal feminism influenced science education programs in several significant ways. First, liberal feminist studies emphasized the ways of bringing women and minorities "into science" by focusing on achievement, attitudes, and participation in science (Baker & Leary, 1995; Harding, 1986; Jones & Wheatley, 1990; Kahle & Meece, 1994; Scantlebury & Kahle, 1993). Results from these studies were helpful in highlighting the ways in which women and minorities have been marginalized from entering the sciences; identifying classroom activities that fostered perceptions of science as uninteresting; noting a lack of role models, after school programs and incentives; identifying science teaching practices that perpetuated scientific knowledge as objective, rational, and androcentric; and utilizing educational practices that emphasized boys' over girls' achievements in science (Kahle & Meece, 1994).

Second-wave feminism in science education

According to Barton (1998a), "one of the more significant results to emerge from second- wave feminist studies in science education was the challenge to the values and standards of science and science education" (p. 4). These studies moved away from efforts at equity, toward exploring multiple ways of knowing and doing science that are reflective of the social, historical, and political context in which science has been constructed (Barton, 1998a; Barton & Osborne, 2001; Brickhouse, 1994; Roychoudhury, Tippins, & Nichols, 1993). Second-wave feminist studies in science education have focused on "the nature and practice of science" and on "ways of knowing in science."

It is during this phase that feminist researchers in science education draw heavily on the work of feminist philosophers of science such as Harding (1986), Keller (1985), Bleier (1986), and Hubbard (1990). Harding (1986) and Keller (1985) examine the extent to which science may be a "masculine province" which excludes women and in turn, causes women to exclude themselves from it. They suggest science is masculine at three different levels: 1) at the surface level; 2) at the deeper intellectual level; and 3) in the core of the knowledge that is accepted as being scientific. At the surface, men compromise the majority of those who study, teach, and practice science. Examples and applications used in teaching are frequently masculine, and classroom interactions establish male dominance as a norm (AAUW, 1992; Rosser, 1990; Sadker & Sadker, 1994). At a deeper level, scientific thinking and knowing represent, if not incorporate, a masculine worldview (Keller, 1985). What is held as the essence of science among scholars of science is equivocated as being objective, rational, unemotional, and value-free. This explains the common premise for feminist-standpoint theory: "The difference in the social experience of men and women give them different ways of looking at life and interpreting events, and hence, different standpoints" (Harding, 1986, p. 17). Making a personal connection with the subject is unacceptable in science (Keller, 1985). Women may feel as outsiders in science classes when their emotionally connected ways of knowing are not warranted or their experiences are marginalized. Women should not have to reject their real-life experiences and try to assume the male viewpoint. According to second-wave feminists, how women experience science must be considered and valued as much as the men.

In sum, second-wave feminists suggest that the discipline of science demands that the perspectives and insights of women, minorities, and working-class students, who have been traditionally marginalized from participating in science, be included (Harding, 1991). Incorporating the lived experiences and voices of all individuals, especially the experiences of the groups still struggling for a voice and space in science, makes possible the construction of an inclusive science and science education. Much of the work conducted by second-wave feminist science educators has been grounded in a social constructivist framework (Rodriguez, 2001; Roychoudhury, et al., 1995). As a result, questions around the social construction of female-friendly (Rosser, 1990; 1997) and gender-inclusive science (Roychoudhury, et al., 1995) have begun to emerge. Feminist researchers in science education have used the movement to understand science as a social construct to initiate debate about ways of knowing science and the implications this has for science for all (Barton, 1998b; Barton & Osborne, 2001; Eisenhart, Finkel, & Marion, 1996).

Third-wave feminism in science education

The first- and second- waves of feminism have focused on the constructs of "gender and education" (Luke & Gore, 1992). Throughout these periods, the results of gender and education research led to changes both in how teachers teach science and in what science curricula students are expected to learn. In other words, feminist science education researchers have called for teachers to transform their goals, science content, and instructional practices to make science more attractive and inviting to all students, particularly women and minorities (Barton, 1998a; Barton & Osborne, 2001; Bianchini, Cavazos, & Helms, 2000; Brickhouse, 1994; Capobianco, in press; Mayberry & Rees, 1999; Richmond, Howes, Kurth, & Hazelwood, 1998; Rodriguez, 1998; Rosser, 1990, 1997; Roychoudhury, et al., 1995). One approach heralded by feminist researchers concerns the use of feminist pedagogy in the science classroom. According to researchers, feminist pedagogy entails changing not only what science is taught, but also how science is taught (Mayberry & Rees, 1999). It is directed at developing curriculum and instruction that validate the voices, experiences, and viewpoints of all students, especially female students; challenge existing practices as conventional and masculine in nature; place the role of the science teacher as facilitator; and empower students to redefine the role science plays in their own lives.

Since the second-wave of feminist research, there has been a moderate shift from emphasis on gender as a primary form of difference to emphasis on gender, race, class, and other socially significant dimensions (Barton, 1998a; Mayberry & Rees, 1999). Further, the third-wave of feminism demands self-reflexivity (Barton, 1998a; Lather, 1991). Lather (1991) states:

> …if critical inquirers are to develop a praxis of the present, we must practice in our empirical endeavors what we preach in our theoretical formulations. Research which encourages self and social understanding and change-enhancing action on the part of developing progressive groups requires research designs that allow us as researchers to reflect on how our value commitments

> insert themselves into our empirical work. Our own frameworks of understanding need to be critically examined as we look for the tensions and contradictions they might entail. (p. 80)

This feminist stance reflects a subjective, contextual, particular, and uncertain reading of the texts in material-theoretical lives: “There are no finite answers, no certainties in any one position” (Luke & Gore, 1992, p. 5). In short, it emphasizes the situated nature of knowledge (Haraway, 1988), power, and authority (Barton, 1998a).

In addition to recognizing science and curriculum as political texts and schools as drivers of hegemonic ideals, third-wave feminism also recognizes and draws its strength from teachers and students as “agents” and “actors” who actively shape and reshape their own understandings of the world from specific standpoints (Barton, 1998a). Scholarship that continues to emerge from third-wave feminism in science education is focused on issues such as the construction and reconstruction of scientific identities among young women (Brickhouse, Lowery, & Schultz, 2000; Brickhouse & Potter, 2001; Capobianco & Osborn, 2005; Carlone, 2004) and science teachers and scientists (Bianchini, et al., 2000; Helms, 1998; Kozol & Osborne, 2004) and social agency among science students (Barton, 1998b; Roth & McGinn, 1998; Rodriguez, 1998). At the core of this line of thinking is the concerted effort to understand and question the nature of science and scientific knowledge as well as how science can be situated within the larger society. For feminist researchers studying how students learn science, it entails a close examination of how children construct science out of their own questions and experiences, even when those experiences challenge societal norms (see Barton, 1998a; Howes, 2002) and/or studying how situated cognition provides resources for feminists to better understand science learning (see Brickhouse, 2001). For feminist researchers studying science teachers and teaching, it involves explorations in how teachers actively shape relationships around power and knowledge in the science classroom (see Capobianco, in press; Osborne, 1997). Examples of these third wave feminist studies in science education argue that science teaching is political and activist-oriented. For example, Capobianco (in press) has recommended that science teachers become researchers of their own practice and examine critically different ways of making science more accessible to their students. When this happens, teachers transform their practice, gain new knowledge, and generate a cluster of pedagogical possibilities for inclusive science teaching. By engaging in collaborative action research on feminist pedagogy, science teacher-researchers become actively involved in asking new questions about what science they teach, what role science plays in their lives, and who benefits from the uses of science and scientific knowledge.

