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Conceptual change and science achievement related to a lesson sequence on acids and bases among african american alternative high school students': ateacher's practical arguments and the voice of the "other"

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CONCEPTUAL CHANGE AND SCIENCE ACHIEVEMENT RELATED TO A LESSON SEQUENCE ON ACIDS AND BASES AMONG AFRICAN AMERICAN ALTERNATIVE HIGH SCHOOL STUDENTS: A TEACHER'S PRACTICAL ARGUMENTS AND THE VOICE OF THE "OTHER"

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DEDICATION

This dissertation is dedicated to my late parents,

Erie Mae and James Lewis Wood,

For your unconditional love, I owe you so much!

To Jasmine and Janie for the promise you hold. May you both continue your quest toward excellence and be all that God has predestined for you.

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May he give you the desire of your heart and
make all your plans succeed.

We will shout for joy when you are victorious and will
lift up our banners in the name of our God.

May the Lord grant all your requests.

Psalm 20: 4-5

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CHAPTER 1

INTRODUCTION

Background

For more than two decades, science education reforms have been steering policy, research, curriculum and professional development around equity and excellence for all learners (AAAS, 1989, 1993; NRC, 1996). Reaching for equity and excellence in science education means that the study of science practices should be made accessible, relevant, and interesting to all students (Hazen & Trefil, 1990; Tippins, Nichols, & Kemp, 1999). Moreover, current research on culture (Banks, J & Banks, C, 2010; Gay, 2010; Ladson-Billings 1995; Mutegi, 2010) points to the fact that all students can learn science and achieve excellence if they have access to good teachers and sound teaching practices.

Indeed students of all racial/ethnic, language, and income backgrounds can, and some do succeed in learning science in school, enter and graduate from college/university with a science degree, and participate in science-related careers**.** However, for minority children the opportunities for success have been dramatically and persistently different, both locally and across the country. This is because science is not generally taught in a way that is accessible or meaningful to all students, and most instruction does not result in equitable achievement (Ferguson, 2002). In a recent book that looked specifically at White, Black, and Hispanic students, Chubb and Loveless (2002) characterized it in this way: “The difference in educational attainment between white students, on the one hand, and African American and Hispanic students, on the other hand, is large and persistent and in the last decade it has gotten worse” (p. 22). McWhorter (1997) has asserted that “forty years after the Civil Rights Act….African

Americans still perform lower than any major racial or ethnic group in the United States, at all ages, in all subjects regardless of class" (p. 2).

National data on the achievement of students in science education by ethnic groups clearly provide evidence that among all minority groups, the achievement of African Americans is the most disturbing. The poor achievement of African American students in science emerges during the elementary grades and becomes more pronounced as they matriculate through school. Historically, student achievement of African American students can be traced through the results of National Assessment of Educational Progress (NAEP). According to the 2009 NAEP results, 53% of African American fourth graders, 67% of African American eighth grade and 71% of African American twelfth graders performed below a basic level of science proficiency.

The underachievement of African Americans in science is a problem that has been examined and continues to be examined and discussed from several perspectives that include: access (Tate, 2001), teacher expectations (Atwater, 2000), self-perceptions (Rascoe & Atwater, 2005) and cultural identity (Gilbert & Yerrick, 2001).The many explanations that attempt to address the underachievement and disparity of African Americans shed light on the complexity of the problem. Parson (2008) suggests that if research with African American students is to have integrity, it must consider their positionality, which refers to the myriad contexts in which African American students exist.It is imperative that we study teaching approaches and instructional models that support the conceptual understanding necessary for African American students in urban schools to achieve and flourish in science.

How do we provide high quality, relevant science education to African-American students in urban secondary schools? The answer to this question is contained in a 1996 report by the National Commission on Teaching and American's Future: "What teachers know and can do is the most important influence on what students learn.” (p. 34). Teachers knowing and being able to connect to the culture of students and the culture of science, as well as holding students to high expectations, will influence what and how students learn (Mutegi, 2010). Teachers must understand the need for a culturally relevant teaching and learning model that encourages the diverse experiences African-American students bring to the learning environment in order to support their achievement in science. For teacher understanding of the learner, the educational professional community must support teacher development in teaching practices that are expected to have a high impact on student learning (Borko, 2004; Fullan, 1996; Loucks-Horsley et al., 2010). High quality teaching is considered the single most factor influencing achievement gains (Sanders & Horn, 1994; Darling-Hammond, 2000).

Northwood Public Schools is an urban/suburban school district with a student population that is majority African-American but with a teaching population of more than 50% non-African-American. Thus, there is a need in Northwood Schools to make a determined effort to embrace cultural diversity. Providing teachers with professional learning that will build bridges to improved teaching and student learning by embracing cultural diversity is a priority for Northwood Public Schools. Therefore, at the beginning of the 2008-2009, a district-wide professional development effort was launched to adopt sound teaching practices and models. One model that supports good teaching practices and premiere teacher professional development is the core propositions, teaching standards and professional development anchored in reflective practice promoted by the National Board for Professional Teaching Standards (NBPTS, 2004). The NBPTS was established in 1987 to develop and operate a system of advanced certification, which includes a set of high and rigorous standards of accomplished teaching that address diversity, cultural relevance and reflective practice.

Teachers in Northwood Schools pursuing National Board certification use the National Board Standards to describe, analyze and reflect on their pedagogical practice.

To augment the National Board for Professional Teaching Standards certification and professional development process, teachers in Northwood Public Schools are provided with select readings to engage in self-reflections and collegial conversations, focusing on meeting the needs of all students, but specifically the academic achievement of African American students. These conversations were important and foundational as Northwood Public Schools addressed teacher dispositions. Northwood Public Schools also emphasized the critical need for all teachers to welcome cultural diversity and relevant teaching practices that improve students' learning. Hence, the teachers were encouraged to value students' cultural capital in order to achieve high academic expectations.

Amidst seeking for National Board Certification and carrying out Northwood Public Schools imperatives of African-American student achievement, the high school science teachers were given a seminar on the *Common Knowledge Construction Model* (Ebenezer & Connor, 1998) of teaching and learning that systematically uses students' conceptions as theoretical frameworks in order to develop conceptual understanding of science concepts and science practices (NRC, 1996). The Common Knowledge Construction Model consists of four interactive phases: exploring and categorizing students' conceptions; construction and negotiating science cultural meanings; extending and translating the understanding of science concepts to shape socio-scientific inquiry; and reflecting and assessing to value students' learning and achievement.

Problem Statement

A discussion of the origin of the CKCM follows: Ebenezer and Erickson (1996) explored grade 11 chemistry students' conceptions of solutions and developed several "categories of description.” The second part of the same study focused on how the same students’ chemistry teacher attempted to incorporate students’ conceptions in a unit on solution chemistry and reported students’ conceptual change (Ebenezer & Gaskell, 1995).The 1995 and 1996 published studies in *Science Education* served as foundation documents for publishing two textbooks with the CKCM as its core for the preparation of elementary and secondary pre-service teachers in *Learning to Teach Science: A model for the 21stcentury* (Ebenezer & Connor, 1998) and in *Becoming Secondary School Science Teachers: Preservice Teachers as Researchers* (Ebenezer & Haggerty, 1999), respectively.

In subsequent research, Ebenezer, Lugo, Beirnacka, and Puvirajah (2003) promoted the notion of community building among chemistry pre-service teachers in their methods course, in order to communicate their understandings of the CKCM of teaching and learning on Web Course Tools (WebCT). Ebenezer and Puvirajah (2005) developed a CKCM lesson sequence on matter and helped a pre-service teacher to implement it in her practicum setting in a Catholic school, mostly consisting of affluent, high achieving white students. The focus of this study was on argumentation using WebCT. International research on the CKCM was conducted in South Africa (Ebenezer& Fraser, 2001; Lui, Ebenezer, & Fraser, 2002), Canada (Biernacka, 2007), and India (Ebenezer et al., 2010).

Among the foregoing studies, only two studies focused on teacher professional development in the context of student learning with the CKCM. Biernacka (2007) in her collaborative study with a teacher developed a CKCM science lesson sequence on the concept of weather, grounded in grade five Manitoba science curriculum frameworks and implemented it in an inner city school in Winnipeg, Manitoba, Canada. She focused on the teacher’s development, while the teacher reflected on student learning with the CKCM. Similarly, a zoology teacher in

India with the help of Ebenezer, developed and implemented two phases of a CKCM-based lesson sequence on excretion in a seventh grade diverse classroom and conducted a quasi-experimental study on student conceptual change and science achievement (Ebenezer, J., Chacko, Kaya, Koya, Ebenezer, D. L., 2010).

Similar to some of the most recent CKCM studies, the chemistry teacher (hereafter referred to as Bonnie) in my study fully immersed herself in classroom practice with the CKCM, focusing both on her own practice and student learning as she worked towards the National Board Certification. One important similarity, to note is, like the Zoology teacher, Bonnie initiated this study to look into her own pedagogical practices and students' conceptions, conceptual change, and achievement with the extensive help of the creator of the CKCM. Like the zoology teacher's study on excretion, Bonnie designed, developed, and enacted a CKCM acid-base lesson sequence. Bonnie's work was also different in some aspects. First, Bonnie systematically monitored her professional development in the context of the National Board Certification based on the National Board Standards to describe, analyze and reflect on her pedagogical practice. As expected by the National Board Standards for reflective practice, Bonnie used video-recordings to capture classroom interactions and regularly wrote her thoughts and reflections in a journal. Additionally, as part of her work towards the National Board Certification, Bonnie also collected evidence on her students' conceptual changes and achievement based on the CKCM acid-base lesson sequence.

As the Associate Superintendent for Instruction with Northwood Public Schools, I am heavily involved in professional development of teachers as part of my work, which includes the preparation and monitoring of teachers pursuing the National Board Certification. Thus, I decided to situate my in-depth study on the teacher professional development of one teacher currently engaged in Take One! with plans to continue toward full National Board Certification. I intended to work with Bonnie in this study for three reasons. First, Bonnie teaches in the alternative school of the Northwood Public Schools. Second, Bonnie opted to use the CKCM as the pedagogical model for her National Board Certification. Third, I have taken a science education course that focused on CKCM conceptual change inquiry as a part of my doctoral studies. Thus, currently as a doctoral candidate and researcher, I invited Bonnie to take part in my study that focuses on teacher professional development via reflective practice of teaching and learning. The data for my study consists of the chemistry teacher's documentation of the enactment of a seven-week long CKCM acid-base lesson sequence, as partial evidence for the National Board Certification portfolio assessment.

In her quest to work on the National Board Certification, Bonnie worked with the originator of the CKCM and they first focused on depicting all four phases of the CKCM in the design of an acid-base lesson sequence for a grade 11 chemistry course. This lesson sequence was based on *State Curriculum Standards* (MDE, 2007) and *Northwood Public Schools Curriculum Framework* (SPS, 2006). Then, she enacted this lesson sequence in a grade 11 chemistry classroom consisting of 100% African-American students in an alternative school in Northwood Public Schools, which primarily caters to culturally diverse and underperforming students.

In this dissertation, I use the data Bonnie collected in the preparation for her National Board Certification to accomplish the goals of this study. They are to investigate (a) the effect of the CKCM acid-base lesson sequence on African American alternative high school students' conceptual changes and achievement; (b) Bonnie's practical arguments about her classroom enactment of the CKCM acid-base lesson sequence in an African American alternative school classroom based on the video-recordings of classroom events and discourse; and (c) the researcher's voice of Bonnie' classroom practice based on her reflective practice through her own and Bonnie's journaling and interviews. Based on these goals, the following research objectives and questions are outlined in the next section.

Research Objectives and Questions

Objective 1: To qualitatively and quantitatively assess African American alternative high school students' learning

1. What conceptual changes were evident for a group of urban alternative high school students, when immersed in the CKCM-based acid-base lesson sequence?
2. Does the CKCM acid-base lesson sequence significantly improve urban alternative education students' achievement compared to (a) pre- and post-interventional teaching; and (b) traditional teaching?

Objective 2: To study a chemistry teacher's practical arguments about teaching African American alternative high school students

3. What practical arguments does the chemistry teacher advance about her enactment of the CKCM acid-base lesson sequence in an alternative classroom context during teacher-researcher discourse?

Objective 3: To narrate a story of a chemistry teacher's classroom practice in an alternative high school classroom

4. How does a chemistry teacher's classroom practice look like while enacting the CKCM acid-base lesson sequence in an alternative high school classroom?

Significance of the Study

This study is significant for several reasons:

First, this study provides qualitatively differing African American alternative high school students' conceptions of acids and bases and the researcher constructed phenomenographic categories of description that can be used to incorporate in and acid-base lesson sequence. This study indicates students' learning with the CKCM, their conceptual changes and their significant gains in science achievement. An outcome from this study will be an enhanced understanding for the teacher and others of how the culture-culture pedagogy of the CKCM can build the bridge from the sub-culture of African American alternative high school students to the often foreign culture of high school science. This study will assist other teachers and researchers who are looking for a model that addresses the cultural pedagogy necessary to support improved science achievement for African American alternative high school students.

Second, the teacher-researcher discourse using video-clips will add another piece of research evidence to the literature on reflective practice for teacher professional development. This study will, therefore, encourage teachers to work with researchers and be open for research on professional practice. The shift in practical arguments that a chemistry teacher advances in teaching the African-American alternative high school students will benefit teachers, teacher educators and researchers and help them learn how to translate these teaching and learning models and strategies into the classroom.

Third, the voice of the researcher, about a chemistry teacher's classroom practice with the American African alternative high school students, illuminates how to teach these students.

Overview of Methodology

In the context of preparing for the National Board Take One!, Bonnie used a mixed-methods, both qualitative and quantitative (Green, 2007), to document and reflect on her own practice with the help of "the Other" about her classroom practice with the African American alternative high school students. In this process, Bonnie first individually interviewed her students for their prior-conceptions of acids and bases. As well, Bonnie gives them an Acid Base Achievement Test (ABA-T). She then incorporated her students' prior- conceptions in the design, development, and enactment of an acid-base lesson sequence using the *Common Knowledge Construction Model* (Ebenezer et al., 2010). When Bonnie completed a seven-week long CKCM acid-base lesson sequence with her alternative high school students, she assessed her students for post-intervention conceptions and achievement using the same strategies used before she started the lesson sequence.

The researcher used retrospective data, that is, Bonnie's data, to identify the African American alternative high school students' conceptual changes and achievement gains. The researcher used Bonnie's video-recordings of her own classroom enactment to conduct a series of teacher-researcher conversational discourse on the teacher's reflective practice. By audio-recording the teacher-researcher reflective conversational discourse and transcribing it verbatim, the researcher attempted to identify Bonnie's practical arguments about her classroom practice with the alternative high school students. The researcher also revealed her own voice through a story of Bonnie's classroom practice.

Description of Terms

Conceptual Change is generally defined as learning that changes an existing conception (i.e., belief, idea, or way of thinking). This shift or restructuring of existing knowledge and beliefs is what distinguishes conceptual change from other types of learning. Learning for conceptual change is not merely accumulating new facts or learning a new skill. In conceptual change, an existing conception is fundamentally changed or even replaced, and becomes the conceptual framework that students use to solve problems, explain phenomena, and function in their world.

Culturally Relevant Pedagogy is described as an effective pedagogy for culturally diverse classrooms. The purpose of Culturally Relevant Pedagogy (CRP) is the maximization of learning for racially and ethnically diverse students.

Practical argument is a premise or set of premises that indicate teacher beliefs about teaching (Fenstermacher, 1993).

Pre- and Post- test denotes achievement

Prior- and post- intervention denotes conceptual change

Professional development is a comprehensive, sustained and intensive approach to improving teachers' effectiveness in raising student achievement (The National Staff Development Council, 2009).

Professional learning consists of teacher improvement on pedagogical practice and student learning based on classroom data and analysis through a process of reflection on evidence.

Reflective practice is the teacher capacity to reflect on action so as to engage in a process of continuous learning (Loughran (2002).

Science achievement is conceived in terms of science content. In this study science content involves acids and bases.

Overview of Study

Chapter one identifies the issue of equity and excellence of African-American students by providing achievement data. The study argues for the development of quality teachers and teaching practices to combat under-achievement. The answer to improve student learning and achievement is teacher professional development in defensible pedagogical practices. As a method of teacher professional development, the Northwood Public Schools engages teachers in Take One!, and the full National Board Certification process for interested teachers, as well as time to examine their own understanding and value of culture; the students' culture and it's impact on teaching and learning. The CKCM research and development is discussed and argued because the chemistry teacher in this study carries out her reflective practice for the National Board Certification by using the CKCM of teaching and learning. The researcher's relation with the teacher is identified and how she uses the teacher's data is clarified. Research objectives and questions for this study are clearly stated based on teacher data collection for her portfolio development with National Board.

Chapter two presents the first article that discusses the effect of the CKCM on African American alternative high school students' conceptual changes and achievement in an acid-base lesson sequence. Chapter three presents the second article that discussed the teacher practical arguments on her own classroom enactment of the CKCM with a group of African American alternative high school students. Chapter four presents the third article that tells a story of Bonnie, highlighting certain issues she raised about teaching the alternative high school students.

All three article-chapters present and discuss the need for a study that reflects the present status of research in a particular area of research, an extensive literature review, and theoretical frameworks to frame the study. The framework shared by all three articles is the intellectually caring Common Knowledge Construction Model. Each article has framed one or more research questions and the significance of answering these questions. Methodology is described and justified in each article. Results are presented logically and coherently. Based on evidence presented in each article, implications are drawn.

Chapter five concludes the dissertation with a summary of research findings, issues reflecting evidence, and implications.

CHAPTER 2

THE IMPACT OF AN INTELLECTUALLY CARING MODEL ON URBAN ALTERNATIVE HIGH SCHOOL STUDENTS' CONCEPTUAL CHANGE AND ACHIEVEMENT: AN ACID-BASE LESSON SEQUENCE

Abstract

The purpose of this article is to study the effect of an intellectually caring conceptual change model on alternative high school students' conceptual change and achievement in a unit on acids and bases. A mixed-methods approach using retrospective data was utilized. Data secured from the teacher were the audio-recordings of her prior- and post-intervention individual interviews with students, and the results of the students' prior- and post-intervention Acid Base Achievement Test (ABA-T). The audio-recorded interviews were transcribed verbatim. A qualitative analysis of students' prior- and post-intervention conceptions of acids and bases using Phenomenography revealed (a) changes in the number of categories of descriptions; (b) a shift in language use from everyday talk to more chemical talk; and (c) development of chemical knowledge hierarchy. The ABA-T results indicated that students (n=17) in the experimental group achieved significantly higher scores ($p < 0.003$) than students in the control group (n=22) taught by traditional teaching methods. The study outlines three implications: (a) reaching the often unreached mind; (b) developing simple chemical phrases into coherent chemical explanation; and (c) achieving alternative students' success in traditional test. The study recommends the use of an intellectually caring teaching and learning model for high school alternative high school students' academic success.

Key words: acids and bases, alternative students, African American, conceptions, conceptual change, intellectual caring, phenomenography, science achievement

Introduction

Reggie, a high-school student, was referred to Columbus Charter School by his mentor at Big Brothers/Big Sisters when Reggie was 15. During his initial interview, Reggie got up and walked out. At that point in his life, Reggie clearly was not ready to attend Columbus Charter School. Reggie returned to Columbus the following year and decided to enroll in the program. Although he attended some classes, his attendance was sporadic, and he dropped out after a few weeks. The following year, Reggie returned to Columbus. The staff members at Columbus allowed him to enroll but insisted he sign a contract agreeing to remain in the program. His attendance was irregular, and his academic progress slow. He remained quiet and angry, but this time he stayed. Finally, after several months in the program, he began to talk more openly with the counselors on staff. He told them about his family--one brother had served seven years in prison, and the other brother was unemployed. The staff called Reggie on those days when he failed to attend school and began checking in with him regarding his experiences at school and the other aspects of his daily life. It worked. Something clicked. Reggie's attendance improved, he made progress in his classes, and he began to enjoy his schoolwork. His demeanor and outlook changed dramatically, and he earned a great deal of respect from his peers, as well as his teachers. At the Columbus awards luncheon, he was recognized for having been voted the "Most Improved Student." He even gave the commencement address at his graduation from Columbus. After Reggie left Columbus, he entered college at Columbus State University. In the spring, he was selected as a member of a university exchange program to spend six weeks in London (Adapted from *Stories of Transformation,* Youth Build USA).

Reggie is a unique individual, but his circumstances are not. Reggie represents many troubled youth in the urban neighborhoods of the United States who attend comprehensive high schools. Often, students lose hope in the school system and find “life on the streets” a more promising option. We seem to know more about the characteristics of such students than we know about effective instructional practices that will support them from dropping out (Christenson, Sinclair, Lehr, & Godber, 2001).

According to Becker and Luthar (2003), pedagogical practices in many alternative schools emphasize lower-order skills, such as rote memorization. In fact, classroom observations have identified a frequent reliance on teacher-directed activities, including independent seatwork, rote learning, as well as frequent interruptions of learning activities to manage classroom behavior (Haberman, 1991). Such instructional practices appear to have profound ill-effects on students’ motivation to learn, their overall learning experience, and academic success (Darling-Hammond, 2000). Students who cannot handle normal school learning experiences and fail miserably most frequently have been placed in alternative high schools with the hope that teachers in these alternative high schools may positively impact students’ learning and achievement (O’Connor & McCartney, 2007). However, the question remains: How do teachers provide high quality, relevant science education to students--specifically, African-American students in urban secondary schools--who cannot cope with the expectations of comprehensive schools? One answer to this question can be found in the 1996 report by the National Commission on Teaching and America’s Future (NCTAF): “What teachers know and can do is the most important influence on what students learn” (p. 34). Teachers knowing and being able to connect the culture of students and the culture of science as well as holding students to high expectations are primary influences of what and how students learn (Mutegi, 2010).This suggests that more effective learning outcomes and science achievement might be possible if teachers had a better understanding of learning models that value the diverse experiences students bring to the learning environment. In fact, high-quality teaching has been considered the single most important factor influencing achievement gains (Sanders & Horn, 1994; Wright, Horn, & Sanders, 1997). High-quality teaching practices, coupled with an understanding of how to bridge the subculture of urban African-American students with the culture of high-school science classrooms will positively impact student learning and achievement. Implementing caring pedagogical practices will also promote student engagement, active learning, motivation to learn, emotional stability, and success in academic work (Gay, 2010). According to Soto (2005), a pedagogy of caring transcends the formal role of education and is manifested, in part, in teacher acceptance of students' cultural background and values.