Collectively, the main points of feminist research in science education indicate that if all students are to participate freely in science, science education needs to be re-created so that teachers and students can collaboratively create and analyze science and its role in their lives (Barton, 1998a). Hence, feminist research is inherently linked to action taken by students, teachers, and researchers of science education. The goal of feminist research in science education must be to create new relationships with science, to enhance teaching practices and curricula, and to change what we can learn about

ourselves as students, teachers, teacher educators, and researchers of science education. By retracing the historical roots of feminism in science education, researchers can better understand the variety of lenses that they can use to look at different actions taken to make science more inclusive.

Is There a Feminist Research Method?

In her collection of essays entitled, Feminism and Methodology, Harding (1987) explores basic and challenging questions about feminist research. One question in particular includes: Is there a distinctive feminist method of inquiry? To address this question, Harding argues that researchers must take into account the fact that discussion of "methods" (techniques for gathering data or evidence) and "methodology" (a theory and analysis of how research should be conducted) are often conflated with each other and with epistemological issues in feminist research. According to Harding (1989), the term, "method" is "often used to refer to all three aspects of research and consequently, it is not at all clear what one is supposed to be looking for when trying to identify a distinctive 'feminist method of research'"(p. 2). In the following section, I describe different methodologies or what Harding calls "transitional epistemologies" used in feminist research. Then I describe general characteristics of feminist methods. Lastly, I elaborate on specific research methods commonly used by feminist researchers in science education.

Feminist Methodological Frameworks

Harding recognizes three types of feminist inquiry, which she refers to as "transitional epistemologies" (Harding, 1987, p. 3). These include: 1) feminist standpoint research; 2) feminist empiricism; and 3) postmodernism. According to Harstock (1993), a standpoint "carries with it the contention that there are some perspectives on society from which…the real relations of humans with each other and with the natural world are not visible" (Harstock, 1993, p. 159). Harstock contends that women's circumstances "in the material order" provide them with experiences that generate particular and privileged knowledge that reflects both oppression and women's resistance. Feminist standpoint theorists, like Smith (1987), Harstock (1993), and Rose (1983), argue that not just opinions but also a culture's beliefs – what it calls knowledge – are socially situated. Feminist standpoint theorists focus on gender differences, on differences between women's and men's situations which give a scientific advantage to those who can make use of the differences. According to Brickhouse (1998), feminist standpoint research in science education is "a learned perspective that can provide challenges to science and help create theories and technologies that are more beneficial to women" (p. 1071).

Feminist empiricism begins with the position that science and its methods are basically sound, but some practices, procedures, assumptions, and findings of scientists are biased against women; because these practices are detrimental both to women and to science, they must be identified and curtailed. This is in contrast to feminist-standpoint

theory where a less-biased account of the world can be constructed by beginning investigations from the perspective of women.

Postmodernism emphasizes the multiplicity of identities of an individual - not just their gendered identities, but also, their racial, classed, and sexual identities - and it rejects a separation between subject (e.g. researcher/scientist) and object (e.g. nature of science). Thus, when carrying out research on gender and science education, researchers need to take into account that what it means to be a White male from an suburban setting or a Black female from an urban school is highly situated (Brickhouse, 1998). Research that analyzes data simply by placing all girls in one category and all boys in another does not take into account the diverse and intricate meanings of social categories, such as gender, race, or class.

Feminist standpoint research, feminist empiricism, and postmodernism are useful ways to look at different methodological approaches to feminist qualitative research. Furthermore, many feminist studies display different elements of these frameworks, combining and borrowing various tenets in an effort to generate, if not invent, alternative approaches to doing qualitative research. In the next section, I describe various research methods practiced by feminist researchers.

Feminist Research Methods

In her book, Feminist Methods in Social Research, Reinharz (1992) identified ten key themes associated with feminist research methods.

1. Feminism is a perspective, not a research method.

2. Feminists use a multiplicity of research methods.

3. Feminist research involves an ongoing criticism of nonfeminist scholarship.

4. Feminist research is guided by feminist theory.

5. Feminist research may be transdisciplinary.

6. Feminist research aims to create social change.

7. Feminist research strives to represent human diversity.

8. Feminist research frequently includes the researcher as a person.

9. Feminist research frequently attempts to develop special relations with people studied (in interactive research).

10. Feminist research frequently defines a special relation with the reader (p. 240)

Feminist researchers do not consider feminism to be a method per se. Rather they consider it to be a perspective on an existing method in a given field of inquiry or a perspective that can be used to develop an innovative method. This is why a chapter on feminism has been included in this book on theoretical frameworks for research in chemistry and science education. Research methods commonly practiced by feminist researchers fall into one of three categories: 1) listening to informants (e.g. interviewing, oral history, or reflective writing), 2) observing behavior (e.g. direct classroom observation), or 3) examining historical traces and records (e.g. genealogy). Feminist researchers generally do not favor one research method over another. In fact, feminist researchers often combine multiple methods supplied by basic research traditions (e.g. experimentation, ethnography, survey research, content analysis) or created by the research (e.g. drama, genealogy, group diaries). Multiplicity of methods allows feminist researchers to study the greatest possible range of subject matters and attain a broad set of goals. Interview and oral history research enable feminist researchers to hear women's lived experiences first-hard; feminist case studies, cross-cultural research, and ethnography/autoethnography let researchers understand women in their contexts; feminist surveys allow researchers to understand variation within and among populations; and experiments make it possible to measure behaviors and attitudes without contextual distractions (Reinharz, 1992). In sum, there is no single "feminist way" to do research. There is little "methodological elitism" or definition of "methodological correctness" in feminist research. Rather there is a lot of individual creativity and variety.