The notion of "caring" is defined in terms of equity and excellence for all learners in science education reform documents such as *Science for All Americans* (1989), *Benchmarks for Science Literacy* (1993), *National Science Education Standards* (1996), and *A Framework for K-12 Science Education* (NRC, 2011). Based on the ideal of equity and excellence of caring, the reform documents have steered policy, research, curriculum, and professional development. In response, access to equity and excellence (i.e., "caring"--can be addressed within the framework of the theory of conceptual change, which researchers have described as a reasonable vehicle for improving science teaching and learning; Duit & Treagust, 2003). However, conceptual change models have been developed based on widely varying views. In the classic book, *Patterns of Discovery* (Hanson, 1958), the author described a simplistic view of conceptual change by distinguishing between observations that occur without the benefit of appropriate background knowledge (i.e., "seeing as") and observations that involve appropriate background knowledge (i.e., "seeing that"). The challenge, according to Hanson, is to enable student learners to progressively develop from using a lens of "seeing as" to a lens of "seeing that."Posner, Strike, Hewson and Gertzog (1982) have proposed four theoretical conditions for conceptual change to occur: “dissatisfaction, intelligible, plausible, and fruitful” (p. 211). Chi and Roscoe (2002) have defined “conceptual change” as the process of repairing misconceptions. In contrast, they have defined “conceptual reorganization, revision and accommodation as the ongoing development of preconceptions. Pintrich, Marx, and Boyle (1993) have referred to these conceptual models as “cold” and instead proposed a “hot” model of conceptual change that takes into consideration the aspect of student motivation. Any wonder, van Manen (2002) states that the conceptual change models do not help in minority students’ learning. However, this article argues that a specific conceptual change model, alternative to the earlier ones, is built on the principle of caring that reaches the heart and soul of learners. This conceptual change inquiry model has been referred to as the Common Knowledge Construction Model (Ebenezer & Connor, 1998) rooted in Marton and Booth’s (1997) *variation theory of learning* (also called phenomenography). With intellectual empathy, teachers implementing the variation theory of learning use students’ personal and individualized conceptions as important frameworks when developing learning activities. Teachers use these personalized frameworks to create variation and application of concepts within the science context (Ebenezer, Chacko, Kaya, Koya, & Ebenezer, 2010). The variations result in “relational conceptual change” (Ebenezer & Gaskell, 1995, p. 1).

Marton and Booth (1997) as well as Marton and Tsui (2004) have suggested that learning involves a qualitatively different approach to understanding a phenomenon. Elaborating this notion, Ivarsson, Schoultz, and Saljo (2002) have argued that naïve conceptions do not serve a purpose in conceptual change because conceptual change is the appropriation of intellectual tools.

Purpose of the Study

Using the variation theory of learning, this study was designed to help better understand the issues surrounding alternative education students' relational conceptual change and achievement during a unit on acids and bases. A theoretical foundation to this problem of study is a review of the literature focusing on the following areas: conceptions of teacher caring with respect to pedagogy, and the intellectually caring Common Knowledge Construction Model (Ebenezer et al., 2011). Literature review of students' variations of acids and bases and the student science achievement introduce the research objectives and questions. The study also consists of a curriculum design framed by the CKCM that uses alternative high school students' variations of acids and bases.

Theoretical Frameworks

This study is about students' conceptual changes and achievement in the study of a unit on acids and bases who attend the Northwood Scholars Alternative School in an urban Midwest school district. Such students need teacher caring and related pedagogy.

Conceptions of Teacher Pedagogical Caring

Littky (2004) has reinforced the notion that caring for all students and the need to be cared for are essential components of any learning environment. Noddings (2005) also has supported the idea that when students believe teachers care about them, they are more willing to participate in classroom experiences within a social environment, which engages them in dialogues that lead to negotiating mutual understanding and adopting individual perspectives. Gay (2010) has suggested that students who are engaged in school develop a desire to learn, maintain emotional stability, and succeed in their academic work. If Gay's assertion is accurate, then it is likely that implementing caring practices that support improved relationships within schools and classrooms can promote student engagement. When children do not experience caring from adults in school or at home, it negatively influences their desire and motivation to achieve. Many rebel and many fail academically and behaviorally and are placed in classes or schools designed to address their deviant behavior or failure to succeed academically.

McCroskey (1992) has pointed out that it is not simply a matter of caring that counts; rather, it is the perception of caring that is critical. When teachers care deeply, McCroskey has suggested that they naturally communicate that attribute to students. McCroskey has highlighted three key factors that lead students to perceive that teachers care about their well-being: empathy, understanding, and responsiveness. Empathy has been defined as the teachers’ capacity to experience situations from students’ perspectives and experience how they feel about those situations. Understanding has been defined as the teachers’ ability to comprehend students’ ideas, feelings, and needs. Responsiveness has been defined as paying attention to students’ problems by carefully listening to what they say and responding to their needs without delay. When teachers are empathetic, understanding, and responsive, students perceive them to be caring and attribute to them more credibility. The more that students perceive their teachers care about them, the more likely the students are to care about the class, the more likely they are to care about the course content, and the more likely they are to pay attention in class and consequently demonstrate expected learning. The relationship between caring and teaching has most often been described as “pedagogical caring” (Hull, 1997).

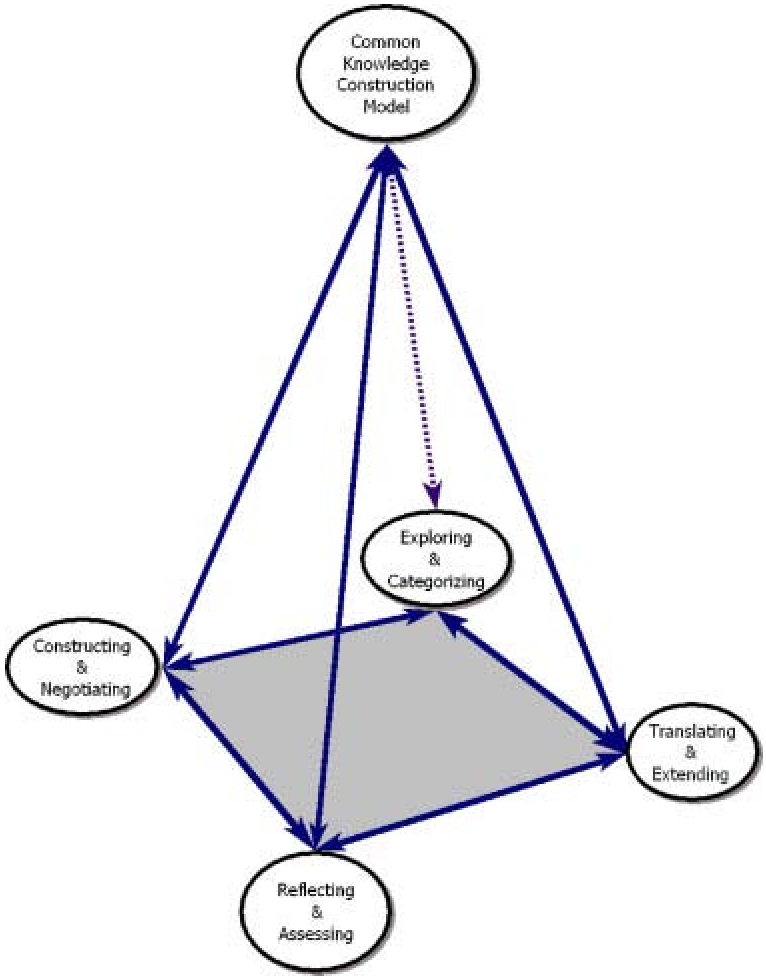
The Common Knowledge Construction Model (CKCM) is a relational conceptual change model that promotes intellectual empathy in a teaching and learning environment (Ebenezer et al., 2010).The CKCM provides teachers a logical pathway to facilitate conceptual understanding in a caring and empathetic manner. The caring aspect of the CKCM has been embodied in

Noddings' (2005) suggestion that school experiences should provide intellectual experiences and opportunities that allow students to connect to their hearts and souls. Noddings (2005) has argued that educators should aim to develop competent, caring, loving, and lovable dispositions as a moral priority in teaching.

For many students in urban and impoverished areas, schools have been safe havens. In these environments, teachers who demonstrate empathy, understanding, and responsiveness open new doors that enable students to escape their out-of-school perils or build bridges to cope more effectively with them. For these children (and most students matriculating in schools today), engaging in meaningful and positive interactions with teachers they perceive as caring enhances their learning experiences. As a result, teachers can create a caring learning environment that naturally contributes to improved student performance. It is believed that high school education needs to build communities of caring that provide strong support for students' ideas. A classroom culture in which students feel cared for and relationships flourish is a critical component for alternative education students, who often have been marginalized by society. Connecting the culture of an alternative high school community with the culture of the science community represents the hallmark of the CKCM model of teaching and learning (Ebenezer et al., 2010; Ebenezer & Connor, 1998) because the model is founded on the principle of intellectual empathy, which may be equated to the whole concept of caring conceptualized by the researchers.

Intellectually Caring Common Knowledge Construction Model

Ebenezer and Connor (1998) developed the Common Knowledge Construction Model (CKCM) for teaching and learning, which has roots in phenomenography, the variation theory of learning (Marton, 1981; Marton & Booth, 1997). The CKCM consists of four interactive phases of teaching and learning as represented by Figure 1: (1) exploring and categorizing, (2) constructing and negotiating, (3) translating and extending, and (4) reflecting and assessing.



Culture – Culture Pedagogy

Figure 1. The Common Knowledge Construction Model (Ebenezer et al., 2010. Modified to include culture-culture pedagogy)

The CKCM affords students intellectual freedom to propose, assess, revise, and shape ideas about natural and socio-scientific phenomena. These characteristics of the CKCM signify the aspects of care that general theorists have advocated (Gay, 2010; Hull, 1997; Littsky, 2004; McCroskey, 1992; Noddings, 2005).

Each phase of the CKCM reflects the principles of caring. Therefore, the present discussion of the various phases of the CKCM makes explicit links to caring (Ebenezer et al., 2010; Ebenezer & Connor, 1998).While the goal of CKCM curriculum design and pedagogy is to emulate the inquiry practices and processes of the scientific community, the burden of reaching all students in learning science with care is an even greater goal. This goal has been established to reach those students of science who often have been neglected. Caring, demonstrated in the classroom, calls for a learning environment that accommodates conditions, contexts, activities, and structures that promote, nurture, and support reasoning practices among students. Such practices promote a learning community with which students can identify (Honig & McDonald, 2005; National Academy of Sciences, 2002; Noam, Biancarosa, & Dechausay, 2003).

Phase 1: Exploring and Categorizing. *Phenomenography* is an experiential perspective. It embodies a relational view of conceptions of a phenomenon--a relationship between the conceptualizing individual and the conceptualized phenomenon. It describes the possible variations in relational conceptions that individuals hold for a phenomenon. In this phase, there is no strong concern for the developmental mechanism that created that variability. Thus, phenomenography may be used as an inquiry tool to generate conceptions of a natural phenomenon. The development and use of second-order questions is advocated in order to explore students’ conceptions. Students explore their ideas using one or two related everyday tasks.

To explore students’ ideas of acid-base concepts, for example, they may be shown a picture of a factory with gases coming out of the smokestacks while it is also raining. The teacher asks second-order questions based on the following scenario: What sense do you make of this picture? Can you see what is happening? More complex questions might be as follows: What do you think happens when gases and water mix? How might the combination of gas and water affect the environment?

When emotional connections are made to an environmental issue through an activity, students have the opportunity to demonstrate caring practices and value what they are learning. To simulate scientific practice, students are provided with opportunities to explore multiple ideas. In doing so, students begin to understand that science is an attempt to explore and explain natural phenomena. Students' ideas are interpreted with much intellectual empathy, not judged as correct or incorrect, as would occur in a diagnostic or deficit model.

Found in the pool of students' expressions are personal ideas with inter- and intra-variations. The researcher identifies and develops commonalities in meanings into "phenomenographic categories" (Marton & Booth, 1997; Marton & Tsui, 2004). The categories of description are ways of denoting the researcher's interpretations of students' conceptions of a phenomenon. Categories of description consist of qualitative and quantitative aspects. The qualitative aspects are the categories of description, while the quantitative aspect is the frequency distribution related to the categories (Renstrom, 1988).

According to Ebenezer et al. (2010), taking class time to explore all students' personal ideas of a science phenomenon with tasks that represent their experience, interpreting those ideas, and categorizing those ideas with intellectual empathy before beginning a sequence of lessons symbolizes "pedagogical care" (Hull, 1997). As a result, caring is shown and felt in the classroom (McCroskey, 2009**)**.In phase one, a first attempt is made to reach all students, including the majority/minority, privileged/under privileged, culturally rich/poor, and regular/alternative education students within the dynamics of urban education. Caring for all students and the need to be cared for are human needs that have been reinforced by Littky (2004). McCroskey (1992) has pointed out that it is not simply a matter of caring that counts; rather, it is the perception of caring that is critical. Students perceive teacher caring when teachers demonstrate a genuine capacity to see situations from students' perspectives and experience how they feel; as well as the ability to comprehend students' ideas, feelings, and needs. Pedagogical caring and learners' perceptions of caring are built into the CKCM. Students enter into the construction and negotiation phase with the confidence that their teachers care for them, respect their values, and respect their ideas.

Phase 2: Constructing and Negotiating. Phase 2 consists of constructing and negotiating meaning. Students share their personal ideas in class so that peers can evaluate the merits of these ideas in an open forum through a process of construction and negotiation. Exposing their conceptions to the teacher and peers for critical inquiry is a sign of strength, not weakness. Scientific explanation based on students' conceptions occurs in this phase. Students must recognize that teachers believe they are capable of constructing and negotiating knowledge. Simply telling or providing students with structured knowledge does not suffice. Providing a learning environment of caring is probably one of the most influential factors that must be established to support the development of scientific knowledge for all students (Gay, 2010). This author believes when teachers attend to their students and care about who they are and how they are performing, it creates an environment that enhances a students' desire to learn and succeed academically. The CKCM provides a framework to support teachers in demonstrating this level of caring.

In Phase 2 of the CKCM, students construct and negotiate understanding through discourse in the comfort and nuances of diverse learners. As students critically analyze and engage in discourse with each other and the teacher in the classroom community, they continue to expose their conceptual variations. In response, the teacher encourages, guides, and pushes students to participate in a community of inquirers generating and validating conceptions of scientific ideas. Students then see themselves as establishing credibility and taking responsibility for the knowledge they have mutually constructed. The teacher encourages students to communicate their scientific understanding using the multi-modal representations with which they are comfortable. This level of engagement and care is important for all students, particularly those who are disadvantaged. Their self-esteem and confidence may have been eroded over time, resulting in a lack of academic success in traditional schools. By maintaining high expectations and simultaneously demonstrating caring practices that reinforce students, the teacher is showing students they are cared for as people and valued, which is tremendously important for students in alternative education settings. During Phase 2 of the CKCM, students who are "in the cradle of care" are nurtured by a "caring teacher" who recognizes that constructing and negotiating meaning will require students to be vulnerable. This confirmation and encouragement of care encourages the students to engage in conversations that expose and challenge their ideas because they are secure in the caring environment and caring structure created by the teacher.

Through the experiences students encounter in Phase 2, they become aware of how they construct scientific knowledge and how conceptual change occurs. Students recognize that conceptual change occurs when they question their original conceptions based on everyday contexts and submit their ideas to critical thinking processes, inquiry, and peer review. Students also realize that collaborative time and effort are required as well as empathy towards fellow learners when formulating scientific ideas. Furthermore, teachers understand that if students show "situational interest" (Swarat, Ortony, & Revelle, 2012) in learning science, conceptual change may be facilitated. Teachers build meaningful bridges from the students' cultural values to the culture of science. Teachers continually monitor and adjust the lesson sequence for future instruction based on their sense-making of students' evolving conceptions and understandings.

Phase 2 of the CKCM manifests caring by creating a learning environment in which students clearly perceive that the teacher cares and supports discursive practice. As teachers engage students in dialogue, they learn about their needs, working habits, interests, and talents. Teachers gain valuable ideas from students about their understanding and then use that knowledge to build meaningful and targeted lessons, along with plans for individual student progress. In these ways, the CKCM inspires authentic caring teachers to increase their own competence to support student conceptual change.

Phase 3: Extending and Translating. The third phase of the CKCM helps students extend and translate their knowledge. Gay (2010) has described one of the tenets of culturally responsive caring as action provoking. During the third phase of the CKCM, teachers ask students to extend and translate their understanding. Students recognize and remain in a learning environment that fosters caring, but now they are asked to extend their thoughts into actions. In Phase 3, students use their ideas to identify issues that influence their own lives and the lives of others.

In this phase, students work collaboratively and cooperatively with empathy for each other's ideas, processes, and values while exploring community-based socio-scientific issues. Encouraging students to collaborate in making responsible decisions and taking collective action is crucial for all students in science classrooms. In this phase, students are nurtured to develop a critical-thinking disposition through scientific inquiry and problem solving. Personal responsibility from students is elicited via a reflective process based on their values. The types of concerns and issues they value and for which they will be responsible and reflect upon will emerge as a result of the caring environment and meaningful discourse (Noddings, 1992).Students must also perceive that the responsibility they are demonstrating is acknowledged and that their insights are understood, shared, and valued. The CKCM supports a social, intellectual, and ethical progression from (a) self-centeredness to (b) ethical partnerships to (c) ethical caring/support to (d) ethical decision making at a global level. Through school-community partnerships, all students can experience an ethically caring environment that enables them to make intellectual decisions and take action in community affairs (Ebenezer, Kaya, D.L Ebenezer, 2011). These authors believe that by ushering deprived students into the scientific community of practice through community partners, they are pointed to STEM higher learning and STEM careers.

Phase 4: Reflecting and Assessing. The fourth phase, reflecting and assessing, is integral to exploring and categorizing students' conceptions, constructing and negotiating shared common knowledge, and translating and extending students' understanding of science concepts into the study of personal and socially relevant scientific and socio-scientific issues. Traditional assessment options, such as fill-in-the-blank items, multiple-choice questions, true/false questions, and matching questions, require students to regurgitate information and provide "the right answer." These methods do not serve as effective assessment practices for conceptual change inquiry teaching and learning, especially when that teaching and learning environment underscores aspects of caring. In the conceptual change inquiry process, assessments should measure how students explore, expose, revise, or reject their conceptions based on evidence and explanation. Measurement should track the small steps that students take to understand difficult science concepts and make conceptual changes. Assessments should determine how effective teaching has been in terms of initiating conceptual change, identifying which concepts need to be further explored, and clearly observing how students use the understood concepts. This assessment information is necessary to design, conduct, and evaluate scientific and socio-scientific inquiries that have personal and social relevance. Measuring these processes of learning continuously and reflectively is vital. Teachers and students both need to engage in formative assessments that enable students to consider *how* they know *what* they know regarding "knowledge claims communicated in science" (Ruiz-Primo & Furtak, 2007, p. 64).

Caring is manifested in this phase when students engage in experiences that confirm *what they know* and, perhaps just as importantly, *how they know* a concept. Noddings (2009) has suggested that teachers should care about not only the knowledge goals for which students are striving but also the ways that students go about achieving these goals. The use of formative assessments is one way that teachers and students can measure continuous and reflective learning. Encouraging and confirming, as highlighted by Noddings (1992), is an integral part of the assessment process.

Variations in Students' Conceptions of Acids and Bases

From high school chemistry classes to the university chemistry curriculum, the topic of acids, bases, and pH has been considered challenging for students to understand (Demircioglu, Ayas, & Demircioglu, 2005; Nakhlen & Krajcik, 1994; Zoller, 1990). Chemistry consists of a sequential and complex network of ideas, and when these ideas are clouded, this confusion has the adverse potential to affect correct understandings necessary for students' conceptual development in chemistry (Acar & Tarhan, 2007; Boo & Watson, 2001; Garnet, Garnet, & Treagust, 1990; Tarhan et al., 2008).

A review of the research literature has revealed several studies that address various aspects of students' understandings of acids and bases. The concepts of acids and bases are connected to other chemistry topics, such as the nature of matter, stoichiometry, solutions, and chemical reactions. In a study conducted by Cros et al. (1986), first-year university students' conceptions of acids and bases were examined, and researchers found that the students knew more about acids than bases. In addition, they also concluded that students held inadequate conceptions of other concrete phenomena, such as heat being released in an acid base reaction. It was also noted in the studies conducted separately by Cros et al. and Ross and Munby (1991) that when students were asked questions about pH, several students answered that pH was a measurement of the degree of acidity. To assess student conceptions of acids and bases, Ross and Munby (1991) conducted two audio-taped interviews (pre-intervention and post-intervention) and administered a multiple-choice test that confirmed again students knew more about acids than bases. The researchers also confirmed that students were having difficulty understanding the ionic nature of acids and bases.

Hand and Treagust (1991) identified qualitatively different conceptions of acids and bases among 60 16-year-old students. They developed and implemented a curriculum on acids and bases using a conceptual change approach. Students' prior conceptions were as follows: (a) an acid is something which eats material away, and an acid can burn you; (b) testing an acid can only be accomplished by using it in an attempt to "eat something away"; (c) to neutralize is to break down an acid or to change from an acid; (d) a base is something which makes up an acid; and (e) a strong acid can eat material away faster than a weak acid. The majority of these conceptions are related to acids. The results supported the instruction that had been implemented using a new curriculum rather than conventional methods. With these and other misconceptions found in the literature, Peterson, Treagust, and Garnett (1986) and, subsequently, Treagust (1988) developed the Concept Achievement Test. Using this test, Demircioglu, Ayas, and Demircioglu (2005) carried out an experimental/control group study designed to compare new curricular materials with traditional instruction during a four-week trial period.

The results from this study indicated that the students in the experimental group, taught with the new teaching material, showed significantly greater achievement in the unit than did the students in the control group. Based on the pre-test, the frequency of students holding prior alternative conceptions was reduced. The results of this study indicated that a conceptual change strategy was more successful when implemented with the experimental group in correcting students' conceptions about acids and bases than with the traditional strategy implemented with the control group

Driver et al. (1994) have provided several reasons that may account for students' misconceptions related to acids and bases. Student ideas about acids and bases are impacted by the current media and sensory experiences, including tasting sour foods, watching advertisements, and viewing crime stories and news about acid rain. This impact transfers into their understanding, or "mis-understanding" about conceptual ideas in science, specifically their understanding of acids and bases.