Feminist Analysis Techniques

Many feminist researchers draw from and combine a variety of traditional approaches to qualitative data analysis. This includes techniques such as narrative analysis (Riessman, 1993), case study analysis (Yin, 2003), document analysis (Bogdan & Biklen, 1998), and grounded theory (Strauss & Corbin, 1998). One example of a qualitative data analysis technique unique to feminist researchers is called "voice-centered" narrative analysis. Introduced by Gilligan (1992), a voice-centered approach is primarily used by feminist researchers interested in discovering the complexity of the participants' thoughts, feelings, and actions and, furthermore capturing the situational, personal, and cultural dimensions of their participants' situations (Lawrence-Lightfoot & Davis, 1997). This involves the researcher scrutinizing transcripts from interviews (individual or group) several times, paying particular attention to subtle meanings and nuanced connections asserted by each participant. The researcher listens for the participants' different voices they used to describe the plots of their respective storied experiences; their personal or professional identities; and how they experience themselves in their respective situations. Through construction and reconstruction of the participants' voiced-centered stories, the researcher can create narratives grounded in the data (Clandinin & Connelly, 2000).

Issues Related to Conducting Feminist Research

Educational researchers need to take into consideration several key issues and concerns when conducting feminist research. In the following section I explore three key issues associated with conducting feminist inquiry in science education and provide examples of studies where researchers have attended to these concerns.

Researcher Bias

In qualitative research, the researcher needs to be confident that the material is unbiased in accurately representing social reality. In quantitative research, this is assessed in terms of "objectivity," maintaining a space between the researcher and the researched so that the researcher is not influenced by the research process. In qualitative research, neutrality is possible by removing the distance between the researcher and the participant to ensure biases the researcher brings into the research are acknowledged and that the participant can confirm the validity of the depiction of their experience and social reality (Glesne, 1999). For example, in teacher action research, the goal is to include the teacher's perspective and voice in all aspects of the research process. The assumption behind this agenda is that the material revealed will be more accurate and objective in representing the reality of the social experience and situation (Hollingsworth, 1994). By including the participants in the process, it is argued that the data will be unbiased and more truthful in representing the event in agreement with the participant. In both instances, the overall objective is for the data and the conclusions reached from the analysis of the data to be accurate and representative of the situation that was studied.

In feminist research, a participant's personal experience is considered a valuable asset of the research project. Personal experience typically is irrelevant in mainstream research, or is thought to contaminate a project's objectivity. In feminist research, by contrast, not only is the participant's personal experience relevant, the researcher's personal experience is relevant as well (see Role of the researcher, p.zzz). Mayberry and Rees's (1999) essay on co-developing and co-teaching an innovative, interdisciplinary course titled "Earth Systems: A Feminist Approach," provides a good example of how feminist researchers weave both their own experiences as well as the experiences of their students — male and female, natural and social science majors — into all aspects of the researchers' account. Mayberry and Rees described their methodological approach as follows:

> Personal experiences…provide the lens through which our discussion is refracted. We analyzed the written narratives of eight students collected from journal accounts compiled throughout the semester. We also conducted oral interviews with six students who volunteered to discuss the impact of the course on their knowledge of the relationships between earth processes and society as well as their commitment to social and environmental change. Finally, to provide an account of our experiences we draw on journals that we, the instructors, kept

> throughout the course and subsequent works that we produce about the course. (1999, p. 194)

Comparing their course-related experiences with that of their students allowed Mayberry and Rees to uncover the challenges both the instructors and students faced when combining geological education, sociological inquiry, and feminist pedagogy. Mayberry and Rees did not anticipate students' initial discomfort with a vaguely structured course syllabus or sitting in a circle and opening all inquiry to discussion. These were instructional approaches Mayberry and Rees, as feminist instructors, were quite familiar with and anticipated students to respond positively. On the other hand, the instructors were surprised by some students' fascination with feminist critiques of science while other students remained reticent to developing a more integrated or interdisciplinary perspective. In response to students' personal experiences, Mayberry and Rees re-framed their course syllabus by incorporating more field-based and practice-oriented experiences (e.g. oil exploration game and a field trip to Death Valley) at the same time balancing a more socio-political agenda through whole class discussions. Mayberry and Rees' work highlights the significant role that both the insider and outsider perspectives play in feminist research.

Trustworthiness

The notion of "validity" or what is called trustworthiness in qualitative research refers to the plausibility of the relationship between data and concepts; it implies the collective agreement of intended audiences that interpretations of data are not only compelling but convincing (Lincoln & Guba, 1985). This means that research procedures have to be "rigorous"; there has to be "quality control" throughout the stages of knowledge production (Lincoln & Guba, 1985). Some feminist researchers find the traditional discourse of rigor too "masculine" but others accept it, more or less willingly, because they feel it will lead to wider acceptance (mainstreaming) of the findings of feminist-inspired research and to a greater use of qualitative feminist research to guide public policy development. Feminist and other qualitative researchers have successfully challenged some of the traditional ways that validity and rigor are defined, and have helped raise the standards of social science by insisting that transparency in all aspects of the research process be a key criterion of validity and rigor (see Lather, 1991).

Feminist researchers address trustworthiness in different ways depending on how they frame their approaches to research (Olesen, 1994). Those employing research methods including interviewing and direct observation will seek out ways to establish credibility through strategies such as triangulation, member checks, and audit trails (Lincoln & Guba, 1985). Lather (1991) recommends that in addition to these traditional practices, researchers need to employ construct validity, face validity, and catalytic validity as further measures to build data credibility. By construct validity, Lather (1991) refers to an awareness of the researcher of the ways in which theories and other constructs are created. Face validity provides a 'click of recognition' (Lather, 1991, p. 67), a realization that what is being described or explained makes sense. Catalytic validity represents "the degree to which the research process re-orients, focuses, and energizes

participants toward knowing reality in order to transform it…" (Lather, 1991, p. 68). Underpinning each of these strategies is one essential argument — feminist research is committed to capturing and representing differences while engaging in ethical and socially responsible research that demands both relevancy and rigor.

Role of the Researcher

A key feature of feminist research is the acknowledgment that the production of knowledge is a social process in which the researcher herself plays an important part (Luke & Gore, 1992; Reinharz, 1992). Feminists, along with other critical researchers, concern themselves with what constitutes valuable knowledge and in whose interests it operates (Wolf, 1996). For these reasons, the feminist researcher is encouraged to place herself within the research process.

The use of 'self as source' presents a very different relationship between the researcher and the researched when compared to that of the "traditional" researcher and subject. In feminist research, at the very least, both are to be regarded as having the same status as participants or collaborators in the same enterprise (Reinharz, 1992). The researcher carries a responsibility to critically assess her own, as well as the informants', changing positions and subjectivities (Lather, 1991). Each researcher brings particular values, interests and experiences to the research and has lived through particular circumstances. While these values, interests and experience do not necessarily determine particular points of view, they give researchers perspectives on topics and discussions. The feminist researcher must then be prepared to situate herself reflexively in the research account and provide an analysis of the social relations underpinning the research process (Lather, 1991; Luke & Gore, 1992).

The importance of this process of reflexivity for both qualitative and feminist research is in how it makes visible the ways in which the researcher, who is central to the research, both influences and is influenced by the research. Of significance is an awareness of how feminist researchers participate as subjects in their own research (Olesen, 1994). In her work with community college chemistry students, Barton (1998a) describes her position in her research as very personal, often using pronouns such as "our" instead of "their" when referring to her chemistry students, a choice that embeds herself in the group where she is studying versus distancing herself from it. Alberto Rodriguez (2001), a Latino male science teacher educator, describes reflexive accounts of his work in becoming a cultural warrior in science education.

Sharon Parsons (2001), a Black female science teacher educator, uses autoethnography to chronicle her sacred stories of transforming her practice as a feminist science educator. Both researchers position their science methods students as central to their own transformation as science teacher educators and researchers of feminist and cultural science studies.

Feminist Studies in Science Education

Feminist studies in science education can be found in scholarly journals such as the Journal of Research in Science Teaching, Science Education, International Journal of Science Education, Journal of Women and Minorities in Science and Engineering, and the Journal of Chemical Education. Other notable works on feminism in science education can be found in books, such as the International Handbook on Research in Science Education (Fraser & Tobin, 1998), the Handbook on Research in Science Teaching and Learning (Gabel, 1994), and Feminist Science Studies (Mayberry, Subramaniam, & Weasel, 2001).

There are relatively few studies on the role of feminism in chemistry education. Two articles deserve particular attention. In the first article entitled, “Women and chemistry: Shifting the equilibrium toward success,” Brickhouse, Carter, and Scantlebury (1990) examine the implicit assumptions and gender biases in chemistry curricula and offer more inclusive practices to help retain and recruit more women in the field. The idea that chemical research is competitive and highly authoritative is replaced with the notion that teachers can make science more female friendly by integrating cooperative group work, female role modeling, and students’ experiences, specifically girls’, as central to class discussions.

The second article titled, “What is feminist pedagogy? Useful ideas for teaching chemistry?” (Middlecamp & Subramaniam, 1999) combines feminist theory with pedagogy in the chemistry classroom. Middlecamp and Subramaniam (1999) define feminist pedagogy as sharing “its roots with alternative pedagogies but distinct in its focus on women and their experiences both in and out of the classroom” (p. 520).They view feminist pedagogy not as prescribing a series of formulas for chemistry teachers to implement, but as offering teachers ideas to inform their own instruction given particular teaching styles, student needs, and institutional constraints. In other words, they understand feminist pedagogies to “enhance our ability to use our individual ways of teaching to promote student interest and learning” (1999, p. 521). The authors identify several salient themes held across feminist pedagogies. These themes include recognizing women’s lived experiences and interpreting unequal gender relations; fostering existence of multiple authorities in the classroom; presenting people and knowledge as positioned within and across different contexts; empowering students to draw from their own resources; utilizing their own strengths; and serving as their own mentors; helping students find their own voices; and finally, challenging claims that scientific knowledge is free of value or interests.

Feminist Research Studies in Science Education

Research studies related to feminist science education fall into one of four categories: 1) gender equity studies; 2) transformative practices in science education; and 3) studies on gender and learning in science; and 4) studies of identity and agency in science education (see Table 1). Gender equity studies encompass research on girls’ attitudes, participation, and/or engagement in school science and/or outreach projects.

Examples of gender equity studies include the work of Baker and Leary (1995), Kahle and Meece (1994), and Jones and Wheatley (1990). Studies related to transformative practices involve ways of knowing, doing, and teaching science. Barton (1998a), Mayberry and Rees (1999), and Roychourdhury, Tippins, and Nichols (1995) have focused primarily on how frameworks, such as feminism, critical theory, situated learning, and socioconstructivist or sociocultural theories inform how science teachers teach science, what science teachers teach, and how students interact with science. Studies on gender and learning explore one of two possible areas: 1) how the construct of gender shapes learning in science, or 2) how young women learn science in different environments. These studies include Brickhouse (2001) and Jones, Brader-Araje, Carboni, Carter, Rua, Banilower, and Hatch (2000), and Mason and Kahle (1989).

Research studies relatively new to feminist science education include the work of Brickhouse and Potter (2001), Brickhouse, et al. (2000), Capobianco and Osburn (2005), and Carlone (2004). These studies use the construct of identity to examine how young women view themselves as individuals and as participants in science. Research studies on social agency and science education examine the significant role teachers and researchers can play in bringing about social change for those in disadvantaged positions. Barton's (1998b) article titled "Teaching science with homeless children: Pedagogy, representation, and identity" explores what it means to create a science for all from the perspective of urban homeless children. Common to these research studies is the unique way researchers draw on the work of critical and feminist scholars in science and education as well as on teaching and research to question how inclusive the science education community is in its efforts to understand the national imperative of science for all.

Table 1: Examples of feminist studies in science education based four main categories.

Reference Citation	Purpose of the study
Gender equity studies	
Piburn & Baker (1989)	Examines the variables that influence females' success in science by experimenting with the outcomes of measures of formal reasoning ability.
Jones & Wheatley (1990)	Examines classroom interactions for gender differences that may contribute to the underrepresentation of women in physics and engineering courses and subsequent careers
Kahle & Meece (1994) *	Describes a synthesis of research depicting gender differences in science achievement.
Baker & Leary (1995)	Describes a study that involved 40 girls in grades 2, 5, 8, and 11 in an effort to determine what influences girls' decisions to choose science

Weinburgh (1995)	Presents a meta-analysis of literature which examined gender differences in students' attitudes toward science, and correlations between attitudes toward science and science achievement.
Bianchini, Hilton-Brown, & Breton (2002)	Investigates the role of dissent in a community of university scientists, engineers, mathematicians, and social scientists engaged in a two-year professional development project on issues of equity and diversity.
Baker (2002)	Examines the effects of single-sex middle school science and mathematics classrooms with high minority enrollment on achievement, affect, peer, and teacher-student interactions
Transformative practices	
Roychourdhury, Tippins, & Nichols (1995)	Examines the integration of feminist recommendations into a physical science course to gain new insights into the gender issues in science.
Barton (1998a) *	Entails an in depth look at science education from a feminist perspective
Mayberry (1998)	Explores a critical comparison of two pedagogical approaches to reforming the science classroom: collaborative learning and feminist pedagogy.
Mayberry & Rees (1999) *	Entails the results of developing and implementing a unique interdisciplinary course that infuses geological education with sociology and feminist pedagogy.
Bianchini, Johnston, Oram, & Cavazos (2003)	Explores teachers' attempts at the nature of science and implementing equitable instruction in classrooms.
Studies on gender and learning	
Mason & Kahle (1989)	Describes a teacher intervention program designed for teachers to modify classroom techniques and environments for fostering the participation of high-school girls and improving their science learning.
Meece & Jones (1996)	Examines gender differences in fifth- and sixth-grade students' self-reports of confidence, motivation goals, and learning strategies in whole-class and small-group sessions.