Problem Statement

Of the studies presented related to acids and bases, only Demircioglu, Auas, and Demircioglu (2005) and Hands and Treagust (1991) have addressed student conceptions of acids and bases. They used a concept achievement test (CAT) to explore the degree of conceptual change students underwent during a unit related to acids. In comparison to prior studies that used the CAT, this study uses phenomenography and variation theory of learning to identify students' conceptions and conceptual changes related to acids and bases. However, both types of studies (CAT and phenomenography) are beginning to have a positive impact on student science achievement (Demircioglu, Auas & Demircioglu, 2005; Ebenezer et al., 2010; Eryilmaz, 2002; Sungur, Tekkaya, & Geban, 2001). In response, it is helpful to link students' conceptual changes to their achievement in the topic of acids and bases.

Additionally, similar to prior conceptual change studies that revealed an impact on science achievement, this study aimed to explore the impact of a caring conceptual change inquiry model on students' achievement. Based on these two research goals – that is, conceptual change and its effect on achievement – two related questions were formulated:

1. What conceptual changes were evident for a group of urban African American alternative high school students, when immersed in the CKCM-based acid-base lesson sequence?
2. Does the CKCM acid-base lesson sequence significantly improve urban African American alternative students' achievement compared to (a) prior- and post-interventional teaching; and (b) traditional teaching?

This interventional study uses both qualitative and quantitative methods to study the effect of a theoretical model of teaching and learning on conceptual change and achievement during the enactment of an acid-base lesson sequence. An in-depth analysis using both methods provides confidence in the CKCM. Although the reform-based CKCM has been studied in three middle school classrooms: urban (Biernacka, 2006), affluent (Ebenezer & Puvirajah, 2005), and diverse (Ebenezer et al., 2010), this is the first time the model has been used in an urban African-American alternative high school classroom. On account of these research studies, model's practical effectiveness is gaining grounds. The choice of subject matter (acids and bases) for classroom instruction is justified on the basis of the research literature. However, an acid-base lesson sequence demonstrates the efficacy of the CKCM and serves as a research platform of the model. The study adds to the limited number of studies that have been reported on the classroom instruction of the concept of acids and bases. The Common Knowledge Construction Model known for intellectual empathy has been for the first time theoretically defended with literature on conceptual caring in order to use it with the alternative high school students. Thus, the results of this study may be helpful in assisting other teachers and researchers who are looking for a caring teaching and learning model to be used with alternative high school students.

Methods

Northwood Scholars Academy

Students attend the Northwood Scholars Academy (NSA), an alternative high school in Northwood Public Schools, because they are behind academically and have failed in previous learning environments. They are often branded and labeled as students unable to cope with the learning demands of traditional comprehensive schools. Most have been on an academic trajectory characterized by poor achievement, poor attendance, and unacceptable behavior in and out of school. The stories of students prior to attending NSA are often filled with anger, confusion, pain, transience, poor instruction, and dysfunction.

The enrollment at NSA during the 2011-2012 school year was 460 students. Students matriculate for one year, and, after their tenth-grade year with demonstrated improved academic achievement, may return to their comprehensive high school. However, most students do not wish to return to their comprehensive high school and instead choose to remain at NSA.NSA offers the same required academic courses that are offered in the comprehensive high schools in

Northwood Public Schools. The NSA is an academic intervention designed to support and increase opportunities for students to graduate on time and attend post-degree programs. The environment embraces a small-school structure and a very strong emphasis on student-teacher relationships. The school is proud of its 85.1% attendance rate and 76.42% graduation rate. However, the students at the NSA have not met the Adequate Yearly Progress (AYP) assessment required by the federal government for the past two years. For example, in 2010-2011, the eleventh graders at NSA were 14.3 % proficient in English Language Arts/Reading and 1.5% proficient in mathematics. It is evident from the state assessments that students are not demonstrating basic skills in mathematics and English that are required for science learning and achievement.

Chemistry Classroom

The classroom is not a traditional high school chemistry laboratory setting. Teachers share a common preparation and science, chemical, and equipment storage area. The classroom combines a collaborative seating arrangement that supports independent and group collaborative inquires. The students work in collaborative groups of 4 to 5 students. A smartboard is available because the teacher uses electronic technology frequently to supplement the excursions and experiences that she may not be able to provide directly to her students.

Participants of the Study

The participants in this study consisted of 48 students (23 boys and 25 girls, 15 to 18 years of age).These students were enrolled in two science classes at NSA. However, due to the transient nature of students entering and leaving NSA, not all 48 students completed both the pre-achievement assessment and the post-achievement assessment. Seventeen students in the experimental group completed both the pre- and post-intervention achievement assessment, and

18 students in the control group completed both assessments. All students in the control group and experimental group were African American and most were from economically disadvantaged households.

The chemistry teacher, Bonnie, a pseudonym used for the purpose of this study, is a veteran science teacher in the Northwood School District. As a result of district staffing changes due to budget reduction efforts, she and many other teachers were displaced from courses and grade levels they traditionally had taught prior to the budget reductions. Therefore, the 2010-2011 school year was Bonnie's first year teaching chemistry at the high-school level. Prior to this assignment, Bonnie taught biology and an integrated physical and earth science course. Therefore, this was a premiere time for her to begin learning about the CKCM and to enhance her expertise in teaching high-school chemistry.

Furthermore, Bonnie was preparing for the National Board Take One!, which is an introduction to the National Board Certification process and serves as one of the requirements for teachers interested in pursuing full National Board Certification. National Board Take One! is a professional development initiative directed by the National Board for Professional Teaching Standards and has entered into a partnership with the Northwood School District to improve teacher practice. Professional development through the National Board Take One! supports classroom-based research. Engaging teachers in the process of posing questions and reflecting on their practice is integral to the Take One! and Bonnie wanted to experience it.

Bonnie did not complete her National Board Take One! portfolio during the 2010-2011 school year; however, she was committed to continuing her quest to complete it during the 2011-2012 academic school year. Bonnie is experienced in experimental design and conducting controlled experiments, and because of this, she began her personal quest to study her practice using the CKCM in the context of the National Board Take One!

During the 2010-2012 school year Bonnie started her professional learning with the developer of the CKCM. Additionally, during the 2011-2012 school year she was assigned to teach a general science elective class with a chemistry focus for the first semester. This allowed her to repeat the unit on acids and bases and design a lesson sequence that complemented students' conceptual learning. She wanted to implement the CKCM lesson sequence on acids and bases during the fall and employ all of the lessons she learned during the previous school year to reflect on her practice. She mentioned that the author of the CKCM made constant reference to the notion of empathy underpinning the model during a district-wide professional development session consisting of secondary science teachers in Northwood Public Schools. Recognizing the value of the instructional model that embraced intellectual empathy encouraged and motivated Bonnie to pursue a deeper understanding of it.

The author of the CKCM supported Bonnie in deepening her understanding of the CKCM through district professional learning. This author, along with the researcher of this study, provided appropriate assistance to the teacher in the following ways: (a) the development of exploration activities, (b) the development of phenomenographic categories of description, (c) the construction of a matrix matching categories of description with the State Science Standards (see Table 1), and acid-base-lesson sequence using students' conceptions of acids-bases, neutralization, and students' views of the effects of acid rain on the environment (see Table 2).

Teaching in the Experimental and Control Classes

The school follows a block schedule rotation, which means the chemistry teacher taught each of her classes for 90 minutes twice weekly and every other week she had an additional 55 minute instructional period with the students. The implementation of the intervention occurred over seven weeks. The instruction started in late September and concluded in mid-November.

The experimental and control groups of students were both taught an acid-base lesson sequence aligned to the Northwood Public Schools Curriculum Framework. The District curriculum framework was directly aligned to the State High School Curriculum (MDE, 2007) for secondary chemistry. The control group was taught an acid-base lesson sequence with the same objectives and a traditional teaching methodology that included mostly lecture, direct instruction that focused on concepts, note taking, high reliance on the textbook, virtual lab experiences and tests. Aligned to the District's content standards and objectives for chemistry, as the teaching intervention for experimental group (see Table 1), Bonnie used the CKCM acid-base lesson sequence (see Table 2).

Table 1

Descriptive Categories of Prior Conceptions Matched with the State's Conceptual and Epistemic Knowledge Representations

Phenomenographic Categories of Students' Conceptions of Acids and Bases	Science Benchmarks/Content Expectations	Essential Questions	Science Activities
Characteristics of acids and bases	Describe tests that can be used to distinguish an acid from a base.	What tests can be used to distinguish an acid from a base?	Perform pH experiments to identify acids, bases and neutral substance.
Examples of acids and bases Identification of pH value	Classify various solutions as acidic or basic, given their pH.	Based on the pH values of various solutions, how would you classify acids and bases?	Demonstrate how to use a pH scale, i.e. weak and strong acids, bases, and neutral.
Neutralization	Recognize formulas for common inorganic acids, carboxylic acids, and bases formed from families l and ll.	What are the various acids, carboxylic acids, and bases formed from families I and II?	Determine if a household solution is an acid or base and rank the relative strength according to pH
Identification of reactants and products	Predict products of an acid-base neutralization.	How do acids and bases help your body maintain a state of equilibrium?	Acid-base titrations
Impact on the environment	Explain why lakes with limestone or calcium carbonate experience less adverse effects from acid rain than lakes with granite beds.	Why do lakes with limestone or calcium carbonate beds experience less adverse effects from acid rain than lakes with granite beds?	Perform an experiment to test whether the presence of soil in water will influence the pH of water and will change when an acid or base is added
Reaction of chemicals Impact on the environment	Explain why sulfur oxides and nitrogen oxides contribute to acid rain.	How do sulfur oxides and nitrogen oxides contribute to acid rain?	Perform an experiment to test whether the presence of soil in water will influence the pH of water and will change when an acid or base is added

Table 2

Enactment of an Acid-Base CKCM-Based Lesson Sequence in the Experimental Class over Seven Weeks

Lessons based on Students' Conceptions	Activities	CKCM Strategies
	Phase 1: Exploring and Categorizing	
Lesson 1 Exploration and categorization of students' conceptions of acids and bases	After individually interviewing 10 students with four acid-base activities outside the class, the teacher explored all students' conceptions of acids and bases through writing and drawing on specially designed worksheet.	Exploration and categorization
Lesson 2 Students' awareness of their conceptions	The teacher discussed the descriptive categories of acids and bases with students.	Awareness of students' conceptions of acids and bases was revealed through discussion
	Phase 2:Constructing and Negotiating	
Lesson 3 Determination of pH of a variety of acids and bases.	Students were given a variety of common substances and asked to test the substances using litmus and pH paper. Students ordered substances based on their strength. This activity was the precursor to the directed instruction related to the use of indicators and pH.	Student-student, student- teacher discourse
Lesson 4 Determination of a pH of a variety of acids and bases with various indicators	The teacher reviews prior lesson on indicators and testing of common substances and re-visits the pH scale. The teacher introduces pH paper, litmus paper and universal paper as different types of indicators. Students predict, observe, and explain as they engage in a guided activity testing a variety of acids and bases with different types of indicators and recording results. The teacher asks students to note patterns. The teacher allows students to explore testing other substances including substances that they have in their personal possession such as lip gloss, lotion, water etc.	"POE", Predict, Observe and Explain conceptual change inquiry strategy Flexible grouping to facilitate student peer discourse
Lesson 5 Creation of a pH scale	Students prepared their own cabbage juice indicator and tested various pre-selected substances with the cabbage juice. Students observed color changes and collaboratively determined the strength of the acids and bases and constructed a pH scale.	Inquiry and student discourse
Lesson 6 Determination ofpH of unknown substances	Students designed and implemented their own experiment using seven unknown substances.	Inquiry and student discourse
Lesson 7 Conceptual understanding of Hydrogen and hydronium ions	Students were engaged in a series of learning activities that addressed the function of potential hydronium (pH).The teacher later engaged students in a discussion about ions and led them to an understanding that acids generate hydronium ions in aqueous solutions and bases generate hydroxide ions in aqueous solution.	Explanation of theoretical ideas of acids and bases

Lessons based on Students' Conceptions	Activities	CKCM Strategies
Lesson 8 Conceptual understanding of neutralization	Students observe teacher demonstration of an acid combining with a base. The teacher engages students in constructing an equation to represent the neutralization reaction, highlighting the hydrogen ion and hydronium ion.	Teacher demonstration and large group interpretive discussion
Lesson 9 Conceptual understanding of neutralization	Students conducted a neutralization activity by combining a common acid (HCl) with a base (NaOH)to form salt and water.They begin to connect the idea of dissociation in lesson 8 to neutralization.	Student inquiry, small group peer discourse Teacher explanation and probe for deeper understanding
Lesson 10 Titration Lab	Students conducted a titration lab to reinforce their emerging understandings about neutralization and concentration of acids and bases.	Student inquiry, small group peer discourse Teacher explanation and probe for deeper understanding
	Phase 3: Extending and Translating	
Lesson 11 Exploration of students' conceptions of acid rain	Students were led in an engaging conversation about acid rain. Students collected water and soil samples from around the school. Students tested the soil samples for pH and charted their results.	Teacher-Student discourse – predict, observe, explain (POE). Student inquiry and small group discourse
	Phase 4: Reflecting and Assessing	
Lesson 12 Students' depictions of acids and bases	As a formative assessment, the students created children's books to teach about acids and bases.	Students' drawings for conceptual understandings Teacher probe for deep understanding
Lesson 13 Exploration of students' post-intervention conceptions of acids and bases	Teacher explored students' post-intervention conception of acids and bases through the same worksheet used in prior-intervention Teacher explored the same 10 students' conceptions of acids and bases through individual interviews after the intervention	Post-teaching conceptions
Lesson 14 Final test	Teacher assesses student achievement in a unit on acids and bases ABA-T	Post-test

Research Design

An exploratory sequential mixed-methods design (Creswell, 2003) was employed in this study and included both qualitative and quantitative inquiry methods. To determine students' conceptual changes, "phenomenographic individual interviews" (Ebenezer et al., 2010) were conducted prior- and post-intervention. To measure achievement, a quasi-experimental pre and post-test design (Campbell & Stanley 1963) was used. The study used "retrospective data analysis" (Shavelson, 2002).

Data Collection

Bonnie collected data in the context of her preparation for the National Board for Professional Teaching Standards Take One! The researcher used Bonnie's data to conduct this study. Data collection is represented in Table 3.

Table 3

Data Collection Summary

Data Collection by Bonnie		Retrospective Data Analysis by the Researcher	
Qualitative Data	Quantitative Data	Qualitative Data	Quantitative Data
Audiotape prior- and post-intervention interviews.	Administer pre- and post-intervention achievement test to both control and experimental groups.	Transcribe and analyze prior- and post-intervention interviews.	Analyze the pre- and post- intervention achievement test to both control and experimental groups.

To explore urban African American alternative students' conceptions of acids and bases; to determine tasks and questions for the in-classroom specially-designed worksheet to explore all students' conceptions; and to determine conceptual changes, Bonnie used a qualitative (phenomenographic) assessment tool consisting of four tasks and related questions that focused on the concepts of acids, bases, and neutralization. These topics were selected for the prior- and post-intervention interviews because they constituted the major themes of the state's science curriculum (MDE, 2007). The activities and question prompts are summarized as follows:

Task A consisted of the teacher showing a lemon and asking the student to answer the following questions: (a) How do you think the lemon tastes? (b) Why do you think it has that taste? (c) How do you mentally picture the taste of a lemon? Task B consisted of showing liquid soap and asking the student to answer the following questions: (a) How do you think the liquid soap might taste? (b) Why do you think it has that taste? (c) How do you mentally picture the taste of liquid soap? Task C consisted of having the student predict, observe, and explain what happens when lemon juice is added to baking soda?

Bonnie randomly selected 10 students from the experimental class and explored their conceptions using the above three tasks. Each student's interview was audio-recorded. Based on the data Bonnie gathered from these pre-intervention interviews, she constructed a worksheet with similar activities and questions and administered it to all the students in the class to explore their conceptions. However, the data from the worksheets were used only for classroom purposes. The teacher collected all of the student exploration worksheets. With the help of the CKCM developer, she constructed phenomenographic categories and aligned them with the conceptual and epistemic knowledge outlined in district science curriculum (sees Tables 1 and2).

Both the experimental and control classes were administered the Acid-Base Achievement Test (ABA-T) designed by the teacher. ABA-T was aligned to concepts in the Northwood Common Chemistry Assessment. The pre- and post-intervention ABA-T was administered to both the control and experimental groups during the same week at the beginning and end of the lesson sequence.

As intervention in the experimental class, Bonnie implemented the 14-lesson sequence on acids and bases using the CKCM as the instructional intervention to study conceptual change and student achievement in the experimental class. The retrospective data analysis was conducted by the researcher. The data sources consisted of audio-recordings of prior- and post-intervention interview transcripts.

Conceptual Change Analysis

Data gathered through individual interviews and worksheets by Bonnie was analyzed by the researcher. First, all 10 prior- and post-intervention individual interviews were transcribed verbatim. The researcher reviewed the transcriptions from the prior-intervention interviews as well as worksheets and identified descriptive categories based on students' conceptions of acids and bases. Because the conceptions were similar, the worksheet information is not used in this paper. The researcher then identified passages within each interview that aligned to the descriptive categories identified from the prior-intervention interview. The same procedure was completed for the post-intervention interview. A few descriptive categories were developed from the post-intervention interview transcripts. Frequencies were tallied.

Achievement Data Analysis

The study compared the results from the quantitative analysis of pre- and post-intervention tests on acid-base concepts for a sample group of 39 students, including an experimental group (n = 17) and control group (n = 22).The first analysis compared the pre-intervention test scores between the two groups to determine the statistical equivalence of the groups prior to beginning the intervention. This analysis was needed because the students could not be randomly assigned to the experimental and control groups due to classroom assignment. The post-intervention test scores were compared between groups using t-tests for independent samples. This analysis was considered appropriate, as the groups were statistically equivalent prior to starting the intervention. The change in the experimental groups' scores from pre- to post-intervention test was examined using t-tests for dependent samples. This change is used to determine the effects of the intervention on the knowledge that students gain from participating in the intervention. The control group was tested at the same time as the experimental group, but their change scores were not compared, as this was not a focus of the study. However, the post test scores for the control and experimental group were compared to determine the extent to which the CKCM improved the experimental group's conceptual understanding of acids and bases.

Results and Discussion

The purpose of this study was to investigate the effects of the Intellectually Caring Common Knowledge Construction Model (CKCM) intervention on high school students' conceptual change and achievement following the implementation of a lesson sequence on acids and bases.

Urban African-American Alternative High School Students' Conceptual Changes

The results of students' prior- and post-intervention data provide evidence in three areas of study in a lesson sequence on acids and bases. They are as follows: acids, bases, and neutralization**.** Tables 5 and 6 present the four exploration activities and associated categories of descriptions, and the frequency of students' conceptions. Based on the descriptive categories presented in Tables 4 and 5, the study observed the following trends: (a) changes in the number of categories of description; (b) shift in language use from everyday talk to chemical talk; and (c) hierarchy of chemical knowledge development.

Table 4

Descriptive Categories of Students' Conceptions of Acids And Bases

	Prior	Post	*F*	
Descriptive Categories	Examples of Students' Expressions	Examples of Students' Expressions	Pre	Post
Students' Conceptions of Acids				
Sour Taste	*Taste sour because of juice* *Has a twang like skittles*	*Sour taste, its highly acidic*	15	5
Irritates and Tingles	*If juice squirts in eye it will burn* *Makes the taste buds tingle*		11	0
Acid turns paper red		*Acid turns paper red*	0	12
pH value for acid (below 7)		*Acids have a pH that is below seven* *A pH scale can determine whether something is an acid or a base* *I remember we used cabbage to make a pH scale to determine if it was an acid or base*	0	8
Students' Conceptions of Bases				
Soapy taste	*I taste soap*	*Bitter*	9	2
Slippery to touch	*It is slippery*	*Smooth and slippery*	16	2
Characteristics of base		*It burns*	0	2
pH value for base (above 7)		*Bases have a range from eight to fourteen*	0	9

Table 5

Descriptive Categories of Students' Conceptions of Neutralization

Students' Conceptions of Neutralization				
	Prior	Post	*F*	
Descriptive Categories	Examples of Students' Expressions	Examples of Students' Expressions	Pre	Post
Reactants	*Baking Soda and lemon juice*	*Water is neutral in terms of being an acid or based*	4	0
Reaction of chemicals	*See reaction of chemicals when the lemon juice hits the baking soda*	*Product sodium chloride*	1	3
Neutralization of acid and base		*When you combine an acid and base it neutralizes and yields salt and water*	0	5
Dissociation of acid and base		*Dissociation occurs when acids and base break apart in water*	0	7
Application of acids and bases		*We can neutralize an acid river with limestone* *Limestone is actually a base*	0	4

Knowledge Claim 1: A Change in the Categories of Description

Observation of Tables 4 and 5 clearly reveal positive conceptual changes, sophisticated language use, and hierarchy of knowledge development. Each knowledge claim is characterized with pertinent examples taken from prior- and post-intervention interview excerpts.

Positive conceptual changes are illustrated with descriptive categories of students' conceptions of acids. Lemon tastes "sour" is the common expression made by all students in the pre-intervention. When asked why lemon is sour, 15 students were not sure what was in the juice but confident that the juice had something in it, or something was added to it, or likened it to the taste of "skittle." that made it sour. Twelve students stated that acids are sour and that is why they "tingle," "irritate," or "burn." The reason about acids being sour because of something added to it during the post-intervention occurred only five times. In the post-intervention, the sour taste was attributed to the "acidic" nature of the lemon. The property of acid that it "burns" remained in the minds of nine students. A deeper understanding of acid is evident in prior and post-intervention Excerpts 1 and 2, respectively.

Excerpt 1– Shelly (prior-intervention)

1. T: Alright. You mentioned the lemon has a sour taste. Why is it that you think it has a sour taste?
2. S: I'm not sure, but it taste bitter and probably because it's a citrus fruit. That's probably why it's sour. I'm not sure exactly why a lemon is sour. You can use lemons in cooking such as shrimp scampi or different pasta dishes to give it a little bitter taste or twang.
3. T: The twang. Now let's talk a little bit about that twang. What is it?
4. S: It's just a bitter taste or just a sour taste. That's why you make lemonade with it.