Jones, et al. (2000)	Examines how elementary school students use tools when constructing new knowledge during science instruction, how gender intersects with tool use, and how competition for resources impacts access to tools.
Brickhouse (2001)	Explores the contributions of women to science education and their impact on the understanding of science teaching, curriculum, evaluation, and teacher education. Discusses the role of gender in shaping science learning
Studies of identity and agency	
Barton (1998b)	Explores what it means to create a science for all from the perspective of urban homeless children.
Brickhouse, et al. (2000)	Describes four middle school African American girls' engagement with science.
Barton & Osborne (2001)	Examines current debates concerning schooling and the need for liberatory education; the social construction of science and identity; and systems of race, class, and gender oppression and domination.
Brickhouse & Potter (2001)	Examines the scientific identity formation of two young women of color who attended an urban vocational high school.
Carlone (2004)	Examines the meaning of science and science students in a high school physics classroom and the ways in which girls participated. Suggests that students' agency in resisting or accepting the practice, identities, and knowledge of school science is worth understanding for the improvement of science education.
Capobianco & Osburn (2005)	Explores females' personal and professional identity construction throughout their undergraduate studies in engineering.

* book or book chapter

Conclusion

Feminist research in science education involves tackling some of the most difficult issues and barriers faced by students, teachers, teacher educators, and researchers in science. Additionally it involves the amalgamation of research methods, methodologies, and epistemologies practiced by theorists and philosophers from the humanities, social

sciences and the natural/physical sciences. Drawing from the work of scholars in women's studies, feminist researchers in science education have demonstrated that the boundaries between fields such as women's studies and science have been transgressed and redefined.

Feminist researchers have made significant strides in the scholarship of science education, moving from issues of equity and diversity to concerns for identity formation and social agency as new and exciting research agendas. The scope of feminist science education research has also expanded from an earlier focus on gender and education to a more inclusive perspective that encompasses race, ethnicity, class, sexual orientation, disability, and other significant social dimensions. Above all, it appears that feminist research in science education is much more self-reflexive, culturally responsive, and sensitive to issues not only relevant to the researched and researcher but the research processes, as well. Given the diversity and complexity of feminist research practices in science education, it is not likely that there will be an accepted or uniform approach in the near future but rather a continued commitment to diversifying research methods and agendas to further our working understandings of what it means to make science accessible to all students.

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16

The Afrocentric Framework

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Biographies

Chana Hawkins is a graduate student at Purdue University completing her master's studies in Science Education with an emphasis on the issues of underrepresented groups — particularly African Americans — in the context of science. She became interested in this subject while reflecting on her experiences during high school in southeast Michigan, her undergraduate studies in biochemistry at Xavier University of Lousiana (B.S. earned in 1998), her transition to graduate school, and her career as an African-American in science. Issues of African American cultural and historical concern have been part of her as far back as high school, when she researched literature and various expressive texts and conducted peer interviews about the state of the Black family. Her experiences in her family, the Christian church and ministry, what felt like school segregation in the 1990s, the community, and motherhood have all had a place in the work she is led to do. Before accepting her current position as Extension Educator at Michigan State University, she worked in K-12 school systems, with seniors and youth in the community and church, and as a chemistry instructor at Washtenaw Community College.

Michael Thompson received his B.S. in Biology/Chemistry in 1999 from Saint Joseph's College and his M.S. in Biochemistry from Purdue University in 2002. While working toward his doctorate in Biochemistry, Michael "saw the light" and decided to further his studies in Chemical Education at Purdue University. Currently, Michael Thompson is a Ph.D. candidate in the Chemistry Department at Purdue University with a research focus in Chemical Education.

Introduction

Asante (1991) defined Afrocentricity as "a frame of reference wherein phenomena are viewed from the perspective of the African person" (p. 172). Mazama (2001) argued that "the Afrocentric Idea rests on the assertion of the primacy of the African Experience for African people" (p.388). *Afrocentricity* or the *Afrocentric Idea* (Asante, 1998, 2000,

2003) is a potentially important theoretical framework for research in chemistry or science education because it reminds us that the European voice that dominates so many other theoretical frameworks is just one among many, and not necessarily either the best or wisest one (Mazama, 2001).

The Afrocentric framework was originally designed for use with African people and people of African descent (King & Mitchell, 1995). It provides a useful framework, however, for thinking about research that seeks to understand the ways of knowing used by other ethnic, racial, or cultural groups. The contribution that the Afrocentric framework makes to the discussion of theoretical frameworks for research in education is the assumption that people make meaning and understand the world from the perspective of their particular sociocultural and historical experiences of race, class, and gender. The Afrocentric framework assumes that meaning-making is not only an intersubjective achievement that occurs among or between individuals, but that it also involves transsubjectivity, that is, knowledge and meaning generated within the collective experience of a group (King & Mitchell, 1995).

From the perspective of the Afrocentric framework, the individual is not separated from the phenomenon or experience being studied; he or she is a living and dynamic producer of that experience. There is a strong element of critical theory in the Afrocentric perspective. King and Mitchell (1995) argued that the object of an Afrocentric inquiry is “the systematic knowledge of the condition of authentic African and African American existence and developing critical awareness as part of the process of cultural regeneration which racism makes necessary” (pp. 70-71). As King and Mitchell (1995) noted, “... an inquiry of this type seeks to enable people to understand social reality in order to change it” (p.71).

Eurocentricity “... presents the particular historical reality of Europeans as the sum total of human experience” (Asante, 1987 p. 171). Afrocentricity, on the other hand, does not condone assigning value to one particular ethnocentric orientation at the expense of degrading other groups’ perspectives (Asante, 1991). The Afrocentric framework seeks to produce a more humane response to the cultural and political phenomena confronted in Western society by people of African descent. It seeks agency and action and is very specific in its reliance on self-conscious action (Asante, 1998), as opposed to an objective, neutral, and detached mind frame and action (King & Mitchell, 1995). The Afrocentric framework poses as a revolutionary scheme, within the context of critical theory, because it challenges the tradition of a patriarchal, hierarchical, racialized society and the accepted dominance of one gender, class, race or sexual identity over another. Thus, in its most authentic presentation, the Afrocentric framework is antisexist, anticlassist, and antiracist. As Hoskins (1992) has argued, “Afrocentrism not only trains but also equips African peoples with the necessary tools and research methodology to engage in critical thinking and analysis of themselves, their history, and their future from their perspective and reference point” (p. 254). A vital outcome of such engagement is self-empowerment. Those involved in research in chemistry or science education might therefore wish to consider the Afrocentric framework as a perspective upon which to base studies of not only African or African-American populations, but

other groups that have been viewed as marginal social categories — based on race, class, or gender — from the perspective of the dominant society.

Origins of the Afrocentric Framework

The origins of the Afrocentric framework can be understood by acknowledging the history of African people in an America that has historically operated in an economically, socially, politically, and religiously ingrained racial context. The Afrocentric framework is a reaction to an environment to which Africans and other ethnic or racial groups have been subjected, in which the dominant culture, through either deliberate or unintentional practices, suppresses the culture of the people it seeks to maintain in the margins. This process of actively working to marginalize the culture, social existence and contributions of people from non-dominant groups is a form of deculturalization. The Afrocentric framework also recognizes that these non-dominant groups have been subjected to *reculturalization*, or attempts to assimilate them into the dominant culture.

The historical origins of the Afrocentric paradigm, therefore, rest in the need of people of African descent to partake in the intellectual and communal production of knowledge about the experiences of people of African descent. The development of a doctoral program in Africological studies at Temple University in 1988 was viewed as providing the opportunity to build "... an army of scholars who were going to challenge White supremacy in ways it had never been challenged before — an army of scholars whose aim was to finally set us free from mental slavery" (Mazama, 2001, p. 403). In sum, the functionality of the Afrocentric paradigm is that it is a true paradigm for African liberation (Mazama, 2001). Afrocentricity was designed as a way of thinking that places the person of African descent at the center of the experience, of the knowledge production, and of the quest to answer questions relevant to the historical, present, and future life of the community represented by people of African descent.

Afrocentricity as a Philosophical Model

Schiele (1994), outlines Afrocentricity as a philosophical model that is "distinct from" and "oppositional to" Eurocentricity in terms of cosmology, ontology, epistemology, and axiology:

- Cosmologically, the Afrocentric framework views the structure of reality from a perspective of interdependency. All elements of the universe — people, animals, inanimate objects, and so forth — are viewed as interconnected. There is no separation between the spiritual and the material in the Afrocentric framework; reality is viewed as being simultaneously both spiritual and material.

- Ontologically, Afrocentricity assumes that all elements of the universe, including people, are spiritual. *Spirituality* is taken here to imply the nonmaterial or invisible substance that connects all elements of the universe.

- Epistemologically, the Afrocentric perspective places considerable emphasis on an affective way of obtaining knowledge — one that affects or excites emotion.

- Axiologically, Afrocentricity significantly underscores the value of harmonious interpersonal relationships; it offers a human-centered perspective toward life rather than an object- or material-centered perspective. In the Afrocentric framework, the value of maintaining and strengthening interpersonal bonds overrides the concern over acquiring material objects and accumulating wealth.

The Ontological in the Afrocentric Framework

Ontology traditionally focuses on the form and nature of reality (Guba & Lincoln, 1994). From the traditional perspective, matters of aesthetic or moral significance fall outside the realm of legitimate scientific inquiry. It might therefore be tempting to dismiss the Afrocentric idea of including spirituality as non-scientific since the denial of the presence of the moral question in traditional views of ontology stands in stark contrast to Afrocentricity. It is important to note, however, that proponents of the Afrocentric framework are not concerned with whether it should be viewed as “scientific” from the perspective of traditional ontology. The Afrocentric approach seeks to examine the form and nature of reality from the perspective of individuals of African descent, regardless of whether this perspective is “scientific.” Rather than restrict itself to Eurocentric criteria of legitimate scientific inquiry, the Afrocentric framework asks “are there other ways of knowing?” — ways of knowing which, perhaps, researchers in science education have missed by conducting their studies within a Eurocentric frame of reference.

From an Afrocentric frame of reference, the moral and aesthetic aspects of reality are not only of great significance (Asante, 1998), but they are as much a part of the scientific enterprise as the traditional claims of neutrality, objectivity, and detachment (King & Mitchell, 1995). The Eurocentric view of the form and nature of reality explicitly denies what the Afrocentric view holds to be a truth of reality: the aesthetic and the moral are wholly and holistically significant to any inquiry. Inasmuch as the human experience is not void of moral and aesthetic questions, both moral and aesthetic issues must be raised within the context of studies of these experiences.

People of African descent have historically been marginalized, dominated, and invalidated by the dominant culture. This has also been true in terms of participation in and contribution to the development of science (Harding, 1993). Asante (1998) offers Afrocentricity as a moral as well as an intellectual approach that posits people of African descent as subjects rather than as objects of human history and that establishes a valid and scientific basis for the explanation of African historical experiences and ways of knowing that can affect research and practice in teaching and learning.

Epistemology in the Afrocentric View

The traditional questions of epistemology revolve around assessing what people know and why they believe something to be true (Hill-Collins, 2000). Within the context of Afrocentricity, “considerable emphasis is placed on an affective way of obtaining knowledge” (Schiele, 1994, p. 153). Akbar (1984) argued that “the focus on affect in Afrocentricity does not prevent recognition and use of rationality. Rather, affect, as a means of knowing, is viewed as offsetting the use of rationality” (p. 410).

The epistemological assumptions of Afrocentricity hold that the lived experiences of an individual provide the foundation of what that individual believes to be true and that the knowing gained through lived experiences becomes known through emotion or feeling (Schiele, 1994). Emotion or feeling is, therefore, not only a valid aspect of research on these experiences, but one that is critical to knowing from an Afrocentric perspective.

Consider what Asante (1998) refers to as African-American transcendence:

> ... the African finds energy and life in the midst of persons; he or she does not escape to the mountains or the valleys or the seashores to find the energy. There is no “great tradition” of withdrawal in the African or African American tradition; ours is preeminently a tradition of remarkable encountering with others. (p. 203)

Asante goes on to note that “encountering, for us [Africans/African-Americans], is always accompanied by words and, as such, it is profoundly verbal (p. 203).

It is in this verbal exchange that African-Americans have historically generated and validated what can be known; it is in this verbal exchange that a subjective attachment (in contrast to the Eurocentric objective detachment) allows the discoverer to be part of what can be known and what we can know about reality. Both individual and collectively shared experience become criteria of meaning and, therefore, how we know what we know.

Afrocentric theory is based on a cultural and historic perspective, a basis that inextricably ties the knower to what can be known. The nature of the relationship of the knower or would-be knower is intentionally, inherently, and explicitly rooted in the cultural and historic perspective; and human actions cannot be understood apart from the emotions, attitudes, and cultural definitions of a given context. The Afrocentric situated way of knowing and the relationship to what can be known assumes that what I know comes from both what I experience and what others experience — from what we have lived both intersubjectively and transsubjectively.

The Afrocentric Methodology

An Afrocentric methodology reflects certain principles of the philosophy and culture of the Black Experience: it is communal, spiritual and holistic. For example, this methodology recreates the simultaneous, holistic affirmation of black individuality and

collectivity, two opposing tendencies in the Eurocentric perspective that find harmonious expression in black life and in black art (Nobles, 1980; Stuckey 1987). The Afrocentric methodology requires that the knowledge produced must be emancipatory in the sense that it opens the heart (Mazama, 2001). This methodology recognizes that knowledge of the world contained in people's daily cultural practice and social experience is generated from and grounded in their culture and experience and can be liberating as well (King & Mitchell, 1995).