Shelly talks about the "bitter" taste to lemon because of the "twang" nature of the "citrus fruit" (2).She supports her argument with her experience in cooking dishes with lemon to give that "twang" taste. When the teacher asks her about the twang, Shelly explains, "you make lemonade because of its "bitter taste or twang." Now I turn to what Shelly states after studying about acids and bases (see Excerpt 2):

Excerpt 2– Shelly (post-intervention)

1. T: Okay, what do you know about lemon juice?
2. S: It has a sour taste, <u>it's highly acidic</u>.
3. T: You said it's acidic. What can you tell me about acids?

4. S: Um…Acids are <u>typically sour</u>….Using <u>litmus paper, acids turn red</u>.

Shelly does not use the term “twang.” She retains the sour tasting aspect of acids. She states that lemon is “highly acidic”. She substantiates her understanding of what an acid is by pointing out a classic test for acids, which is acids turning litmus paper red. It is evident that Table 5 indicates that students in the post-intervention talked about the litmus paper turning red (see Shelly, 4; and Justin, 2), testing the acid with a pH scale (Justin, 4, 5), and neutrality of a substance if test indicates 7 (Justin, 6). These assertions are evident in Excerpt 3.

Excerpt 3– Justin (post-intervention)

1. T: What do you think about acids?
2. S: If you <u>test</u> it. If it is an acid, it will turn red
3. T. Okay, so how do you test it?
4. S: A pH scale.
5. T: Oh! Well, talk to me about the pH scale.
6. S. Um, okay. A pH scale can determine whether something is an acid or a base. I know the middle number is seven and that means it’s like neutral.

Justin describes his understanding about testing substances to determine if they are acids. He says “it will turn red” (2), as he reflects on the use of litmus paper and implies its use and to indicate his beginning understanding as related to pH (6).

Knowledge Claim 2: A Shift in Language Use

Shift in language is illustrated with descriptive categories of students’ conceptions of bases. The teacher showed dishwashing soap to explore student ideas about bases. According to Table 5, students’ use of everyday language based on their sense of taste (bitter) and touch (slippery) declined from 9 to 2 and 16 to 2, respectively. Chemical characterization about soap has risen from 0 to 9. Two excerpts from the interview transcripts of Jennifer are represented to illustrate the vivid shift in language from everyday talk to more chemical talk.

Excerpt 4 –Jennifer (prior-intervention)

1. T: If you had to taste dish washing liquid, what would it taste like?
2. S: Disgusting, bitter
3. T: Okay, you mentioned that it tastes bitter. What substance in soap would cause it to taste bitter?
4. S: Probably chemicals. I'm not sure which chemicals, but probably chemicals that they put in there to help get it cleaner. That's why it will make it taste bitter.

Jennifer states that soap is bitter (2).She knows the taste of soap, perhaps because of tasting it. She thinks that there are certain chemicals (4) that are put in it for cleaning purposes make soap bitter (4). What does Jennifer state in her post-intervention interview?

Excerpt 5–Jennifer (post-intervention)

1. T: Now, take a look at the dish of washing liquid. How would you classify it?
2. S: The dish liquid?
3. T: Right, would you classify…how would you classify?
4. S: Um, base.
5. T: Okay, tell me about a base.
6. S: Um, bitter taste.
7. T: Uh huh.
8. S: When you test it, turns litmus paper blue, has a pH of seven and greater, negative charge.
9. T: Okay and for a base can you recall what is in it?

10. S: Yeah, hydroxide.

11. T: Hydroxide and what does that look like? You mentioned that the H for an acid.

12. S: OH negative

Jennifer's post-intervention interview shows signs of increased understanding of bases because she uses chemical language to describe bases. The teacher asks Jennifer to classify liquid soap. Jennifer without hesitation states that it is a base (4). When the teacher asked to tell more about the base, Jennifer said that it has a bitter taste (6); turns litmus paper blue (8);has a pH of 7 and greater, (8); has a "negative charge" (8); a "hydroxide" (10); and OH negative (12). Jennifer was able to state at least six properties of a base when liquid soap was shown to her at the post-intervention interview. This sort of chemical talk by an alternative high school student is impressive.

Knowledge Claim 3: A Hierarchy of Knowledge

Students explored their ideas related to combining an acid with a base. There were four descriptive categories identified based on students' conceptions of neutralization from pre- to post-intervention interview. These categories are: (a) *reactants; (b) reaction of chemicals; (c) neutralization of acid and base; and (d) dissociation of acid and base* (see Table 6).These categories of description depict a hierarchy of knowledge. Excerpt 6 illustrated the student's focus on the reactants.

Excerpt 6–Stephanie (prior-intervention)

1. T: Okay, try to put a little bit of equal amounts…why do you think it fizzed.
2. S: I think the baking soda
3. T: Yeah, with the baking soda and the lemon juice what happens?
4. S: Because that's sour and that's bitter

5. T: Yeah, so what's happening? Why do you think it fizzed?

6. S: Because of the baking soda.

7. T: What's happening? Can you explain that?

8. S: Uh-uh. No, because they're both different. I think the lemon juice.

The reaction is obvious because fizzing is visible. However, Stephanie is focusing on reactant at a time. First she talks about the "baking soda" (2).Despite teacher's simultaneous talk about baking soda and lemon juice, the student talks about baking soda (6).Then Stephanie focuses on the lemon juice (8).

In contrast, Gary describes what he saw when the lemon juice and baking soda were combined and begins to state what happens and why. See Excerpt 7 for this evidence:

Excerpt 7 – Gary (prior-intervention interview)

1. S: A different analysis. A totally different reaction of chemicals in it because I see the reaction when the lemon juice had hit the baking soda, came like a different reaction with more bubbles. I think that they are mixed together and it's a totally different ingredient now.

2. T: Okay. Do you know what those bubbles are?

3. S: Those are chemicals from the lemon juice.

It is evident from Gary's responses, that he has rudimentary knowledge about chemical reaction. He explains "there is a totally different ingredient now" (1) "when the lemon juice had hit the baking soda" (1).

In the post-intervention interviews there were examples of student expressions that showed increased understanding supporting the fact that there was the development of knowledge: simple to sophisticated. Shelly offers a simple explanation when she talks about acids and bases (see Excerpt 8).

Excerpt 8—Shelly (post-intervention interview)

1. T: In terms of acids or bases…very reactive with them.
2. S: Sodium Chloride
3. T: Okay, what about sodium chloride? …That brings me to what happens when you combine an acid and a base?
4. S: They become neutral.

Shelly begins to share her emerging understanding related to the process of combining an acid and base. She states that they become neutral (4).

In contrast, Rita's explanation is more sophisticated. She describes her understanding of neutralization process and products (see Excerpt 9)

Excerpt 9–Rita (post-intervention interview)

1. T: When you think of substances combining…
2. S: It's when, I guess they combine and they make salt water.
3. T: Okay, when what combines?
4. S: Uh, like hydrochloric acid and hydroxide
5. T: Ok, is it specifically hydrochloric acid and sodium hydroxide or is there a concept behind that? Is it only hydrochloric acid and sodium hydroxide that will produce a salt and water?
6. T: Let's take a look at…
7. S: Oh, phenolphthalein. I remember that.
8. T: What is that?

9. S: It’s the…isn’t it a combination of the two…these two items?
10. T: Just tell me, when you saw the phenolphthalein how was it used?
11. S: Uh, for neutralization
12. T: For neutralization?
13. S: Uh huh
14. T: Well, what’s neutralization?
15. S: It’s like…when both cancels out. Like a chemical cancels out another chemical to make like a neutralize…it’s like neither a base or acid

Rita, instantly states when hydrochloric acid and hydroxide combine (4), they make salt water (2).She remembers that phenolphthalein has something to do with this (7). But she does not refer to it as an indicator. When the teacher asked how it was used (10), then she talks about the neutralization (11).I presume that this learning may have resulted from titration lab. Rita explains neutralization as follows: “It’s like…when both cancels out. Like a chemical cancels out another chemical to make like a neutralize…it’s like either a base or acid” (15).

Talia takes us further with respect to the hierarchy of knowledge development. Talia, describes the process as follows.

Excerpt 10 – Talia (post-intervention interview)

1. T: Anything that you found interesting or any comments about this unit on acids and bases?
2. S: Dissociation
3. T: Dissociation! I’m glad you brought it up. Talk to me about dissociation.
4. S: Um, okay. Say..like..okay, you’ve got water, you got acid, and then a base and they break apart.

5. T: Yes
6. S: and
7. T: What's being separated? Specifically in terms of particles?
8. S: Hydrogen ions.
9. T: Yes and what type of ion charge is associated with an acid?
10. S: Positive ions…and with a base is hydroxide…negative hydroxide.
11. T: Can you recall the names of those ions…the name of the positive ions?
12. S: Um, cations.
13. T: And, the negative.
14. S: Anions
15. T: Okay. What about the elements for an acid...that represents an acid and the elements that represent a base?
16. S: Hydrogen, the H+, and OH-

The teacher asks a very general question about the unit on acids and bases? Immediately Talia comes with the term "dissociation (2). The teacher sounds surprised and takes the opportunity to probe Talia what she means by dissociation (3). Talia begins by saying that acid and base break apart (4). Upon the teacher's further probing, Talia names the ion (Hydrogen ions), when dissociation occurs (8).The teacher talks about the ionic charge associated with an acid. Student talks about the positive ion of an acid and negative ion of hydroxide (10).The teacher and Talia talk about anion and cation (19-22). The teacher wants to make sure about the elements of an acid and a base (23).Talia represents the charge for the hydrogen ion and the hydroxide ion (24).

Student Achievement

To determine whether students in the experimental and control groups were similar prior to starting the intervention, a pretest was completed that measured students' conceptions of "acids and bases." The scores on the prior test were obtained and compared using t-tests for two independent samples. The results of this analysis are presented in Table 6.

Table 6

t-Test for Two Independent Samples – Acids and Bases Achievement Prior-Teaching Test by Group Membership

Group	N	Mean	SD	DF	t-Value	Sig
Control	22	5.18	2.26	37	1.13	.267
Experimental	17	4.41	1.91			

The results of the t-test for two independent samples provided no evidence of statistically significant differences between the control and experimental groups on the prior-teaching test Acids and Bases Achievement Test, $t\ (37) = 1.13$, $p = .267$. This result indicated that although the control group ($m = 5.18$, $sd = 2.26$) had higher scores than the experimental group ($m = 4.41$, $sd = 1.91$), the difference was not substantial enough to be statistically significant. Based on this finding, the two groups were considered statistically equivalent prior to starting the intervention.

Following completion of the intervention, the same test was administered to the two groups, control and experimental. The scores on the post-teaching test were compared between the two groups using a t-test for two independent samples. Table 7 provides results of this analysis.

Table 7

t-Test for Two Independent Samples – Acids and Bases Achievement Post-Teaching Test by Group Membership

Group	N	Mean	SD	DF	t-Value	Sig
Control	22	7.50	1.97	37	3.16	.003
Experimental	17	10.65	4.11			

The results of the t-test for independent samples comparing the experimental group (m = 10.65, sd = 4.11) and the control group (m = 7.50, sd = 1.97) on post-intervention test Acids and Bases Achievement Test was statistically significant, t (37) = 3.16, sd = .003. This result indicated that following the intervention, the mean scores for the experimental group were significantly higher than the mean scores for the control group.

To determine the extent to which the experimental group's understanding of acids and bases changed from pretest to posttest, the mean scores for the pretest and posttest were compared using t-tests for dependent samples. Table 8 presents results of this analysis.

Table 8

t-Test for Two Dependent Samples – Comparison of Prior and Post Acids and Bases Achievement Test (Experimental Group Only)

Time	N	Mean	SD	DF	t-Value	Sig
Pretest	17	4.41	1.91	16	7.91	<.001
Posttest	17	10.65	4.11			

The results of the t-test for dependent samples comparing the pre-test mean scores (m = 4.41, sd = 1.91) with the post-test mean scores (m = 10.65, sd = 4.11) on the Acids and Bases Achievement Test was statistically significant, t (16) = 7.91, p < .001. This result provided support that the students' knowledge of acids and bases improved significantly following the intervention of the CKCM.

Implications

The purpose of the study was to determine the effect of the Common Knowledge Construction Model on the alternative high school students' conceptual changes and achievement in a unit on acids and bases. The exploration of students' conceptions of acids and bases at the onset of the study were compared to the students' conceptions gathered after the implementation of a caring relational conceptual change model anchored in phenomenography. Similarly, the experimental and control students' achievement results based on district-wide common assessment in a unit on acids and bases were compared. Based on the results, implications were drawn advocating the adoption of a caring conceptual change model for (a) reaching the often unreached mind; (b) developing simple chemical phrases into coherent chemical explanation; and (c) achieving alternative students' success in traditional test.

Reaching the Often Unreached Mind

The phrase "alternative high school student" invokes feelings that these students cannot be intellectually reached. This is because alternative students enter high school without experiencing academic success. Believing that these students can succeed academically, I moved forward with this study in the context of a teacher preparing for the National Board Take One! a national professional development initiative The teacher's wisdom to use an intellectually caring conceptual change model with students who have not been reached through traditional educational environments is a step in the right direction.

My assumption is that alternative students are very capable of learning, and they deserve the support of teachers who will place instructional value on their ideas. Evidence in this study suggests that using an intellectually caring conceptual change model--the *Common Knowledge Construction Model* (Ebenezer et al., 2010), theoretically rooted in the *variation theory of learning* (Marton & Booth, 1997) is effective in facilitating African American alternative high school students' conceptual changes and achievement in the positive direction. The variation theory of learning posits that learning is relational and involves a qualitatively different approach to understanding a phenomenon.

At the outset of the study, the prior-intervention interview provided a vehicle to identify students' existing conceptions. This assessment provided valuable information that allowed the teacher to begin the process of lesson planning. The exploration tasks and assessment questions were appropriately related to student experiences. The opportunities that the CKCM provides for the teacher to intimately learn from the student and understand their ideas and the context of these ideas is an aspect of care.

The conceptual change data were reported based on three chemical concepts namely, acids, bases and neutralization. With respect to the concept of neutralization, a hierarchy of knowledge development was observed based on the differences between the prior- and post-intervention assessments. The knowledge hierarchy was supported by the change in frequency of the descriptive categories and the addition of new descriptive categories--"neutralization of acid and base" and "dissociation of acid and base." The data revealed that the most apparent conceptual change occurred in the descriptive category of "neutralization of acid and base" (see Table 5). Conceptual change is evidenced when Rita's understanding about neutralization improved (Excerpt 9:5) and when Talia articulated her understanding about dissociation (Excerpt

10:4, 8 and 10). Students demonstrated increased clarity in their thinking and responses to questions related to acids and bases that confirm their conceptual understanding. An example of this is when a student stated that “limestone can be used to neutralize an acidic body of water” (see Table 5). The data support the absence of these conceptual ideas prior to the intervention teaching; however, after the intervention, the addition of new conceptions confirms conceptual change. These examples of change infer the nature of conceptual change and provide evidence that the rarely unreached intellect was reached.

Much care was taken to explore students’ conceptions before and after the acid and base lesson sequence. Students’ prior-conceptions of acids and bases were systematically linked to the district and state science curriculum standards (see Table 2) so that these alternative students have equal opportunity to learn chemistry. Furthermore, the teacher tracked students’ conceptual change by looking at students’ prior- and post-intervention conceptions. Conceptual change reflected reduction and addition of descriptive categories, shift in language use from simple to more sophisticated, and development of knowledge hierarchy.

This study developed a phenomenography of acids and bases using the students’ prior-conceptions like the Ebenezer and Erickson’s (1995) study on solution chemistry. It also tracked conceptual change following Ebenezer and Gaskell (1995) on solution chemistry and Ebenezer et al.’s (2010) study on the concept of excretion. Adopting a caring conceptual change model, although rare, has been highly successful as exemplified by Ebenezer’s former studies and this study with the CKCM is no different, although used with alternative high school students. Exploring the value of a caring model in supporting teachers who also believe academic success is possible was the impetus for testing the CKCM with this group of alternative high school students. What is gleaned from this study is that facilitating a caring conceptual change model is important for students similar to those who attend the Northwood Scholars Academy.

Developing Simple Chemical Phrases into Coherent Chemical Explanation

An example of a simple chemical phrase was when students denoted the dissociation process of acids and bases--giving birth to new chemical species, the H^+ and OH^-. The alternative students have begun to articulate chemical language. It is evident that the teacher also appreciated the students' use of chemical language (see Excerpt 10). A shift from everyday use (e.g., twang) to simple chemical talk (e.g., ions) is noteworthy and commendable. However, we cannot remain complacent about the alternative students' attainment to express their chemical understandings in simple chemical phrases. Teachers need to strive for developing students' simple chemical phrases into coherent chemical explanation.

Chemistry educators have long realized that students struggle to differentiate between macroscopic observation and sub-microscopic explanation and the need to help students to move seamlessly among the three types of chemical knowledge—the macroscopic, the sub-microscopic, and the symbolic (Driver, Squires, Rushworth, Wood-Robinson, 1994; Duit & Treagust, 2003; Kind, 2004). This study has provided a platform to discuss the importance of not only differentiating among these type of knowledge and mitigating the difficulties that student have in the usage of this knowledge, but also achieving the greater aim of helping students to develop and articulate coherent chemical explanations. There was change in the sophistication of the expressed ideas. Instead of saying, "when the lemon juice hits the baking soda," (excerpt:) students following the intervention began to use more sophisticated and appropriate scientific language, such as "when you combine an acid and base, it neutralizes and yields salt and water."

(excerpt) Replacing common language with more sophisticated language directly aligns with the need to explore ideas and expressions of the students prior to teaching the scientific language. Brown and Ryoo (2008) have suggested that when we explore and consider students' social language that they commonly use, it is the first step in enhancing their understanding of new concepts and express these in specialized or academic language. Not only the developing of specialized language is important, but developing specialized language into coherent explanation is even more important (Thagard, 19983).

For this process to begin, teachers ought to listen very carefully and empathetically to students' use of simple chemical phrases to convey their chemical understanding. Just because students use one or two words to express their understanding, a beginning chemical articulation should not be treated trivially. Gradually developing chemical language from simple phrases to more complex forms of expressions should be a priority in a chemistry classroom. Any wonder, the Common Core Assessment for Language Literacy is promoting the idea that writing and reading should be taught in every subject matter, which is a welcoming idea. For example, Lindo (2006) asserts that literacy must be emphasized in subject areas. This should be done in a manner that does not minimize the student rather celebrates successes through small steps in language use. To achieve this, teachers should listen carefully to student talk and strategically help students to reformulate their thoughts, both oral and written, to convey the meaning they are attempting to convey. Many alternative students demonstrated their chemical understanding, but their articulation does not convey the sophisticated level (coherent chemical explanation) that is desired in secondary chemistry class.

Not only teachers listen carefully to students' talk, but the students need to realize that their ideas and the language they use to express their ideas will not be dismissed or looked down.

To dismiss and devalue the language or experiences students share is not complementary to the caring CKCM. Ignoring everyday and/or simple chemical talk not only shuts down the desire of students to share their understandings but also denies a forum for the teacher to begin to help students develop their language into coherent chemical explanation through social discourse in the classroom. Creating an intellectual community for social discourse supports chemistry learning. A teacher needs to create a learning environment where respect and care are expected and demonstrated not only by the teacher but equally expected and demonstrated by students. It is important for teachers to have an awareness of the impact of classroom talk and to facilitate the development of conceptual ideas and usage of more sophisticated conversation in the science classroom (Morton, 2012).

Achieving Alternative Students' Success in Traditional Test

The teacher implemented the intellectually caring conceptual change Common Knowledge Construction Model with the experimental group and implemented traditional classroom pedagogy with the control group. The results of the t-test for independent samples comparing the experimental group ($m = 10.65$, $sd = 4.11$) and the control group ($m = 7.50$, $sd = 1.97$) on post-intervention test Acids and Bases Achievement Test was statistically significant, $t (37) = 3.16$, $p = .003$.Following the intervention of the CKCM, the mean score for the experimental group was significantly higher than the mean score for the control group.

Schroeder, Scott, Tolson, Huang, and Lee (2007) conducted a meta-analysis of national research on the effects of teaching strategies on student's science achievement. In the list of 10 strategies, not even one strategy pertain conceptual change teaching and learning that impact student achievement. As indicated earlier in the need for this study, conceptual change studies are beginning to have a positive impact on student science achievement (Demircioglu, Auas &

Demircioglu, 2005; Ebenezer et al., 2010; Erylimaz, 2002; Sungur, Tekkaya, & Geban, 2001). This is the second time a caring conceptual change model has been tested for achievement. It was a bold move to subject the CKCM to study its effect on alternative high school chemistry learners. The results of this study encouraged me to recommend that similar studies should be conducted to test the efficacy of the CKCM to improve student achievement, including the alternative high school students.

CHAPTER 3

TEACHER PROFESSIONAL LEARNING USING THE COMMON KNOWLEDGE CONSTRUCTION MODEL: ELICITATION, APPRAISAL AND RECONSTRUCTION OF TEACHER PRACTICAL ARGUMENTS

Abstract

Science teacher education research has focused on teacher belief and practice and the nature of interaction between the two in order to encourage teacher change. The purpose of this study is to elicit, appraise and reconstruct a chemistry teacher's practical arguments based on teaching events in an alternative high school chemistry classroom. Practical arguments refer to the integration of teacher beliefs and practices. Data for this study consist of the audio-recordings of the discourse between the chemistry teacher and the researcher (the "Other") as they reflect on the video-recordings of the chemistry teacher's enactment of the Common Knowledge Construction Model acid-base lesson sequence. The verbatim transcripts of the teacher-researcher reflective discourse revealed three major qualitative shifts in teacher practical arguments: (a) inadequate preparedness to adequate preparedness; (b) low confidence to high confidence; and (c) surface learning to deep learning. This practical argumentation study implies that engaging teachers with the "Other" to elicit and appraise practical arguments enables the reconstruction of beliefs and practices through reflection. For successful argumentation, developing mutual trust between the "Other" and the teacher is vital for exposing teacher belief and practice. This research, in general, contributes to the literature on change in teacher beliefs and practices. In particular, this study contributes to practical argumentation research.