Background on Emancipatory Knowledge

Emancipatory knowledge is rooted in a community's desire to confront oppression, gain self-determination, and use knowledge for the purpose of uplifting the community. Historically, most of the research in education published in the U.S. has been generated by educators who are white, professionally educated, heterosexual, English-speaking, and middle or professional class. As a result, whether intentionally or not, this knowledge base tends to reflect the experiences and perspectives of dominant social groups. Sheurich and Young (1997) define the result of knowledge production that consistently has the effect of favoring whites as a group "epistemological racism."

Emancipatory knowledge emerges from and embraces the social histories of historically marginalized communities (see the discussion of critical theory in Chapter 14). Emancipatory research is conducted with people from historically marginalized racial, ethnic or social classes, is often led by a researcher or research team who are indigenous members of one of these groups, and is interpreted within the intellectual framework of that group. Emancipatory research engages members of the community being studied as co-constructors or validators of the knowledge being produced.

Emancipatory research is often done by individuals interested in how members of a non-dominant group see themselves and their roles in society. The emancipatory domain therefore often focuses on "self-knowledge" or "self-reflection." Results from this research can lead to emancipation from institutional and environmental forces that limit the control members of the non-dominant group can achieve over their lives.

One of the goals of emancipatory knowledge is insight that is gained through critical self-awareness. Knowledge is gained by self-emancipation through reflection, leading to a transformed consciousness or a "perspective transformation" (MacIsaac, 1995). Although emancipatory research takes advantage of self-knowledge obtained from self-reflection, it is important to recognize that no single individual is the sole contribution to either the definition of the problem to be solved or the success of actions taken to alleviate the problem.

Mazama (2001) summarizes the principles of Afrocological methodology as follows:

> The African experience must determine all inquiry, the spiritual is important and must be given its due place, immersion in the subject is necessary, holism is a must, intuition must be relied on, not everything is measurable because not

> everything that is significant is material, and the knowledge generated by the Afrocentric methodology must be liberating. … the methods used by Afrocologists vary depending on their particular topic of study. However, Afrocological methods devised by particular scholars must be informed by the principles outlined above. (p. 400)

The Afrocentric Method and Analysis

One method of data collection when conducting research using the Afrocentric framework is the "group conversation method" (King & Mitchell, 1995). This method is based on the central tenets of dialogue and dialectic, which are characteristics of the oral history of African people (Asante, 1987). The use of this method is consistent with what Freire (1993) has described as a *thematic investigation*, which involves the assessment of the thinking that occurs when one seeks to understand reality within the context of a community as individuals reflect on a situation. Dialogue allows teachers, scholars, and critical thinkers to cross boundaries and barriers that may have occurred due to race, class, professional standing, or other differences (hooks, 1994).

The group conversation method has its theoretical roots in critical reflection about participants' shared experiences. This method acknowledges and reflects the communal and collective attribute associated with African and African-American culture, a communal and collective attribute connected through oral discourse based on the "spoken word" (Asante, 1987). Based on the Afrocentric Idea, this "spoken word" is the active principle that unifies African-American culture and traditional African culture. The "spoken word" has been described as having the power to bring things into being (Asante, 1987; King & Mitchell, 1995). In the group conversation method, the transcendent power of the "spoken word" is considered to be the essence of communal black spirituality. Speaking and listening to each other's stories generates knowledge of the collective black condition and the self-insight needed to understand and respond effectively to the "challenge of Blackness" (Bennett, 1972). This challenge involves surviving with one's soul intact in a society that is often hostile to blackness and black people (Prager, 1982).

It is through the lens of the "spoken word" that one emphasizes the communality and spirituality of the Black Experience. This approach to inquiry provides the context and process for a critical examination of one's experience. By enabling the enhancement of the participant's self-knowledge through identification of the social origins of one's shared emotions and experiences, this approach to data collection takes on an emancipatory perspective.

The group conversation method is a metaphorically enhanced creative interviewing strategy that elicits reciprocal dialogue, which enables the researchers to learn with the participants about what "we" do and to reflect on why "we" do it. This interviewing strategy engages participants in a mutual search for self-understanding (Asante, 1987). In this approach to data collection, there is no objective researcher. The researcher is specifically connected to the conversation, the conversation must be rhythmic in nature,

and the conversation must be authentic. Rather than neutrality, reciprocity is the principle mode of relationship not only among the participants but between the participants and the researchers, who take a partisan stance toward improving the Black condition.

King and Mitchell (1995) showed how the group conversation method can be used in action. In their work, they used African-American literature to initiate group conversation and critical reflection about the participants' shared experiences within the context of raising sons. In the course of data collection, the researchers forfeited detachment and neutrality for interdependence with the participants, sharing perspectives about the common experiences of raising sons. For the researchers, who participated fully in the dialogue, this reciprocal, reflexive group conversation was a way of coming to know the Black Experience. As the participants and researchers reflected on the literature they had read and shared their personal experiences, thoughts, and emotions, the group became co-researchers in the inquiry process. For both the participants and the researchers, the group conversation was a way of becoming more critically aware of the collective Black Experience through reflexive examination of their own reality.

The Afrocentric Researcher and the Afrocentric Inquiry

Reviere (2001) outlined a set of basic beliefs researchers must hold to be considered Afrocentric. They must:

- hold themselves responsible for uncovering hidden, subtle, racist theories that may be embedded in current methodologies;
- work to legitimate the centrality of African ideals and values as a valid frame of reference for acquiring and examining data; and
- maintain inquiry rooted in a strict definition and interpretation of place.

Afrocentricity establishes agency as the key concept for freedom. It assumes that an individual is most free when that individual is most active on the basis of their own volition (Asante, 1998). This is equally true for both the researcher utilizing an Afrocentric framework and for the individuals with whom the researcher engages for action and agency. Believing that people are capable of reconstituting themselves as authentic beings requires that the researcher be engaged, be capable of listening with caring, and be accountable to the study participants.

The Afrocentric framework relies upon the ideas of center/location/place, dislocation, and relocation as key concepts. Mazama (2001) defines these concepts in the following manner:

- The concept of center (also location and place) is fundamentally based upon the belief that one's history, culture and biology determine one's identity, an identity that, in turn, determines our place in life, both material and spiritual.

> … to practice and live one's culture and to apprehend oneself in a manner that is consistent with one's history, culture, and biology is to be centered or to proceed from one's center.
>
> - Dislocation occurs when one lives on borrowed cultural terms and/or when one apprehends reality through another group's center …
>
> - Relocation, therefore, is the re-centering of oneself and proceeding from the center of one's history, culture, biology, and so on. (p. 397)

The researcher, through the choice of language, attitude, and direction, must explicitly reveal his or her answer to the fundamental question "who am I?" Asante (1998) and Reviere (2001) have argued that this is something that needs to be done both before the study is begun and after it has been completed. They refer to the result of this process of both introspection and retrospection as defining the researcher's "place." In the Afrocentric framework, *language* is defined as a regularized code that has been agreed upon by a community of users; *attitude* refers to a "predisposition to respond in a characteristic manner to some situation, value, idea, object, person, or group of persons" (Mazama, 2001, p. 397); and *direction* is the line along which the author's sentiments, themes, and interests lie with reference to the point at which they are aimed. It is the intentional and overt naming of place by the researcher and the centering of the inquiry authentically within the context of the African that creates the Afrocentric inquiry.