Key Words: acids and bases, beliefs and practices, common knowledge construction model, practical argument, teacher professional learning, the "Other" in reflective practice

Introduction

While beliefs have been coined as being the most valuable construct for enhancing teacher practice (Pajares, 1992), it is also one of the most difficult to define because it is interchangeably used with other personal constructs such as attitude (Garmon, 2004), knowledge (Kagan, 1990), and theories and philosophies (Simmons et al., 1999). Thus, the study of beliefs through empirical means is not straightforward (Mansour, 2009). For in-depth discussion of synonymous use of belief and variations in belief--personally connected (Richardson, 1996), externally connected (Fishbein & Ajzen, 1975), and emotionally connected (Nespor, 1987) see Luft and Roehrig (2007) and Pajares (1992). In my study, belief is conceptualized as a personal construction or affiliation (Richardson, 1996). This is because I am attempting to study a chemistry teacher's beliefs through her classroom practice of a reform-based conceptual change inquiry model, referred to as the Common Knowledge Construction Model (Ebenezer, Chacko, Kaya, Koya, D.L. Ebenezer, 2010).

Understanding the twin concepts of teacher belief and practice--belief influencing classroom practice (Fang, 1996; Guskey, 1986) has been an important research focus in science teacher education for years, however, the issue on the nature of interaction between the two still exist (Hashweh, 1996; Jones & Carter, 2007; Luft, 2001; Tsai, 2002; Wallace & Kang, 2004). In fact, observation and experience dictates that belief can be born within practice and practice can inform and change belief. For example, Richardson (1996) emphasizes that the professional development has an impact on teacher belief that can change, modify, or elaborate existing beliefs. Whether it is one way direction or two-way direction the two personal constructs (belief and practice) are lenses to understand classroom events and both should be under critical inquiry.

In science teacher education, teacher belief and practice may be predisposed to either traditional or inquiry teaching and learning. While science education reform advocates teacher adoption of the latter for learner-sake and to achieve learning outcomes (NRC, 1996, 2012), facilitating teacher professional learning to support this sort of teacher practice and teacher change has not evolved with the expediency as desired or even expected. Even if professional learning is provided and teacher accepts the central beliefs, intrinsic drive to change practice encounters challenges (Richardson, 2001).

Tsai (2002) asserts that the beliefs of many traditional science teachers stem from their own science experiences. Trumbull and Slack (1991) note that many teachers fail to change practices because they have experienced success in a traditional education environment. However, the new generation of students is not experiencing the same level of success that many teachers have experienced in their own K-12 science learning. Richardson (2001) asserts that teachers do change, but the change in practice that facilitates improved student learning and academic potential must be accompanied by a change in their beliefs. This change in beliefs may be achieved through immersive practice in inquiry models of teaching and learning. The most successful models for teacher professional learning are those that provide an opportunity for teachers to be immersed in experiences where they must model inquiry forms of teaching (e.g., Buckley, Gobert, Kindfield, Horwitz, Tinker, Gerlits, & Wilensky, 2004; Bybee, 1997; Duschl & Grandy, 2008; Ebenezer et al., 2010).

Reformers argue that professional development must be both intensive and sustained (Hawley & Valli, 1999; Smylie, Bilcer, Greenberg, & Harris, 1998). The National Science Education Standards (NRC, 1996, 2012) and the National Science Foundation programs such the Discovery Research K-12 call for more long-term, coherent teacher professional learning.

Carrying out concrete teaching tasks with students for the study of one's own teaching pays great dividend (Darling-Hammond & McLaughlin, 1995). Teachers having authentic opportunities to learn from and with colleagues within the school is also an asset. Teacher professional learning involves deepening of subject-matter knowledge (Cohen & Hill), pedagogical content knowledge (Shulman, 1986); and epistemology of science (Duschl & Grandy, 2008). To facilitate belief change, both "peripheral or dispositional beliefs and core or coherent beliefs" (Brownlee, Boulton-Lewis, & Purdie, 2002), teacher immersive practice with reform-based models should accompany deep reflection. This deep reflection refers to thoughtful consideration of one's own experiences in applying knowledge to practice while being coached by colleagues in the profession (Schon, 1996). Critical reflection, including self-learning from experience, requires teachers to examine their beliefs and practices continuously. Thus, it is important for teachers to have an open mind for making room for beliefs that are evolving as a result of professional learning.

In a study conducted by Fox, Kidd, Procter, and Ritchie (2009) at George Mason University, an advanced teaching and learning program was designed to provide professional development to educators that emphasizes critical reflective practice advocated by Brookfield, (1995) and Schon (1983, 1987). This program involved collaboration, continuous improvement, and student achievement. The program outcomes were aligned with the five core propositions of the National Board for Professional Teaching Standards (NBPTS) (2010)—see Methods for description. The program included three additional learning outcomes that related to diversity, technology integration, and teachers as change agents. Additionally, a goal of the program was to determine how a portfolio such as the portfolio constructed by NBPTS candidates might reveal the teachers' knowledge and growth that occurred during the portfolio development and certification process and how they applied this process to their practice. The results of the study conducted by Fox et al. (2009) suggest that portfolios can provide insights into whether teachers are truly achieving the teaching and learning goals in their practice and that teachers in this study had understood the importance of reflective practice as a part of their ongoing classroom work. However, I argue that one important component missing from the NBPTS' reflective assessment, is reflection facilitated by the "Other" as evident in the practical argument reflective process (Morgan, 1993; Richardson & Simmons, 1994). Using the voice of the "Other" even with the teacher portfolios, I believe will lead to deeper reflection of the reasoning behind many of the actions in the classroom that leads to student learning. However, teacher reasoning with the "Other" based on the teacher acts in the classroom captured through video-recordings is even more powerful than portfolio evidence. But the drawback is scale-up of this sort of luxurious professional development (Biernacka, 2007; Ebenezer, 1991).

The social process in which teachers inquire about their practice in the company of one or more "others" even in small ways has now been incorporated as a significant feature within many different models of teacher professional development. One such model is practical argumentation (Fenstermacher, 1986). However, apart from Richardson and Anders (1994), empirical studies on practical argumentation are non-existent. Ebenezer and Gaskell (1995) used Fenstermacher (1993) as a theoretical lens to view a chemistry teacher's practice. However, this study did not go beyond the elicitation process of the Fenstermacher's model that involves not only elicitation, but also appraisal and reconstruction. Similarly, Ebenezer (1996) conducted a practical argument study with Christian pre-service teachers and that also did not go beyond elicitation. The study at hand, similar to Richardson and Anders (1994), documents the processes by which a chemistry teacher, called Bonnie, reflects upon her practice as a teacher and researcher in the context of her preparation of the National Board Take One! The primary difference in my study and Richardson and Anders' study is that the teachers' beliefs were elicited prior to intervention. My study is based on retrospective data, meaning that Bonnie's beliefs were elicited only after her enactment of the CKCM acid-base lesson sequence.

In accordance with the guidelines of NBPTS, Bonnie video recorded all of her lessons. Using the videos, the researcher (the "Other") engaged the teacher in reflective practical argumentation. Practical argument is defined as a devise used to assist teachers in examining their beliefs and possibly restructuring them (Fenstermacher, 1987). As opposed to merely complying with policies or minimally enhancing teachers' knowledge, professional learning is focused on developing teachers' professional knowledge, understanding, and abilities to recognize and help students overcome learning problems (Loucks-Horsley, Stiles, Mundry, Love, & Hewson, 2010). One important requirement for ensuring that professional learning is aligned with student outcomes is to focus professional learning on what is actually happening in classrooms, that is, the nature of teaching and learning (Ball & Cohen, 2000; Mumme & Seago, 2002). My study focuses on teacher epistemological beliefs (Hofer & Pintrich, 1997)—how immersive practice with teaching African American alternative students learning chemistry and discussing issues with the "Other" result change in beliefs and practices.

This article first describes the processes by which a chemistry teacher reflects on her professional learning after designing and enacting a lesson sequence on acids and bases using the CKCM (Ebenezer et al., 2010) with urban African American alternative high school chemistry students. The researcher facilitates teacher practical arguments as a vehicle to support reflective practice with the "Other". Results of this study reveal how the teacher and researcher together reflect upon the chemistry teacher's experience as she journeys through district-sponsored professional learning initiative. The study also describes how the learning initiative aligns with the core propositions of the NBPTS and the notions of a university science educator and researcher, who encouraged Bonnie to reexamine learning through the lens of conceptual change inquiry as a way of teaching chemistry. The researcher provides practical recommendations that promote teacher professional learning on “conceptual change learning,” not only through NBPTS-recommended self-reflective practices but also through social reflective practices such as practical argumentation. Finally, teacher practical arguments from this study are discussed and implications drawn for teacher belief and practice.

Theoretical Frameworks

The theoretical frameworks for this study are two complementary conceptual models: (a) practical argument as a reflective practice tool to support professional learning (Fenstermacher & Richardson,1993); and (b) the Common Knowledge Construction Conceptual Change Model (Ebenezer et al., 2010) that the teacher adapted for her classroom teaching.

Teacher Practical Arguments

The first conceptual model that informs this study is based on practical argument. In response to educational reforms spurred by “A Nation at Risk” (NRC, 1983), many researchers have attempted to develop new processes and methods that enable teachers to reflect more deliberately about their practice. Several researchers (e.g. Fenstermacher, Green, & Schon, **?**) have suggested new methods for providing professional development--methods that include reflection as a central component. Both Green and Fenstermacher were leading scholars in the field of educational philosophy. Schon (1991), who was not an educator and did not directly address the field of education or the work of teachers, asserted that the tradition of academia wrongly extended privileges of theoretical knowledge over practical knowledge**.** The aspect of theoretical knowledge over practical knowledge hit a chord with a group of educational researchers who were seeking appropriate ways to describe the work of teaching (Pennington, 2006). This group of researchers described the foundation of pedagogy as a process of practical reasoning. Practical reasoning serves as a critical lens that allows teachers to understand how their subjective theories connect to their practice. Green was the first to use the phrase “practical arguments” as he described competencies teachers needed to influence children’s thinking positively. Fenstermacher furthered the notion of practical arguments in the minds of children to practical arguments in the minds of teachers, and later introduced practical arguments into the contemporary analysis of teaching.

The practical argument process was an attempt on Fenstermacher’s part to encourage teachers to think more deliberatively and robustly about their pedagogical practice. He was trying to find a way to advance teaching practice that respected the beliefs and experiences of teachers while at the same time opening those beliefs and practices to scrutiny and appraisal. This method of practical arguments was initially devised by Fenstermacher and then later enacted and further developed by Fenstermacher and Richardson (1993), Vasquez-Levey (1993), and Morgan (1993). This method of practical argument involved dialogue with the “Other,” such as an educational researcher, who engaged the teacher in dialogue. The goal of this dialogue was to promote enhanced understanding of the subjective theories that underpin teachers’ pedagogical practices. When practicing the method of practical argument, the teacher and the “Other” work through three distinct phases of dialogue: (a) eliciting teachers’ beliefs about teaching, (b) appraising teachers’ beliefs, and (c) reconstructing these beliefs and practices into a more formalized chain of thinking or reasoning (Fenstermacher, 1988; Penlington, 2006). Together, these three processes constitute “practical argument.”

Critics of the practical argument process have questioned its use as a tool for investigating and positively improving teacher reasoning or thinking. Pendlebury (1993) has argued that focusing on practical arguments neglects the skills required for sound practical reasoning, particularly as they pertain to teaching and the fluidity of teacher thinking. However, in spite of criticism, the practical argument model proposed by Fenstermacher and colleagues is not an attempt to depict how teachers actually reason. Instead, practical arguments – as conceptualized by Fenstermacher and Richardson – "are descriptions of practical reasons that the teacher indicates are fair and accurate accounts of why the teacher acted as they did" (Fenstermacher & Richardson, 1993, p. 104). Therefore, the process of engaging teachers in practical arguments is better understood not as a formal tool for evaluating critical thinking but rather as a tool to provide an idealized model for how teachers might explain and reflect on teaching and thereby improve their practice (Penlington, 2006).

Absent within the research literature for the past several years has been empirical research exploring the use of practical arguments. This study attempts to (a) explore the use of practical arguments to engage a teacher and the "Other" (the researcher) in discussing an aspect of the teacher's practice, (b) construct a practical argument by eliciting and developing the premises that underpin the teachers' practice, and (c) seek ways of improving practice.

Fenstermacher (1999) stated that "one of the most powerful ways to prevent our images of teaching and our teaching practices from being captured by the systems where we work is to stand away from our experience and reflect on it." Fenstermacher believes that the use of practical arguments will generate capacity for this reflection. It is through this reflective practice that teachers can reconsider or reconstruct their teaching experiences and advance the understanding of their teaching. The phases of practical arguments are described in greater detail as follows.

Phase I: Elicitation. The first phase of the practical argument process is called elicitation. In this phase, the “Other” seeks to elicit the practical argument from the mind of the teacher. During this phase, teachers build a framework that characterizes and describes their reasons for acting (Fenstermacher & Richardson, 1994). Practical arguments are created *post-hoc* and generally occur sometime following the enactment of the lesson. During this phase, teachers review and describe the teaching enactment and attempt to explain or justify the teaching incident. During this time, the “Other” avoids making judgments or value statements as much as possible. Teachers explain the reasons for the actions they took and the decisions they made while delivering the lesson.

In the elicitation phase, many practical arguments begin with the teacher and the “Other” viewing a video of the instructional lesson. This facilitates dialogue and elicitation of beliefs about approaches to teaching and student learning, which begins the construction of the practical argument. During this process, teachers can be sensitive about their practice and reluctant to discuss their thoughts. Therefore, when engaging in the practical argument process, it is important that the teacher trust the “Other”. If this trust has not been established, the honesty required to ensure the success of the process may be compromised. The questions posed by “the Other” provide guidance in order to elicit a complete practical argument, which includes not only providing explanations but also examining beliefs. These beliefs aligned to four premises (Richardson & Anders, 1994):

> The *value premise* is a statement of the benefit to be derived from an action. The *situational premise* is a statement that describes the context in which the teacher’s

> action takes place. The *empirical premise* is a statement that makes a claim about the world, and is thus is subject to scrutiny, usually in the form of a test of some kind. The *simulative* premise incorporates the ways teachers make meaning out of their work (p. 34).

During this phase, the “Other” is needed to assist the teacher through this thinking process. This is difficult for the teacher to do on her own since beliefs are often hidden from their awareness. However, it is through dialogue with the “Other” that teachers can make their beliefs visible or explicit and later begin the process to appraise and reconstruct their beliefs and actions. The “Other” uses both open- and closed-ended questions during the elicitation phase. Literature on teaching, classroom management and organization, student learning and pedagogy, provided alternative premises as the “Other” facilitated dialogue and thinking from the elicitation to the appraisal phase of practical argumentation with the teacher.

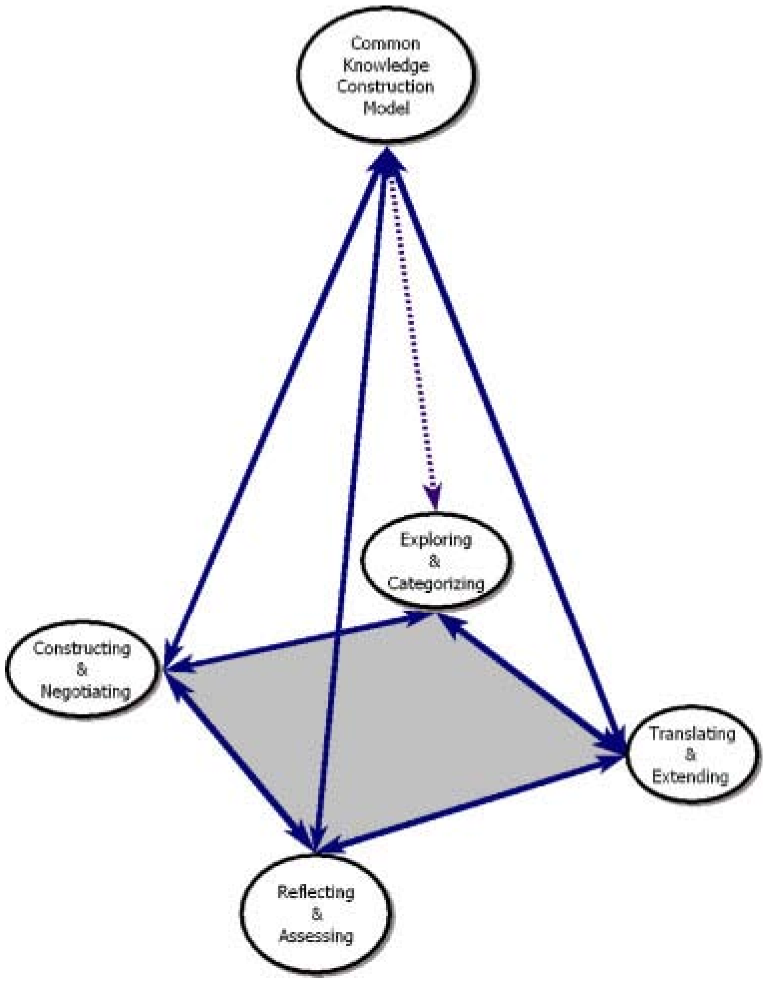
Phase II: Appraisal. In this phase, the “Other” asks questions designed to help teachers articulate issues and ideas that until now may not have been considered by the teacher. This is an important step in the practical argument process as this is where the “Other” assists the researcher with aligning the argument to contextually defensible standards of teaching and learning. This is when the teacher begins to recognize the reasons behind their actions and engages in dialogue with the “Other” that supports a different perspective from their original premise. These appraisal conditions are very important as the “Other” addresses the teacher and his or her actions that have moral, stipulative, empirical, and situational dimensions (Fenstermacher & Richardson, 1994).

Phase III: Reconstruction. In this phase, the “Other” introduces alternative premises and practices for the teacher to add to his/her repertoire of teaching practices. In this process, the old premise may be rejected or reconfigured or elaborated. This reconstruction occurs most often when the “Other” begins to probe and check the elicited argument along normative dimensions and introduce new premises and practices for teacher consideration. As a result of engaging in this process, they jointly construct a revised practical argument. During the reconstruction phase, classroom observations of previously videotaped instructional lessons may be reviewed several times and assessed to track teacher change.

Penlington (2006) asserted that the practical argument model offers experienced teachers a valid method of reflecting on their practice and engaging in meaningful discourse. The practical argument model draws upon relevant educational research and a broad humanistic theory as a way of establishing the criteria used to evaluate quality teaching practices.

Intellectually Caring Common Knowledge Construction Model

The second conceptual model that informs this study is the Common Knowledge Construction Model (CKCM).Ebenezer and Connor (1996) developed the CKCM to enhance and improve both teaching and learning, which is rooted in Phenomenography, the *Variation Theory of Learning* (Marton, 1981; Marton & Booth, 1997). The CKCM consists of four interactive phases of teaching and learning: (a) exploring and categorizing (b) constructing and negotiating, (c) translating and extending, and (d) reflecting and assessing. The CKCM accords students intellectual freedom to propose, assess, revise, and shape ideas about natural and socio-scientific phenomena. These characteristics of the CKCM signify the aspects of care that general theorists have deemed important and relevant for intellectual development (Gay, 2010; Hull, 1997; Littky,2004; McCroskey, 1992; Noddings, 2005).



Culture – Culture Pedagogy

Figure 1. The Common Knowledge Construction Model (Ebenezer et al., 2010. Modified to include culture-culture pedagogy)

Each phase of the CKCM reflects the principles of caring. Therefore, the present discussion of the various phases of the CKCM provides explicit links to the concept of "caring" as an important component within education (Ebenezer & Connor, 1998; Ebenezer et al., 2010).While the goal of CKCM curriculum design and pedagogy is to emulate the inquiry practices and processes of the scientific community, the burden of helping all students learn science while applying principles of care is even greater. This particularly applies when attempting to reach science students who often have been neglected. Caring requires a learning environment that accommodates conditions, contexts, activities, structures that promote, nurture, and support reasoning practices among students. Such practices promote a community and culture of learning that provide students an educational context with which they can identify (Honig & McDonald, 2005; National Academy of Sciences, 2002; Noam, Biancarosa & Dechausay, 2003).

Phase 1: Exploring and Categorizing. Phenomenography is a way of examining phenomena from an experiential perspective. It embodies a viewpoint in which relationship plays a central role in understanding any phenomenon--a relationship between the conceptualizing individual and the conceptualized phenomenon. Phenomenography allows for and accommodates the possible variations in relational conceptions that individuals hold about a phenomenon. Phenomenography de-emphasizes a strong concern for the developmental mechanism that created this variability. Phenomenography may be used as an inquiry tool for the generation of conceptions of a natural phenomenon. Phenomenography advocates the development and use of second-order questions in order to explore students' conceptions. Using this approach, students can explore their ideas using one or two everyday tasks that are related to each other.

To explore students' ideas of acid-base concepts, for example, teachers may show students a picture of a factory with gases coming out of the smoke stack and rain falling on the factory. The teacher may ask second-order questions based on the picture: "What sense do you make of this picture? Can you see what is happening?" More complex questions might be as follows: "What do you think happens when gases and water mix? How might the combination of gas and water affect the environment?"

When students make emotional connections to environmental issues through an activity, they are provided with opportunities to demonstrate caring practices and value the concepts they are learning. To simulate scientific inquiry and practice, students can be provided with opportunities to explore their ideas. In doing so, students can begin to understand that science is an attempt to explore and explain natural phenomena. With this in mind, teachers can interpret students' ideas with intellectual empathy, not judge them based on whether those ideas are "right" or "wrong," as might occur when applying a diagnostic or deficit model of conceptual change learning.

When applying this model, a teacher finds within the pool of students' expressions personal ideas with inter- and intra-variations. Teachers and researchers can then identify commonalities in meanings and place them into "phenomenographic categories" (Marton & Booth, 1997; Marton & Tsui, 2004). These categories are ways of denoting researchers' interpretations of students' conceptions of a phenomenon. These categories consist of qualitative and quantitative components. The qualitative components consist of the descriptions within each category, and the quantitative components consist of the frequency distribution related to the categories (Renstrom, 1988).

According to Ebenezer et al. (2010), taking class time to explore all students' personal ideas about a science phenomenon using tasks that represent their experience while interpreting and categorizing those ideas with intellectual empathy before beginning a sequence of lessons symbolizes "pedagogical care" Hull (1997). In this way, according to McCroskey (2009), teachers demonstrate care in the classroom that students recognize and to which they respond. In phase one (exploring and categorizing), teachers make a first attempt to reach all students, including the majority/minority, privileged/under privileged, culturally rich/poor, and regular/alternative education students. Littky (2004) has confirmed and supported the value of caring in the classroom. McCroskey (1992) has pointed out that even more important than actually caring for students is ensuring that students perceive they are cared for by their teacher. Students perceive that teachers care for them when teachers demonstrate willingness and a capacity to view a situation from students' perspectives and experience how they feel about it (i.e., the ability to comprehend their ideas, feelings, and needs). Pedagogical caring and students' perceptions of whether they feel cared for are built into the CKCM. Students enter into the construction and negotiation phase with the confidence that their teachers care for them, respect their values, and respect their ideas.

Phase 2: Constructing and Negotiating. Phase two (construction and negotiation) begins when students experience confidence as a result of knowing that the teacher cares for them and respects and values their ideas. Students share their personal ideas in class so that peers can evaluate the merits of these ideas in an open forum through a process of construction and negotiation. According to Ebenezer et al. (2010), exposing their conceptions to the teacher and peers for critical inquiry is a sign of strength not weakness. Scientific explanation based on students' conceptions occurs in this phase. According to Gay (2010), simply telling student information or providing them with structured knowledge does not suffice. Rather, Gay has asserted that providing a learning environment in which students feel cared for is probably one of the most influential factors in supporting the development of scientific knowledge among all students. This author believes when teachers attend to their students, care about who they, and care about how they are performing, this creates an environment that enhances students' desire to learn and succeed academically. The CKCM provides a framework to support teachers in demonstrating this level of caring.

In the second phase of the CKCM, students construct and negotiate understanding students' discourse. Students' critically analyze and engage in discourse with each other and the teacher in the classroom community, they continue to expose their conceptual variations. Therefore, the teacher encourages, guides, and challenges students to participate in a community of inquirers generating and validating conceptions of scientific ideas. Students then gain self-confidence because they witness themselves developing and constructing their own ideas. The teacher encourages students to communicate their scientific understanding using the multi-modal representations with which they are comfortable. This level of engagement and care is important for all students, particularly those who are disadvantaged. Their self-esteem and confidence have eroded over time, resulting in a lack of success academically in traditional schools. Having high expectations and simultaneously demonstrating caring practices that reinforce the message that students are cared for and valued is very important in alternative education settings. During this phase of the CKCM, students who are "in the cradle of care" and nurtured by a "caring teacher" can recognize the importance of constructing and negotiating meaning and allow themselves to be vulnerable. This vulnerability allows student to engage in conversations that expose and challenge their ideas because they are secure in a caring environment and a caring structure created by the teacher.

Through the experiences students encounter in Phase 2, they become aware of how they construct scientific knowledge and how conceptual change occurs. Students recognize that conceptual change occurs when they question their original conceptions based on everyday contexts and submit their ideas to critical thinking processes, inquiry, and peer review. Students also realize that collaborative time and effort are required as well as empathy towards fellow learners when formulating scientific ideas. Furthermore, teachers understand that if students show “situational interest” (Swarat, Ortony, & Revelle, 2012) in learning science, conceptual change may be facilitated. Teachers build meaningful bridges from the students’ cultural values to the culture of science. Teachers continually monitor and adjust the lesson sequence for future instruction based on their sense-making of students’ evolving conceptions and understandings.

Phase 2 of the CKCM manifests caring by creating a learning environment in which students clearly perceive that the teacher cares and supports discursive practice. As teachers engage students in dialogue, they learn about their needs, working habits, interests, and talents. Teachers gain valuable ideas from students about their understanding and then use that knowledge to build meaningful and targeted lessons along with plans for individual student progress. In these ways, the CKCM inspires authentic caring teachers to increase their own competence to support student conceptual change.

Phase 3: Extending and translating. Phase 3 of the CKCM helps students extend and translate their knowledge. Gay (2010) has described one of the tenets of culturally responsive caring as action provoking. During the third phase of the CKCM, teachers ask students to recognize and remain in a learning environment that fosters caring, but now they are asked to extend their thoughts into actions. In Phase 3, students use their ideas to identify issues that impact their own lives and the lives of others.

In this phase, students work collaboratively and cooperatively with empathy for each other’s ideas, processes, and values while exploring community-based socio-scientific issues. Encouraging students to collaborate in making responsible decisions and taking collective action is crucial for all students in science classrooms. In this phase, students are nurtured to develop a critical-thinking disposition through scientific inquiry and problem solving. Personal responsibility from students is elicited via a reflective process based on their values. The types of concerns and issues they value and for which they will be responsible and reflect upon will emerge as a result of the caring environment and meaningful discourse (Noddings, 1992). Students must also perceive that the responsibility they are demonstrating is acknowledged and that their insights are understood, shared, and valued. The CKCM supports a social, intellectual, and ethical progression from (a) self-centeredness to (b) ethical partnerships to (c) ethical caring/support to (d) ethical decision making at a global level. Through school-community partnerships, all students can experience an ethically caring environment that enables them to make intellectual decisions and take action in community affairs (Ebenezer, Kaya, & Ebenezer, 2011). These authors believe that by ushering deprived students into the scientific community of practice through community partners, they are pointed to STEM higher learning and STEM careers.

Phase 4: Reflecting and assessing. The fourth phase, reflecting and assessing, is integral to exploring and categorizing students' conceptions, constructing and negotiating shared common knowledge, and translating and extending students' understanding of science concepts into the study of personal and socially relevant scientific and socio-scientific issues. Traditional assessment options, such as fill-in-the-blank items, multiple-choice questions, true/false questions, and matching questions, require students to regurgitate information and provide "the right answer." These methods do not serve as effective assessment practices for conceptual change inquiry teaching and learning, especially when that teaching and learning environment underscores aspects of caring. In the conceptual change inquiry process, assessments should measure how students explore, expose, revise, or reject their conceptions based on evidence and explanation. Measurement should track the small steps that students take to understand difficult science concepts and make conceptual changes. Assessments should determine how effective teaching has been in terms of initiating conceptual change, identifying which concepts need to be further explored, and clearly observing how students use the understood concepts. This assessment information is necessary to design, conduct, and evaluate scientific and socio-scientific inquiries that have personal and social relevance. Measuring these processes of learning continuously and reflectively is vital. Teachers and students both need to engage in formative assessments that enable students to consider *how* they know *what* they know regarding “knowledge claims communicated in science” (Ruiz-Primo & Furtak, 2007, p. 64).

Caring is manifested in this phase when students engage in experiences that confirm *what they know* and, perhaps just as importantly, *how they know* a concept. Noddings (2009) has suggested that teachers should care about not only the knowledge goals for which students are striving but also the ways that students go about achieving these goals. The use of formative assessments is one way that teachers and students can measure continuous and reflective learning. Encouraging and confirming, as highlighted by Noddings (1992), is an integral part of the assessment process.

Problem Statement

Fenstermacher (1986, 1994) suggests that conducting teacher research without addressing their beliefs is often useless and rarely changes practice. He reasons that the value of educational research to support practice is evident when the teachers’ beliefs about the nature of teaching practices are explored and reflected with the aid of the “Other.” Practical argumentation serves as a tool for facilitating change in teacher beliefs and practices. Ebenezer and Gaskell (1995), in their study of one single chemistry teacher in Canada, argue for practical argumentation as a theoretical lens for teacher change as opposed to applying a constructivist model that is used to change student “misconceptions” (Stoefflet). This is because, in science learning, we expect students to be honed into the learning of theoretical constructs, whereas, the study on teacher pedagogical knowledge change and practice, the purpose is to provide alternative frameworks to be included in their repertoire of teaching. Hence, I believe that practical argumentation is a sensible way to elicit teacher beliefs and show them alternative frameworks for reconstruction.

In this study, practical argumentation is used to engage an African American chemistry teacher (Bonnie) to reflect with the "Other" to uncover her beliefs about chemical pedagogical practice pre- and post-intervention of the CKCM lesson sequence on acids and bases. I report Bonnie's practical arguments that arise as a teacher converses with the "Other" about teaching chemistry to alternative high school students. Among the scarce studies found in the literature on practical arguments, Ebenezer and Gaskell (1995) focused on the prior teacher beliefs. The study at hand goes beyond and appraises Bonnie's beliefs and captures the reconstructions. Furthermore, this is the only study situated in a chemistry classroom at the secondary level with urban African American Alternative Education students.

The current study adopts Richardson and Anders (1994) study on the elicitation, appraisal, and reconstruction of practical arguments on reading pedagogical practices. This study elicited English reading teachers' beliefs prior to any intervention. A retrospective study was used in the present research. Only after the implementation of the acid-base lesson sequence by the teacher for her own preparation for the National Board Take One!, did the researcher engage the teacher in discourse using the classroom video-recordings to elicit her changed beliefs. Thus, this in-depth study focused on one chemistry teacher's beliefs about her practices as she designed and enacted an acid-base lesson sequence using the CKCM. The following research question frames this study:

What practical arguments does a chemistry teacher advance as she dialogues with a researcher (the "Other") about her enactment of the CKCM acid-base lesson sequence in an alternative classroom context?

Significance of the Study

The study is significant for two reasons:

First, a narrative of one chemistry teacher's practical arguments about teaching a group of alternative high school students on acid-base lesson sequence with the CKCM may provide insights that may inspire and inform other science teachers to engage in practical argumentation with the "Other" for their own professional learning.

Second, a chemistry teacher's conversations with a researcher using video-clips add another piece of research evidence to the literature on reflective practice through practical argumentation for teacher professional learning.

Methods

The National Board Take One! is described because the data that Bonnie collected in the context of her preparation for Take One! are used for this retrospective study on practical argumentation. Then the context of an alternative high school in which Bonnie enacted the CKCM acid-base lesson sequence is described to portray the sub-culture of the students in which this study on practical argumentation takes place.

The National Board Take One!

The National Board Take One! was introduced in Northwood Schools during the 2009-2010 school year. Take One! is the first step toward the National Board for Professional Teaching Standards Portfolio Development Process (NBPTS). The overall purpose of Take One! is to support teachers with standards and procedures to improve their teaching practices.

Northwood schools partnered with the National Board to support over 180 teachers in this program and Bonnie was one of them.

Like the full NBPTS certification process, the Take One! Professional learning program is based on the following fundamental tenets (NBPTS, 2010): Evidence-based teaching, five core propositions, the NBPTS standards, and the architecture of accomplished teaching. *Evidence-based teaching* is a way of structuring classroom planning and instruction that allows teachers to continuously collect, interpret, and use evidence of student learning to make decisions that guide future instruction. *The five core propositions* are the foundation and guide the work of National Board. They are as follows: (a) teacher commitment to the learner and learning, (b) teachers knowledge and the ability to teach subject matter, (c) teacher responsibility to manage and monitor student learning, (d) teacher systematic thinking about practice and learn from experience, and (e) teacher membership in learning communities. These core propositions describe the core characteristics of an accomplished teacher and are at the heart of the National Board certification process.

The NBPTS standards for teaching science are as follows: Teachers believe that all students can learn. Teachers know the unique characteristics of their students and use this knowledge to determine students' understanding of science and to design and implement appropriate instruction to enhance student learning. Teachers take steps to understand and value the diversity of all students and know that providing each student with equitable access to an empowering science education requires responding effectively to diversity. Teachers understand and use a variety of instructional strategies to enhance student learning and help students make real-world connections from their scientific explorations. Teachers believe and understand that learning is maximized when students and teachers engage in dialogue while working jointly. In such dialogue, accomplished science teachers assess individual students' abilities and provide the assistance necessary for students to accomplish a given task. Teachers involve students in the processes of inquiry and understand that inquiry itself is not a uniform series of predetermined steps. However, in this process, students learn to recognize problems, ask relevant questions, formulate working hypotheses, and determine the best way to observe phenomena, handle data accuracy, reach conclusions and express themselves clearly about the significance of findings. Teachers employ a variety of assessment methods to obtain useful information about student learning and development to guide instructional decisions, and to assist students in reflecting on their own learning. Teachers understand that they should be reflective practitioners who constantly strive to become masters of their profession by analyzing, evaluating and strengthening their practice in order to improve the quality of their students' learning experiences.

The Architecture of Accomplished Teaching represents the relationship between the five core propositions (see above) and the NBPTS and accomplished teaching practice. An important element of accomplished teaching is <u>reflecting on one's practice</u>. The National Board expects teachers to consider nine fundamentals when completing their portfolio entry which requires rich reflection on practice. I outline the fundamentals that are pertinent to my study: reflect about the students' knowledge; reflect back to lesson goals; provide evidence and examples of student learning.

Table 9 presents four key characteristics of each of the reflective models (The CKCM, Practical arguments, and National Board Take One! Each adopts core beliefs and values. Each recognizes the importance of discourse and reasoning with an expert "Other". Each garners classroom evidence via video-taping.

Table 9

Comparison of the tenets of intellectually caring Common Knowledge Construction Model, practical arguments, and the National Board for Professional Teaching Standards Take One!

Common Characteristics	Intellectually Caring CKCM	Practical Arguments	National Board Take One!
Core Beliefs and Values	An empathetic, non-judgmental teaching and learning model throughout all four phases	Elicitation of teacher beliefs about teaching Appraisal of said beliefs Reconstruction of beliefs into a more formalized chain of reasoning	Commitment of teachers to diversity Teacher responsibility for managing and monitoring student learning
Dialogue	Dialogue with peers and teacher	Dialogue with the "Other"	Dialogue with student peers
The Use of Video and Prompts	The CKCM is a model that requires both classroom video-taping and collection of artifacts to capture the enactment of the lesson sequence or series	Video-clips are used to reflect on the pre- and post-lesson enactment	Video capture of teacher implementation of lesson sequences
Reflective Practice	Teacher and student reflections through journaling and formative assessment	Teacher change involves elicitation of prior beliefs, appraisal by others, and reconstructions by self through the medium of reflection on their practice	The teacher reflects and constantly strives to become the master of their profession by analyzing, evaluating, and strengthening their practice in order to improve the quality of students' learning experiences. (NBPT, 2010)

The professional learning experiences aligned to this study with one chemistry teacher mirrors the professional development offered to teachers in Northwood Schools. In Northwood Schools, teachers who elect to become candidates actually become teachers-as-researchers and reflective practitioners within their own classrooms. Teachers also convene in small groups by grade level or content area to study classroom practices by watching videotapes of classroom teaching and engaging in conversation that point to evidence of accomplished teaching and the core propositions of National Board. Teachers apply their enhanced view of teaching and learning to their classroom practices. As a result of this discursive and reflective conversation, teachers learn from each other and develop professionally.

The portfolio process for secondary science teachers completing the Take One! portfolio, requires that they submit one 15-minute video recording that portrays the teacher engaging students in a discussion that focuses on the interpretation of scientific data that has been collected during student scientific investigation. The scientific discussion takes place in the context of a small group of students or a whole class with the teacher or a combination of both. Additionally, the teacher must write a commentary paper that provides a context for the video recording that describes, analyzes, and reflects on the discussion and students' development of inquiry skills (NBPTS 2010) represented in the lesson.

The teacher in this study was inspired to reflect on her practice beyond the requirements of Take One! by videotaping lessons to capture an entire sequence of lessons for analysis and reflection with a researcher. The analysis used for this professional learning was Practical Arguments.

Northwood Scholars Academy

Bonnie works in an alternative school. Many of the students entering the Northwood Scholars Academy (NSA), an alternative high school in Northwood Public Schools, are on the cusp of losing hope of ever escaping the turmoil of prior life experiences, and for some, the turmoil that still exists in their young lives. Consequently, for those who have lost hope, do not have positive relationships, or have someone who they feel cares for them; their academic growth becomes secondary or non-existent. The students who enter the Northwood Scholars Academy are behind academically and most are at the crossroad of dropping out of school physically or emotionally. Their turmoil is often the result of physical or sexual abuse, pregnancy, stress of a depressed economy, along with some who are living amidst the confusion of family mental health problems. These are the academic, social, emotional and psychological baggage that are a part of the life story of students entering and matriculating at Northwood Scholars Academy.

Because of their deviant backgrounds, students who attend Northwood Scholars Academy enter as a result of failure in previous learning environments. They are branded as individuals who could not cope with the demands of learning in the comprehensive schools. Most have been on an academic trajectory of poor achievement, coupled with poor attendance and unacceptable behavior in and out of school. The story of each student prior to attending Northwood Scholars Academy often was filled with anger, confusion, hurt, transience, poor instruction and dysfunction, all too often, precipitated by the adults who are in their lives. The life passage of many students at Scholars Academy, and their lack of experience handling the challenges of life, creates a scenario that allows many of these dysfunctions to filter into their school life and unfortunately prohibit or counter support academic success. Over the past 15 years, Northwood Scholars Academy has consistently improved this important component of caring that ensures each student experiences positive relationships with adults at the school.

Bonnie is quite proficient in experimental design and conducting controlled experiments. Therefore, she launched into her personal quest to study her practice using the CKCM as the teaching intervention with the National Board as the vehicle to study her practice. During the 2010-2011 school year, Bonnie started her professional learning with the developer of the CKCM and the Northwood School District’s initiative with National Board Take One! Bonnie did not complete her Take One portfolio during the 2010-2011 school year, however she was committed to continue her quest to complete it during the 2011-2012 academic school year. At the beginning of the 2011-2012 school year, she learned she was assigned to teach a general science elective class with a chemistry focus for the first semester. She implemented CKCM acid-base lesson sequence in the fall of 2011 that manifested a better understanding of the CKCM compared to the acid-base unit that she implemented the previous school year. This allowed her to repeat the unit on acids and bases, and design a lesson sequence based on the four phases of the CKCM.

An added attribute is Bonnie's background and experience in social work and multicultural education. Her knowing the culture of African-Americans and the sub-culture of alternative high school students was essential to this study. Her interest in teaching methods designed to improve student conceptual understanding for all students in the first place led her to the pedagogy of the CKCM to improve teaching and learning. She mentioned often how the term empathetic learner and empathetic teacher resonated with her. She was, therefore, eager to investigate the implementation of the CKCM in her classroom. She heard this phrase in the context of a district-wide professional learning when the developer of the CKCM introduced it to secondary science teachers in Northwood Public Schools. Recognizing the value of the teaching model, Bonnie pursued a deeper understanding of it while pursuing the NBPTS Take One! that supports professional learning through classroom based research.

Teacher Professional Learning

Throughout this study, Bonnie was coached to implement the CKCM by a professor in the science education department at Wayne State University (WSU). Professor Ebenezer helped Bonnie with the pedagogical practices of the CKCM. In particular, she went to Bonnie's school and modeled how to ask probing questions to explore students' conceptions. She also helped

Bonnie develop worksheets to explore students' conceptions of all students in her classroom. On other visits by Professor Ebenezer to the school and Bonnie's visit to the university, Professor Ebenezer also clarified Bonnie's understanding of the sub-microscopic and symbolic aspects of acid-base chemical content. The researcher of this study, who is a district administrator, coached Bonnie prior to classroom implementation of the acid-base CKCM lesson sequence on the procedural expectations of the NBPTS Take One! and assisted with the alignment of the lesson sequence to the District Curriculum.

For this study it was also important to keep four factors in mind as Bonnie enacted the study to develop professional learning. They provided: (a) assistance appropriate to the characteristics of the alternative high school students and the physical facilities of the classroom; (b) content-based pedagogical practice support; (c) a reflective process over time; and (d) support for teacher transformation during the period of practical argumentation (elicitation, appraisal, and reconstruction).These characteristics were carefully integrated into each of the three phases of the study while Bonnie was immersed in the study of her own teaching practice.

Phase I: Coaching the Teacher. Bonnie conducted a pilot study in the first year to develop deeper understanding of the four phases of the CKCM that espouse conceptual change. Based on this experience Bonnie adapted an existing, standards-based seven-week long chemistry unit on acids and bases into a CKCM lesson sequence in year 2 of her in-depth study. Bonnie reviewed the concepts of acids and bases with the help of Professor Ebenezer. The classroom learning environment was structured in order to support the intellectual care alternative high school students will need for successful learning of chemistry during the implementation of the CKCM. The researcher was also coached by Professor Ebenezer throughout the period of this study. The assumption was that these strategic steps in professional learning will enable Bonnie to know and be able to practice the CKCM conceptual change inquiry approach to science teaching and learning science while paying attention to the issues of the Alternative African-American students.

In Phase I, the researcher regularly coached by Professor Ebenezer spent four weeks meeting two or three times each week with Bonnie to collaborate on the design and development an acid-base CKCM lesson sequence. They also met in the virtual space through Skype to discuss issues in the lesson sequence design and development. They also shared components of lesson sequence through e-mail attachments. Each session of the teacher-researcher conversation to discuss the design and development of the lesson sequence was audio-recorded for future analysis.

The lesson sequence was framed with the following conceptual structures pivotal to the study of acids and bases: classification of acids and bases, writing of formulae and equations, including ionic forms, and chemical reactions. These core concepts were expected to facilitate understanding of the concepts specifically related to acids and bases such as neutralization, pH and indicators, strength and concentration along with ionic representation.

Phase II: Enactment of the CKCM Acid-Base Lesson Sequence. Bonnie implemented the acid-base CKCM lesson sequence, conscientiously integrating caring practices. Although the researcher did not gather data in Bonnie's classroom each week of the unit implementation, the researcher observed the video-recordings consisting of the classroom enactments and student engagement in the lesson activities. The researcher prepared a narrative of the each of the video-recorded lessons.

Phase III: Practical Argumentation Study. Following the enactment of the entire lesson sequence using the video-recordings of lessons and the narratives of the teacher enactment, the researcher conducted practical argumentation study with Bonnie. Embodied in this process are the three steps necessary to engage Bonnie in meaningful reflection and reasoning about her beliefs and actions. The three steps are: (a) elicitation of the argument, (b) appraisal of the argument and (c) reconstruction of the argument. All of the conversations with the teacher were audio-taped and transcribed verbatim. Based on these transcripts, the premises of the practical argument were identified and matched with the definitions of the premises:(a) value – the benefit or good to be derived from the action (b) stipulative premise – statements that establish meaning, (c) empirical – statements that are subject to empirical scrutiny and (d) simulative – statements that describe the context in which the action takes place.