Mazama (2001) has argued that the following consensus exists among Afrocentric scholars regarding Afrocentric epistemology, methodology, and methods:

> - A people's worldview determines what constitutes a problem for them and how they solve problems. As a result, Afrocentric scholarship … must be centered in the experiences of African people.
>
> - The essence of life and therefore of human beings is spiritual. This is not to deny the material aspect of life; however, when all is done and said, what remains is not the appearance of things but the indivisible essence of life that permeates all that is, the spirit — the ultimate oneness with nature, the fundamental interconnectedness of all things.
>
> - Afrocentric knowledge is validated through a combination of historical understanding and intuition; that is, knowing is both rational and superrational. ...
>
> - The ultimate aim is liberation, and thus, the Afrocentric methodology must generate emancipatory knowledge that will free us and empower us. (p. 399)

Research in Chemistry/Science Education on Afrocentric Issues

A search of the literature identified several studies that addressed some of the questions raised by the Afrocentric perspective, although none of these studies contained either an explicit reference to this theoretical framework or was carried out using a methodology consistent with the Afrocentric framework. Post, Stewart and Smith (1991), for example, used math/science self-efficacy surveys to study 111 Black first-quarter freshmen at a large Midwestern university. Maple and Stage (1991) used a set of three surveys over a four-year period to study more than 2000 Black students in order to explore the relationships among factors such as students' choice of mathematics and science-related careers, parents' education, locus of control, parental influence, school influence, test scores, mathematics attitudes, high-school mathematics and science experience, and achievement. Neither of these studies could be described as Afrocentric because of the absence of the dialogue and dialectic required in that framework.

Lewis and Collins (2001) reported a case study of three African-American college students that was done in order to understand the career decisions these students make. They noted that, although these students had all begun college interested in science-related careers, only one of the students was still interested in a career in science by the end of the study. This study was closer to being consistent with the Afrocentric framework, but the methodology relied on a series of one-on-one interviews rather than a focus group approach that would have introduced an intersubjective aspect into the dialectic.

A Detailed Example of an Afrocentric-Based Study in Chemical Education

On the basis of her own experiences as an undergraduate chemistry major and a graduate student in chemical education, the first author became interested in understanding some of the issues associated with recruiting and then retaining Black graduate students in chemistry. As she read the research literature — especially the quantitative research unsupported by critical qualitative analysis — she reacted to the absence of the student "voice" in this work. Black students were taken to be the objects of this research, rather than subjects who might be the primary source of analysis of the research objectives from their own perspectives. She concluded that the students were theorized, categorized, and quantified — all with minimal focus on realizing and critically analyzing the student voice.

She decided to build her M.S. thesis (Hawkins, in preparation) around the realization that there is a need to acknowledge the role that affective experiences play in retention of minority students — an affective experience that was unacknowledged in recruitment and retention efforts, an affective experience which is only superficially addressed in the commonly used surveys or questions to which students are asked to respond in traditional research on minorities.

She became convinced of the need for a body of research that focused on each of these students as a person, as a member of an ethnic group, as a member of a gender group, as someone who came from a particular socio-economic class, as a marginalized member of the scientific culture, and so on. She postulated that questioning the status and conditions that shape possibilities for Black students from the perspective of critical theory might help uncover why these groups have a high attrition rate and why these rates have remained virtually unchanged for nearly 30 years.

Her study was based on the assumption that the reality of being a Black graduate student was defined by a multiplicity of factors, including the student's life, the support system among friends and/or family, the departmental support, the atmosphere of the department, the personal status of the graduate student, the student's cultural values, the cultural values of the scientific enterprise, the conflict or congruence between personal cultural values and scientific cultural values, and so on. Her work was based on the assumption that these contextual factors were not likely to surface through superficial contact with the students. They had to be addressed explicitly through active participation by the students themselves, with the primary focus of the study being the voice of the students in order to understand the experiences of Black graduate students in science, in general, and chemistry, in particular. The goal of her work was therefore to explore the lived experiences of Black graduate students in chemistry at a major research university to gain an understanding of their cultural beliefs, their personal experiences and experiences in science, and their beliefs about the culture of science in order to give voice to a population that has not been previously addressed in such a manner.

The goals of this research were:

- To engage members of an underrepresented group in science (African-American graduate students) in an in-depth critical and dialogic/dialectic exploration of the factors that led to their decisions to pursue careers in science;

- To determine whether participants made or are making appropriate career choices;

- To include the voices — participants' perspectives, perceptions, experiences — from the margins, from members of an underrepresented group as the principal source for understanding and analyzing the context in which these voices have lived. These voices serve as critique and action in this research approach.

The theoretical framework adopted for this study was a mixture of critical theory (Chapter 14) and the Afrocentric framework described in this chapter. Both frameworks were appropriate because the overarching goal of this work is to generate the knowledge that will enable action to be taken to increase the number of minority students who graduate with M.S and/or Ph.D. degrees.

Conclusion

As previously stated, Afrocentricity is intellectual in nature, but it also is analytical. Asante (1998) writes:

> Afrocentricity's intellectual assault on the dominance dogma is initially historical; that is, it presents a set of facts describing events and phenomena in such a way that a more valid interpretation of the agency of African people emerges in the circumstance of oppression. Second, the assault is analytical in the sense that it examines the conceptual frames of domination and makes a critique of domination in the linguistic, social, aesthetic, cultural, political and economic spheres. … Another type of assault is purely analytical and deals with language itself, with conscious focus and reflection on even the terms we use. Unless we reflect on the terms we use, we may continue to use terms that encapsulate us, distort our historical reality, cloud our own minds, and render us impotent in the face of psychological, political, or cultural challenges (pp. 42-43).

Moreover,

> Afrocentricity offers hope for actualizing the masses of Americans around the idea of African people as subjects rather than as objects. … You cannot grant or accept agency for a people who have been marginalized, whether by others or themselves, without fundamentally altering the character of the society. (p. 42).

The Afrocentric framework provides a useful foundation for studies of aspects of the "Black experience" in chemistry/science education that are carried out by individuals of African or African-American descent. We believe, however, that it also provides a useful basis for thinking about critical research (see Chapter 14) that examines the lived experiences of other non-dominant groups that have been marginalized on the basis of race, gender, ethnicity, sexual orientation, or other factors.

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Part

III

CRITICAL THEORY FRAMEWORKS