The researcher made connections from the teacher-research practical argumentation interview transcriptions to the individual interview transcriptions of students' conceptions of acids and bases and prepared evidence of teacher reconstruction of her thought and action. The practical argumentation with the "Other" complements the current process of the National Board Take One! professional learning, which requires teachers to reflect in groups on their practice. However, I believe that adding the <u>expert</u> "Other" as portrayed in this study and following the practical argumentation – elicitation, appraisal and reconstruction provides a deeper analysis for facilitating change in teacher practice.

Table 10 identifies the above three phases of Bonnie's profession learning. The first phase was designed to <u>coach</u> the researcher and Bonnie to implement the CKCM in the context of her district professional learning related to National Board for Take One! The second phase was designed to <u>facilitate support</u> to the teacher by Professor Ebenezer. The design of this study did not allow the doctoral candidate researcher to participate in any of the lesson enactments. It was an integral part of the design of this study to have all lessons video-recorded in the context of Bonnie’s preparation of the National Board Take One! to conduct the practical argumentation study through teacher reflective practice. The third phase of the study was completely dedicated to practical argumentation through video-recordings and the subsequent review and analysis of the verbatim transcripts of audio-recordings of teacher in terms of identifying practical arguments.

Table 10

Support Structures for Scaffolding Three Phases of the Practical Argumentation Study for Teacher Professional Learning

Expert Intervention	**Pilot Study—Year 1: Implementing an acid-base unit**	Duration of Time
	Content of Professional Learning	
Session 1: Seminar for two teachers by University Faculty	Developing understanding of the Common Knowledge Construction Model	2 hours
Session 2 University Faculty and Researcher	Developing understanding of the Common Knowledge Construction Model	2 hours
Session 3 University Faculty and Researcher	The development and alignment of the Acid Base Achievement Test	2 hours
Session 4 University Faculty and Researcher	The content and District chemistry curriculum on acids and bases	2 hours
Session 5 University Faculty	Exploration phase – data review	2 hours
Session 6 University Faculty	Acid Rain Lesson Implementation	Virtual Support 2 hour
Lesson 7 University Faculty and Researcher	Review data of pilot implementation	Virtual and local support 4 hours

Expert Intervention	**Year 2 Study Phase I: Coaching the Teacher**	Duration of Time
Session 8 University Faculty	Prepare for fall implementation with targeting coaching related to the exploration phase of the CKCM. The interviews with students and the process of identification of themes or categories to commence teaching.	3 hours
Session 9 University Faculty	Coaching on chemistry content to allow for deeper understanding and extended questions related to dissociation and neutralization.	3 hours

Expert Intervention	**Phase II: Enactment of the CKCM Acid-Base Lesson Sequence**	Duration of Time
Session 10 Teacher implementation aided by university faculty	Teacher implementing the acid-base CKCM lesson sequence Modeling phenomenographic individual interviews with students Coaching on chemistry content to allow for deeper understanding and extended questions related to dissociation and neutralization. Matching students' conceptions of acids and bases to Michigan curriculum	7 weeks
	Phase III: Practical Argumentation Study	
Session 10-16 Researcher	Reviewing video-recordings of enacted lesson Professional learning about practical arguments Dialogue on each video recording to prompt conversation that would elicit, appraise, and reconstruct teacher premises, teacher reflections and reasons for actions and beliefs evident in the video-recordings for appraisal and then reconstruction.	2 hours each for a total of 14 hour

Data Collection

As mentioned before, this research study took place in the context of a teacher's quest to study her own practice in the context of getting ready for the National Board for Professional Teaching Standards Take One! The National Board Take One! Table 11 summarizes data collection

Table 11

Qualitative Data Collection Summary

Teacher's Data Collection	**Researcher's Data Collection**
Video-recordings classroom lesson enactments.	Reviewed video-recordings for each lesson enactment.
Collected formative assessments and classroom artifacts.	Wrote narratives of each lesson based on vide-recordings.
	Audio-recordings of teacher-researcher conversations with video-recordings

Data in the form of video-recordings of classroom enactments were provided by Bonnie to the researcher. The researcher wrote a narrative for each video-recording to summarize the content of each lesson. The researcher engaged Bonnie in the practical argumentation study using her video-recordings. Video-clips were used to serve as prompts in generating Bonnie's thoughts and reasoning and thought underpinning actions during the enactment of a lesson and her engagement with students in the classroom.

Data Analysis

Teacher-researcher conversations were transcribed verbatim and reviewed later by the researcher to identify key issues surrounding which argumentation took place. Practical arguments were isolated within each issue from the passages of each verbatim transcript. Premises of each practical argument were teased out. While the practical arguments and the issues were grounded and generated from data, the premises of argument were extracted from argumentation.

Results and Discussion

The findings of this study are discussed in the contexts of three science activities, namely, (a) Mystery Solutions Activity; (b) Titration Activity and (c) pH Activity. The discourse between

Bonnie and the researcher, the “Other,” gave rise to several practical arguments related to issues on teaching and learning. The conversations are based on retrospective video-recordings of classroom enactments of a CKCM acid-base lesson sequence over a seven-week period. The transcripts of audio-recordings of these conversations were used to develop the premises of the practical arguments from the perspective of Richardson and Anders (1994). According to these authors, the premises and the definition of each are as follows: “The *value premise* is a statement of the benefit to be derived from an action. The *situational premise* is a statement that describes the context in which the teacher’s action takes place. The *empirical premise* is a statement that makes a claim about the world, and is thus is subject to scrutiny, usually in the form of a test of some kind. The *stipulative* premise incorporates the ways teachers make meaning out of their work. The data described and interpreted in the results and discussion section will provide the researcher’s elicitation of the teacher’s beliefs through a process of questioning, the researcher’s appraisal of the teacher’s reasoning of a particular issue, and the teacher’s reconstruction of her belief because of the appraisal provided by the researcher.

The teacher-researcher discourse reveals shifts in Bonnie’s practical arguments on divergent issues. The issues and associated practical arguments are as follows: (a) Commitment to Preparation –inadequate preparedness to adequate preparedness; (b) Confidence in Learning – low confidence to high confidence; and (c) Character of Learning – surface learning to deep learning. Each of these practical arguments based on the foregoing issues, in turn, is first contextualized, then represented in a table with example(s) of practical arguments (elicitation, appraisal, and reconstruction), and finally presented with one or two excerpts of the teacher-researcher discourse that pertains to the practical argument of a certain issue. The discussion of the practical arguments involves a running commentary based on data provided in the form of dialogue excerpt(s); interpretive comments grounded in premises; and links to the relevant literature.

Issue 1: Commitment to Preparation
Practical Argument –Inadequate Preparedness to Adequate Preparedness

The mystery solutions activity was the sixth lesson in the acid-base lesson sequence. In this lesson, students were asked to design and implement their own investigation to identify whether the unknown substance was an acid or a base. Table 12 reveals Bonnie's shift in belief: inadequate preparedness to adequate preparedness.

Table 12

Teacher Inadequate Preparedness to Adequate Preparedness

Practical Argument Premise	**Elicitation**	**Appraisal**	**Reconstruction**
Value	I was "all over the place" trying to distribute to all groups.	How we organize for teaching and learning…. part of the managing of student learning is the organization required to structure the science learning experiences…	For me this time, it was a lot more organized and better prepared.

The researcher elicits the Bonnie's thoughts on the mystery solutions inquiry activity she conducted with the students. Note the premise revealed in Excerpt 1:

Excerpt 1: Teacher-Researcher Dialogue

1. T: For me it was a lot better in terms of <u>preparation</u>. This was because of your suggestion…when you suggested the little cups for organization.
2. O: Sure

3. T: Compared to the first time I did this activity, I'll be honest, I was "all over the place" trying to distribute to all groups. For me this time, it was a lot more organized and better prepared.
4. O: Well, there were several things going on. One, of the barriers we often talk about in terms of impacting teaching and learning is "time". How we organize for teaching and learning….reminds me of one of the core propositions of National Board that requires we focus on how we manage and monitor learning. Part of managing student learning is the organization required to structure the science learning experiences…so all of these things add to creating a comfortable classroom environment where you are more relaxed and comforted with the level of preparation.
5. T: Yes, and I like to be prepared.

The researcher elicits Bonnie's thoughts on the mystery solutions activity. The foremost issue that comes to Bonnie's mind is "commitment to preparation" not in terms of her chemistry content background rather paying close attention to classroom inquiry activity. Bonnie quickly acknowledges that it is because of the researcher's suggestions in a prior conversation she realizes that teaching science though inquiry requires careful preparation. Bonnie supports the issue of preparation with an example. She refers to the researcher's suggestion of using little cups for holding the mystery solutions for the acid-base classification using the pH test. This suggestion seems to stem from the researcher because of the very fact Bonnie has no access to laboratory facilities in her school that is meant for alternative high school students. The principle, however, is that the researcher points Bonnie to a different method for organizing a variety of substances to be tested rather than not doing the mystery solution inquiry activity.

Value premise stands out when Bonnie compares how she did the mystery solutions inquiry activity the first year with the one she experienced with much preparation the second year. She sees the value of being fully prepared for a science inquiry activity. This time Bonnie feels that she is lot more organized and better prepared. Bonnie values the suggestion of the "Other" after implementing and observing what she followed this year made a huge difference in providing students the learning experience in the inquiry of pH of various mystery solutions. She expresses her "honest" view of her past act in the chemistry classroom in her statement, "I was all over the place" (4).

Without much preparation, the teacher in previous times was trying to orchestrate many things simultaneously in the classroom. This is not unusual because many science teachers feel this way when they must prepare for a science inquiry activity such as the mystery solutions activity, which requires students to actively investigate a problem or question, use materials to collect data and engage them in conversation to make sense of the data. Bonnie is not in a privileged situation having a chemistry laboratory with modern facilities and an assistant to help her get ready with all the materials and supplies she needs. However, with the increasing demands placed on classroom teachers and especially science teachers to conduct inquiry-based science activities and engage all students in rigorous learning experiences, teachers need insights to look for an alternative approach.

When Bonnie confesses her chemistry teaching practice, the researcher gently reminds her about several things that impact a teacher's school life. One of the barriers that the researcher highlights is the issue of time, most often talked about. To overcome this barrier, the researcher puts herself in the experience of Bonnie and uses the plural "we" (4) to suggest "how we organize for teaching and learning" (4) is prime. Without blaming Bonnie and without making her feel that the idea of organization for good teaching and learning comes from her, the researcher refers Bonnie to the core propositions of National Board that provides insight on how to manage and monitor learning (see discussion on National Board Standards discussed earlier). The researcher is reminded to link the core proposition of managing and monitoring student learning to the National Board because Bonnie is researching her own teaching through reflective practice in the context of National Board Take One! The researcher zooms in on science learning and asserts that “a part of managing student learning is the organization required to structure the science learning” (4). The researcher equates this sort of experience, where the science teaching is planned carefully and the core propositions are considered, actually adds to creating a comfortable classroom learning environment. That level of preparation is essential for the teacher to remain more relaxed and comforted. Preparation and organization are critical factors in facilitating experiences that require students to be engaged with a wide spectrum of materials. The “Other”, the researcher, provides meaningful suggestions to Bonnie that enables a new level of understanding and insights. Supporting teachers in understanding the importance of preparing and organizing science inquiry activities such as the mystery solutions is essential for students to actively engage in learning amidst classroom complexities.

Issue 2: Confidence in Learning
Practical Argument 2 –Low Confidence to High Confidence

The inquiry activity on mystery solutions commenced with the teacher explaining to students that they were going to design their own experiment to test seven unknown substances to determine if they were acidic or basic. During, the first part of the lesson the students were engaged in constructing their experimental plan before the materials were distributed for testing.

Table 13

Low Confidence to High Confidence

Practical Argument Premise	Elicitation	Appraisal	Reconstruction
Empirical	Kids that often say, “I don’t want to work with anybody,” they still ended up wanting to work together.	A part of developing confidence is allowing the learners to have time to test and explore together what they have learned or planned.	…If I compare to what I did last year when I had a similar lesson, I too had more confidence now and was able to step back even more this year.
Situational	Their confidence and an eagerness to want to do well…made me know, that they knew what they were talking about.	When students demonstrate confidence and dependence on each other, the inquiry, the application, the sense making is enhanced.	Students have an opportunity to apply what they’ve learned…This lesson provided clarity… they knew what they were talking about and it was good for them to share.

Excerpt 2 demonstrates students completing an experimental design for the mystery solutions inquiry activity that they later conducted in the classroom.

Excerpt 2: Teacher-Researcher Dialogue

1. O: What happened when you implemented the lesson on mystery solutions? How did your students respond to the activity?
2. T: Well, first of all they were very excited because they were going to have the opportunity to work with some of the tools in science for testing substances for acids and bases.
3. O: Oh good.
4. T: When they were told that they could work independently, what I found to be strange is that…for kids that often say “I don’t want to work with anybody”, still ended up wanting to work together.
5. O: I wondered what they were thinking when you gave them the option of working independently?

6. T: Some felt comfortable, but for some the one thing I was concerned about was that they started to erase their answers when someone else started speaking. They were constructing their experimental design. There was a lack of confidence at first, but as time progressed …
7. O: They became for confident?
8. T: They became more confident and you know, I think as the teacher, for myself you know if I compare to what I did last year when I had a similar lesson, I was able to step back even more this year.
9. O: Oh good.
10. T: I had to kind of let go a little bit…um. I do have a few kids who do require more guidance, but even with regards to those kids, I actually observed them thinking more or less for themselves, without a dependency on someone else.

Bonnie observes her students' excitement (2). Bonnie raises an unusual point because that day her students who normally prefer to work independently opt to work together despite Bonnie asking them to work independently (4). She finds her students' behavior wanting to work together a bit "strange" (4). The researcher probes Bonnie's thinking about why the students would behave that way (5). While Bonnie is happy that some students feel comfortable working together, she is concerned with students who erase what they have written about the experimental design in their worksheets upon hearing others speak (6). Bonnie feels that this is because of students' lack of confidence in their own experimental design of the mystery solution inquiry activity. However, Bonnie notes that as time progresses, her students gain more confidence.

While contemplating on her students' confidence to engage in inquiry, Bonnie ponders about her own practice (8). She compares the mystery solution activity she did this year to what she did last year. Her comparison of a similar lesson between last year and this year suggests her practical reasoning is "empirical" in nature. This year's activity makes her "step back", "let go". In the context of her reflections on her own practice, Bonnie points out even the students who normally need more guidance from her to do their work are "thinking" for "themselves" and not depending on someone else (10). An important lesson that comes from this conversation is the notion of independent thinking, not to depend on another and yet work together. It appears that the teacher suggests that students should engage in inquiry together but do independent thinking in order to contribute to that collaborative learning.

Like the mystery solution inquiry activity, the student engagement in the titration activity also portrays student confidence in learning. It is a welcoming experience for high school students to engage in science experiences at a local university. The students in Bonnie's class did just that. They were invited to conduct their titration lab in a chemistry lab at the local university. The 90-minute experience reinforced their knowledge of acids and bases, and their expertise in following new laboratory procedures for using equipment to conduct the titration activity. Excerpt 3 clearly demonstrates student confidence:

Excerpt 3: Teacher-Researcher Dialogue

1. O: Let's talk about the Titration Lab. What stands out in your mind as we reflect on that experience?
2. T: They had confidence and an eagerness to want to do well. It made me know, that they knew what they were talking about.

3. O: When students demonstrate confidence and dependence on each other, the inquiry, the application, the sense making are enhanced.
4. T: It was a good lesson and a shot of confidence for them. I think it provided clarification. In that amount of time, they saw quite a bit. They worked with units correctly…it made sense to them. They were able to work with sodium hydroxide and know it was a base. You could see the look on their face that they know what they were talking about and it was good for them to share. Again, I was able to see the demonstration of what they actually learned. More than anything it's their level of confidence that was enhanced.
5. O: So, if you had to think about what you gained from this experience and how you will make a difference in the future with other classes…what are some of the things that come to your mind?
6. T: One of the things that I really noted is the difference when they worked in pairs. I have a couple of kids that are shy, but under those circumstances they had to…
7. O: Yes
8. T: They had to do it. You can still somewhat get lost in the group or kind of be sheltered or hide behind people in the group. Under these circumstances, especially because they had two trials and there was equity in terms of the experience that each child had.

The context of teacher-researcher talk involves the titration lab activity observed in the video. Once again the issue of "confidence" surfaces (2). Bonnie seemed to be consumed with the thought of confidence. Unlike Excerpt 2 (see above) that pointed to confidence in working together and confidence in their own writing about the experimental design, Bonnie points to the confidence in students' "eagerness to do well" (2). The student eagerness confirmed for the teacher that the students' confidence to share what they had learned in previous lessons (2). The researcher reiterates Bonnie's belief on student confidence. However, the researcher adds another dimension to student confidence. To the researcher, dependence means collaborative peer learning, dependence on each other (3). Excerpt 2 suggests that Bonnie's meaning of dependence seems to be different from the researcher's view of dependence. Bonnie wants her students to do independent thinking and not be dependent on the peers. In contrast, the researcher's idea was for students to depend on one another in a collaborative learning environment for developing their science ideas.

Bonnie believes that her students got a "shot" of confidence because of the titration lab. Bonnie recognizes her students' awareness of deep science learning by the look on their faces that they knew what they were talking about (explained in detail in the next sub-section). Bonnie feels that this type of learning supported deep learning and engagement and was meaningful for the students. This inquiry activity is evidence that Bonnie able to witness what her students had actually learned. The teacher sums up her feelings about her students when she states that above all else, her students' level of confidence had increased, this time because of deep understanding.

The researcher asks Bonnie to share how she would make a difference with future classes based on what she has gleaned from this titration activity experience. Bonnie shares that grouping was something she noted from this lesson. In the previous excerpt, students who typically want to work alone were navigating to work in a collaborative group. It appeared they found value in that the learning is enhanced. Bonnie reflects on the enhancement of learning and considers that she will orchestrate her classroom and learning activities for students to work in smaller groups or pairs. Bonnie reflects on how she feels in a previous school year doing the same lesson and acknowledges that she also has more confidence with this lesson. Evidence in the above excerpts points that Bonnie considers about students' gain in confidence in three ways: gravitating towards collaborative learning, wanting to do well in their work, and learning science for deeper understanding. Students' gain in confidence also impacts teacher confidence.

Issue 3: Character of Learning
Practical Argument--Surface Learning to Deep Learning

In the lesson on pH, Bonnie begins by reviewing the ideas learned on acids and bases to date. She begins the lesson by asking students' to identify what a strong acid is and where selected acids fall on the pH scale. As students share their answers she re-directs some because there are still some students who have the idea that a strong base is still an acid on the pH scale. To support the learning needed Bonnie realizes that she needs to facilitate understanding for those few students who need a review. Note the following video narrative:

Bonnie begins to circulate the classroom speaking with groups about their understanding of pH. She notices that a student does not have a complete understanding, so she goes to the board and draws a pH scale with 7 (neutral) in the middle. She now asks the students draw a pH scale at the bottom of their activity sheet. Bonnie shares with the students that the class can't move any further until we take care of understanding regarding the function of the pH scale.

Table 14 reveals a shift from surface learning to deep learning.

Table 14

Surface learning versus deep Learning

Practical Argument Premise	Elicitation	Intervention	Reconstruction
Situational	I just want to teach this, but some of the information I'm getting, tells me there is a need for more clarification with some of the students. You see I become a bit frustrated.	That's okay. I think frustration is okay. There is often a little bit of discomfort or frustration with growth.	Yes I am. You can see that they're being forced to think. I'll be honest, I wasn't really aware of and two, I didn't really encounter that last year.

The idea of developing conceptual understanding is an important element of the CKCM. Excerpt 4 illustrates Bonnie's thoughts on facilitating a deeper understanding of ideas than simply telling and lecturing to students.

Excerpt 4: Teacher-Researcher Dialogue

1. O: Let's talk about formative assessments and checking for understanding.
2. T: I like doing science daily. Just quick checks at the beginning of the class to facilitate my knowledge of what they understand or do not understand. I give them little things like this and it tells me a lot. I actually have a lot of kids still saying "I don't know what you mean in terms of greater or less than seven." So, I like using little activities to reinforce what they're learning.
3. O: You're just trying to find out what they know based upon what you previously taught. As we formulate their understanding and their ideas, the questions should be directly related to what they've just learned. I would not ask them questions about

ideas they have not been taught or what you're about to teach because we don't want to generate confusion.

4. T: Yes, but Oh my goodness. Now that's the part that I'm sort of feeling the need …to okay…I just want to teach this, but some of the information I'm getting I can tell needs clarification for the students.
5. T: You'll see that I become a little bit frustrated
6. O: That's okay. I think frustration is okay. A certain amount of frustration is Ok and there is a little bit of discomfort with growth.
7. T: Yes I am. You can see that they're being forced to think. I'll be honest that I wasn't aware of and two, I didn't really encounter that last year.

Through Bonnie's moment of frustration, she starts to realize that she did not experience this feeling when she taught the same lesson last spring. She begins to understand her awareness has changed as she compares the conceptual development and her engagement with the students from the previous semester. The significant fact is that her awareness is more crystallized. Now, instead of telling students and lecturing the concepts to be learned, she is facilitating the development of student conceptual ideas in a way that includes some telling, but much more facilitation and discourse. She now is engaged in formative methods which include more teacher-student conversations to uncover what students know and what ideas to be changed or re-directed.

Implications

The purpose of the study was to explore the professional learning of a teacher who reflected with the "Other" based on her experience enacting the Common Knowledge Construction Model. The process of teacher learning with the "Other" involved practical argumentation--"elicitation, appraisal and reconstruction" (Fenstermacher & Richardson, 1993). The study implies that engaging teachers with the expert "Other" to elicit and appraise practical arguments enables the reconstruction of beliefs and practice through reflection. For successful practical argumentation, developing mutual trust between the "Other" and the teacher is vital.

For decades the ideals and needs related to teacher professional development has permeated the literature (see e.g., Borko, 2004; Fullan, 1996; Hargreaves & Fullan, 2012; Loucks-Horsely et al., 2010). Conceptions and intentions of professional development might be lofty and noble. However, professional development has not impacted required change in classroom practice based on 21st century educational policies and reforms (e.g., NRC, 1996, 2010, 2012). Because of complex challenges of today's diverse classrooms and schools such as NSA, teachers need professional development opportunities throughout their careers that support development of knowledge about pedagogical practices through critical reflective practice (Fox & Kidd, 2001). A possible reason why professional development initiatives have not facilitated the change expected is because the initiatives did not address the core beliefs of why and how teachers change practices to best meet the learner and learning. What has become a clear directive is that teacher beliefs and the underlying reasoning for those beliefs must be the foundation for professional learning (Richardson, 2001).

Engaging teachers in reflective professional learning (Richardson & Anders, 2004) in order to elicit their beliefs fosters freedom to examine their reasoning for classroom actions. Elicitation allows teachers to share their beliefs with an expert the "Other", who listens empathetically and helps them to lay out their arguments. This is followed by "the Other" assisting teachers in sorting out their beliefs so that classroom practices will increasingly reflect contemporary ideals of learning. Teachers in discourse with the "Other" reconstruct their arguments with a shift in reasoning that impacts beliefs and eventually pedagogical practices.

The shift in teacher beliefs was evident in this study. Bonnie freely explained what she had learned during the implementation of the CKCM acid-base lesson sequence. The three practical arguments Bonnie advanced based on students' and her experience with the three acid-base inquiry activities (i.e., mystery solutions, pH, and titration), included in this article, point to "epistemological beliefs" (Bendixen, Dunkle, & Schraw, 1994), which pertains to knowledge construction and learning.

The first practical argument that Bonnie advanced was the issue of her preparation for the acid-base activity, namely, mystery solutions. Upon viewing a video recording of the lesson on mystery solutions, Bonnie expressed how "she was all over the place, trying to distribute to all groups" (Excerpt 1:3). This idea of not being totally prepared for a learning activity was something that she now realized within the enactment of the CKCM, which incorporated students' conceptions into instruction. If so, the lesson time should be expended not on frivolous matters such as the ill outcomes of not being appropriately prepared to class, rather on meaning-making of conceptual ideas underpinning the science activity through a social process. It was clear for Bonnie that only as a result of this activity that her reasoning about the importance of time management, monitoring student learning, and developing conceptual ideas took her to a new level of understanding. The conceptual development of the student was supported by the CKCM and was evident in the teacher's elicitation when she reflected on the organization needed to facilitate student learning. The CKCM and the value premise that Bonnie stated for her practical argument supports her unfolding professional learning. It is important for teachers in this phase to reflect on their actions as they respond to the needs of the students and reflect on their practice as they use the information generated by the students to create meaningful discourse and learning in the classroom. It was the "Other" who in the appraisal discussed with

Bonnie the importance of organizing and managing science learning experiences for the reconfiguration and development of conceptual ideas. Bonnie reconstructs her beliefs in this regard and classroom actions are evident in the video. For example, Bonnie was able to focus more on her alternative high school students' learning.

The second practical argument Bonnie advanced was on the issue of student learning with confidence and how her own confidence increased as a result of enacting the CKCM. For example, Bonnie raises the issue of students preferring to work independently so that they feel comfortable not exposing their thinking to their peers. Because the CKCM phase 2 calls for discourse between teacher and students and among peers for construction and negotiation of knowledge, Bonnie desired for her students work together in small peer groups. But Bonnie is aware that she should not disturb the comfort of the alternative students who prefer to work independently. The way the inquiry lesson went because of following the CKCM--to test and explore together what they have learned--students "ended up wanting to work together" (Excerpt 2:4). In the titration laboratory learning, Bonnie states that students clearly demonstrate, "They had confidence and an eagerness to want to do well" (Excerpt 3:2). The "Other" equates this confidence to "dependence on each other" (Excerpt 3:3) for the enhancement of "inquiry, the application, and sense making (Excerpt 3:3). Bonnie states that the titration lab was "a good lesson and shot of confidence" (Excerpt 3:4) for clarity of the concepts of acids and bases and expression of these in units. She also points to group work in Excerpt 3:6 noting "the difference when they worked in pairs" (Excerpt 3:6). In Excerpt 3:8, Bonnie refers to the issue of equity in group work. Self-confidence increases and student understanding of the subject matter also develops when students are engaged in inquiry in small groups (Bransford, Brown, Cocking, 2000).

The <u>third</u> practical argument is based on the issue of surface learning and deep learning. Bonnie seems committed to teaching for a deeper understanding of acids and bases. The lesson is a review lesson and she focuses on where various acidic substances falls on the pH scale. However, students are giving examples of base. Bonnie becomes frustrated that students are unable to distinguish between acids and bases based on the pH scale. So she reviews the lesson again. Bonnie emphasizes that she quickly reviews the previous lesson at the beginning of class to determine whether the students have understood or not (Excerpt 4:2). Bonnie admits her frustration but at the same time she believes that students are forced to think and then she openly states that she was not aware of her students' state of knowing and she did not go through this sort of experience last year. It is very clear that Bonnie is going through changes in beliefs and practices. While she taught the alternative students chemistry, she is now consciously aware that she needs to strive for developing in-depth understanding of students' understanding (Marton & Booth, 1997; Marton & Tsou, 2004). The CKCM founded in variation theory of learning has indeed made Bonnie aware of the need for deep learning.

In order for elicitation, appraisal, and reconstruction to occur, there must be an established level of trust and openness between the teacher and "the Other." Without mutual trust, teacher-researcher discourse will reflect a guarded disposition. The teacher will not be able to openly reveal her "core and/or dispositional or peripheral" (Brownlee, Boulton-Lewis, & Purdie, 2002) beliefs about classroom practices for fear of ridicule, and the teacher will not accept without confrontation. Building a trusting relationship to expose beliefs takes time. This is why professional learning that focuses on teacher reasoning based on beliefs and practices should be over a prolonged period of time (Loucks-Horsley et al., 2010).

In this study, trust was established long before the commencement of research because Bonnie has experienced integrity of “the Other” because she has worked with the researcher on science initiatives, such as curriculum writing and professional learning related to differentiated instruction. Before Bonnie started the CKCM acid-base lesson sequence and made video recordings of her pedagogical practices, it was important for “the Other” to take time to converse with Bonnie, and assure her that her beliefs and practices would be presented with ethical care. For the teacher to share, converse and engage in a process to reconstruct ideas with an intent to facilitate change in practice will only occur when teachers believe and trust the person supporting them through this process. Bonnie shares her premises based on prior beliefs and teaching experiences underpinning such beliefs, and now she realizes and values the change from where she was a year prior to where she is now.

Epistemological beliefs about teaching do evolve and change (Luft & Roehrig, 2007; Richardson, 1996; Yerrick, Parke, & Nugent, 1997) because they are dispositional or peripheral beliefs rather than core beliefs. Pedagogical practices are usually evaluated against contemporary advocacy in education and teachers do readily believe in new ways of thinking. It is not surprising that Bonnie was willing to try the CKCM because it was first introduced to her on a district-wide professional development day and she appreciated it. As well, in science education, conceptual change inquiry is a major strand of research and it is believed to impact conceptual change and achievement as evidenced in my study as portrayed in article one and also demonstrated by Ebenezer et al. (2010). Bonnie witnessed student learning and why will not she embrace teaching with the CKCM. Fang (1996) clearly points out that teacher dispositional belief can be reconfigured on the face of professional learning using contemporary pedagogical practices. When teachers experience reform models, it is important for researchers not to neglect eliciting and appraising their evolving beliefs so that science teacher education and professional learning may be informed through classroom evidence. Science knowledge itself develops because of peripheral and core changes, the former being easier to give up as clearly illustrated by science historians and philosophers. Furthermore, reforms and science education research advocate teachers to engage science students in conceptual change inquiry to model the scientific development of knowledge (Thagard, 1983). Parallel to science knowledge development and conceptual change learning in science classroom, science teaching beliefs and practices may be transformed through elicitation, appraisal, and reconstruction with the support of the “Other”.

CHAPTER 4

A CHEMISTRY TEACHER'S REFLECTIONS ON TEACHING URBAN AFRICAN AMERICAN ALTERNATIVE HIGH SCHOOL STUDENTS: DEVELOPING A STORY THROUGH THE VOICE OF THE "OTHER"

Abstract

Developing a story about the intricacies of teacher professional learning through the voice of the researcher is an authentic form of empirical research. The purpose of this research is to narrate a story through the voice of the researcher (the "Other") about a chemistry teacher's practice as she takes the first step toward the preparation for the National Board certification. The teacher reflects on her teaching a group of urban African-American alternative high school students an acid-base lesson sequence using the *Common Knowledge Construction Model* (CKCM) (Ebenezer et al., 2010). The study relies on three data sources: (a) verbatim transcripts of the audio-recorded discourse between the teacher and the researcher when the teacher reflects with the researcher about teaching the alternative high school students and their learning by using the video-captures of the teacher's enactment of the CKCM acid-base lesson sequence; (b) verbatim transcripts of the researcher's interview with the teacher after the teacher's enactment of the CKCM acid-base lesson sequence; and (c) the teacher's personal reflective paper sent to the researcher via e-mail attachment at the end of the study. The developing story of the chemistry teacher's reflective practice uncovers pedagogical care, comfort and confidence. The study implies the value of the researcher, the "Other" developing a story through her own voice as a way to represent teacher reflections of professional learning.

Key Words: developing story, professional learning, reflective practice the "Other," urban African American alternative high school students

Introduction

Often stories are the best way to enhance understanding and shift thinking. Stories have the power to change the lives of the professionals (Noddings, 1991). As research participants write their stories, transformation takes place within them. Teachers also learn when they read or hear teacher stories. The stories capture the richness and complexities of the experiences that encompass the teaching and learning process (Carter, 1993). The use of stories has become more than simply a rhetorical devise but rather an essential focus for studying teacher practice and conducting research in the field of education. Bruner (1995), a well-known psychologist, speaks of a narrative mode of thought—this could be applied to the study of teaching. Sarbin (1986) speaks of story as a “root metaphor”. Educators (Cole and Knowles 1992) have made story a central element in their analyses of teacher knowledge. Clearly, storytelling as a form of research on how teachers gain insights into their practices and set new directions for their ongoing professional development is emerging (Atwell-Vasey 1998; Lacey 1991; Witherell & Noddings 1991).

In a study of narrative inquiry by Wood (2001), a teacher and a researcher together became co-interpreters of stories and self-reflections generated by the teacher. As a result of this study, the teacher gained insight from her ongoing practice and the researcher gained enhanced appreciation for the complexities of teaching. Although my study somewhat resembles earlier studies on teacher research that engaged teachers in reflective practice and story-telling (Witherel & Noddings, 1991; Wood, 2001), it differs in important ways. In the study at hand, together with reflective practice and story-telling, there is an emphasis on teacher caring that facilitates urban African American alternative students’ learning as they engage in an acid-base lesson sequence. Teaching in urban communities, with a large percentage of African American, Hispanic, Native American and students who are in poverty, requires teachers who understand the needs and lived experiences of these students. To successfully teach urban students, teachers must be willing to learn how to identify and connect with the social and cultural resources of their students.

Tobin, Wolff-Michael, and Zimmermann (2001) attempted to bridge pre-service teachers, who were from non-diverse backgrounds and socially different experiences, to the world of the students by having them co-teach with an experienced urban classroom teacher. The goal was that this co-teaching experience would serve as a supporting link to connect the experiences of the students with the pre-service teachers. The results of this study, however, did not provide evidence for co-teaching as a single factor that supported the teachers with the necessary social capital to support improved student learning. In contrast, the teacher in my study was socially and culturally connected with the majority of the students in her classroom. She exhibited what Gay (2010) describes as culturally responsive practices to her students. Geneva explains when teachers exhibit cultural responsiveness; students perceive them to be caring. When students feel a teacher cares for them, they connect to learning, which, in turn, improves achievement. Teachers who consistently create a caring climate motivate student to actively engage in learning and accomplish higher levels of achievement (Gay, 2010). This study narrates a story of how Bonnie based on her professional learning and caring practices supported the learning of urban African American alternative education students during the enactment of CKCM acid-base lesson sequence.

The study of the chemistry teacher's practice in the empirical research at hand, took place in the context of her preparation for the National Board Take One!, which is the first step toward full National Board certification. The National Board for Professional Teaching Standards (NBPTS) certification process requires teachers to reflect on their classroom instruction through analytical, descriptive, and reflective writing. This writing should support and reflect classroom enactments that have been documented through video-recordings of teaching sessions that demonstrate professionalism and competency in specific content areas (NBPTS, 2010).

To prepare for the National Board certification, the teacher (Bonnie, pseudonym) used the *Common Knowledge Construction Model* (CKCM; Ebenezer, Chacko, Kaya, Koya, Ebenezer, 2010) of teaching and learning to enact an acid-base lesson sequence. This study is based primarily on retrospective data using the video-recordings that Bonnie had collected during the enactment of the CKCM acid-base lesson sequence in an urban African American alternative high school classroom. More specifically, Bonnie used video-recordings of her classroom enactment of the CKCM acid-base lesson sequence as a pedagogical context. Bonnie reflected on her practice with me, the “Other”, the researcher about teaching the urban African American teaching alternative high school students.

Through these personal reflections, storytelling emerged as a powerful and dynamic method of personal engagement in recognizing the way in which teaching practices were greatly enhanced through teacher professional development. The engagement with Bonnie, for example not only encouraged reflection but also helped her in making story connections between the care and value placed in student contributions, confidence, and achievement; and the professional growth of teachers through this practice. By having the opportunity to make these connections, then engaging in dialogue with the “Other” through the process of storytelling, Bonnie was able to develop pedagogical practices to further support these changes, and bring the experience full circle.

Theoretical Frameworks

The theoretical frameworks for this study of the teacher and teaching comprises of two complementary conceptual models: (a) Teacher professional learning; and (b) Intellectual caring Common Knowledge Construction Model (Ebenezer et al., 2010).

Teacher Professional Learning

The first conceptual model that informs this study is based on teacher professional learning. During the course of professional development, teachers must be immersed in the content and context of the learning environment and engage in meaningful opportunities to collaborate and construct understanding. This immersion ideally occurs within teacher communities in the same way that we as teachers ask students to construct understanding within social groups (Vygotsky, 1978). A variety of authors, researchers, and theorists have suggested that teachers should be engaged in active learning, reflecting on their own practice (Fenstermacher, 1987; NBPTS, 2010; Richardson 1994; Schon, 1983). Naturally, then, designing appropriate teacher learning experiences for immersive practice should be related to the daily classroom experiences. The professional learning should incorporate a variety of opportunities that allow teachers to construct new knowledge and make new meaning based on their experiences.

Anchoring teacher professional development in the context of their daily work is important in terms of promoting the type of collaboration and optimal pedagogical growth that is required to meet the diverse learning and instructional needs of students in today's classrooms. However, in order to understand the complex processes of teaching and learning, it is necessary to understand the ways in which teachers construct and translate that knowledge in the classroom. Thus, it is critical to acknowledge the complex situation in which the teacher is working and to underscore the beliefs and the conceptualizations that underlie a teacher's actions.

Historically, political and social reforms have driven the focus of public education and educational practices. The political and social reforms that have taken place during the past 30 years include the No Child Left Behind (NCLB) Act (2002), the National Common Core Academic Standards (NRC, 2012) increased diversity and accountability, inquiry and high-quality curriculum for all students (NSTA, 2012). These reforms have been thrust upon teachers despite beliefs about learning (Mansour, 2009) and knowledge about pedagogy (van Manen, 2002). Van Driel (2001) pointed out the need for restructuring teachers' beliefs and knowledge about pedagogy. Thompson (1999) has suggested that in order for teachers to restructure their pedagogy, they must unlearn much of what they believe, what they know, and how they teach while also forming new beliefs, developing new knowledge, and mastering new skills.

During the past 30 years, teachers have not been afforded sufficient time to reflect upon, synthesize, or collectively discuss the politically- and socially-based reforms and innovations they have been asked to adopt. As a result, while some progress has been achieved, the majority of educational reforms have failed because they have not accommodated the difficulties teachers face in negotiating shared beliefs towards the ideal of the reform (Mansour, 2009). Anderson (2002) has described from a collection of case studies the difficulties teachers have experienced in reforming their practices. Anderson has classified these difficulties into three dimensions: technical difficulties, political difficulties, and cultural difficulties. The technical dimension refers to the challenges faced by teachers who possess a limited ability to teach constructively. This includes teachers lack commitment to or understanding of the curriculum, and a lack of teaching strategies that accommodate the emerging diversity and instructional needs of all students in the classroom. The teachers also are challenged by the use of ongoing assessments to determine levels of student understanding associated with grades and a lack of sufficient professional development needed to support these new roles and teaching practices. The political dimension refers to challenges faced by teachers in a number of social arenas: a lack of adequate parental support, unresolved conflicts with other teachers and administrators; a lack of resources; and the ongoing debate over fair and just practices. The cultural dimension is anchored in teachers' value judgments regarding the curriculum (i.e., what teachers believe is important and not important for students to learn). According to (Bybee, 1993) the political dimension is "possibly the most important because beliefs and values are so central to it" (p. 8). The notion of providing an equitable education for all students by designing and providing instruction to support the academic needs of increasingly diverse students is still not evident as articulated in the vision statement of *Science for All Americans* (1990) more than 20 years ago. Because of these ongoing challenges, meeting the increased instructional needs of a diverse student population, specifically urban African American students in the United States, has become an important goal that cannot be neglected in teacher professional development.

Whether directly or indirectly, change introduced by new innovations and reform proposals also introduce new expectations for teacher knowledge and practice. Clearly, educational reforms call for a change in how we develop teachers. Thus, the argument for quality teacher professional learning today, has never been more pronounced. However, implementation of reform initiatives by teachers may occur only if they perceive a connection between the innovation and their own practices, understandings, beliefs and attitudes. These teacher dispositions obviously influence teacher learning of educational innovation and reform. According to Carroll 2005, dispositions represent the link between teachers' knowledge and beliefs and their behaviors and actions. Thus, the teacher rejection of reform might be more productively seen as a problem of learning than as a problem of implementation (Warren-Little, 2001). If we want to realize teacher acceptance of new reforms and accordingly readiness to change, then the preceding teacher qualities must be carefully considered in the design of professional development. The demands on knowledge and practice require sustained concentration, gradual development and opportunities for relatively private disclosure of struggles and uncertainties. With regard to the effect of teacher professional development on student learning, a number of studies report that the more professional knowledge teachers have, the higher the levels of student achievement. (Educational Testing Service, 1998; Falk, 2001; Grosso de Leon, 2001; Guzman, 1995; McGinn & Borden, 1995; Tatto, 1999). In fact, the report of the National Commission on Teaching and America's Future cites evidence that "investments in teachers' knowledge and skills net greater increases in students' achievement than other uses of an education dollar" (Darling-Hammond, 1999, p.32).

Improving teacher quality should be the primary concern because this is what matters most for student learning (Darling-Hammond (1998). Teacher quality with respect to student learning outweighed the importance of attending to issues such as standards, funding, and class size (Geringer, 2003). To prepare well qualified teachers that support student learning, certain elements of professional development need to be considered. There are four elements that need to be considered for teacher professional development. They are as follows: considering teacher dispositions; providing professional learning over time; engaging teachers in immersive practice; and focusing on content-based pedagogy.

Considering Teacher Dispositions. Teacher dispositions embody the beliefs, values, attitudes and are often stated as the issues of character that have become a key area of concern in this era of education reform. They are important when considering teacher professional development because these dispositions can impede the learning or the acceptance of new learning that is aligned to student learning and achievement. Studies suggest that unless a teacher believes in the need for the professional learning or possesses the will to implement a change as a result of the professional learning, negligible impact on student learning and achievement will occur. According to Carroll 2005, acquiring appropriate professional dispositions for teaching is a socio-cultural process that cannot be meaningfully separated from our daily interactions and performance as teachers.

A forerunner in the establishment of language to define dispositions for teaching was the National Board for Professional Teaching Standards (NBPTS, 2001), an organization created to identify standards for the teaching profession and develop a national credentialing process for teachers. NBPTS provides and measures the dispositional qualities of teachers as part of the overall assessment process. There are two levels of assessment for National Board Certified Teacher Candidates. First the portfolios submitted for each candidate are reviewed by a team of teachers who have been trained to look for evidence of the alignment of practices documented in the portfolio with the standards and Core Propositions of National Board. This evidence will include as in the case of a science teacher, how they are engaging students in an inquiry experience and how they are developing understanding in the assessment practices of National Board. Second, each candidate is assessed in their content matter. These online assessments are directly focused on determining the level of content knowledge for the age level in which a teacher candidate seeks certification. The formative review of the portfolio is conducted with Take One!. However, the content knowledge assessment is administered only to candidates who have elected to pursue the full board certification.

Proposition One states that teachers are committed to students and learning. This statement addresses numerous dispositional issues focused on relations and understanding the developmental issues associated with our students. Teachers pursuing National Board certification must provide evidence from professional learning and reflection on their teaching practice their belief that ALL students can learn and be successful. This is realized in many ways as they work with students. For instance, the teacher will need to show an ability to clearly identify the needs of the students and then differentiate the instruction based on the needs and abilities of the students in relation to the objectives of the lesson (Gardner, 1983; Tomlinson, 2003). Purposefully matching the instructional strategies to the needs of the learner, the learning styles of the learner, and the objectives of the lesson have all been shown to have an impact on student achievement (Marshall, 2004; Marzano, 2003; Wiggins & McTighe, 1998).

Dispositions are rooted in experience, knowledge, personal beliefs, and values, but they are culturally constituted and shaped by interactions with others in social contexts. The social, moral, and cultural nature of dispositions thus strongly suggests that understanding the process by which dispositions develop can be informed by scholarship about learning in communities of practice.

Content-based Pedagogy. Providing learning experiences for teachers to enhance student learning is critical as we prepare students for successful science course matriculation and advanced learning. The National Science Education Standards (NRC, 1996) encourage the integration of content through unifying concepts and processes, articulate classroom pedagogy that accurately portray the nature and history of science and sustain efforts to provide equitable science education for all students." These standards provide clear direction and purpose for professional development of science teachers in terms of content-based pedagogy.

Content based pedagogy is often referred to in the literature as pedagogical content knowledge, described as a knowledge base necessary for effective teaching in many educational reform documents (e.g., AAAS, 1993; NRC, 1996). Pedagogical content knowledge is a type of knowledge specifically possessed by expert teachers. The name makes a conjunction between subject matter content and pedagogy, with the suggestion that this represents the understanding necessary for transforming subject matter into forms that are more accessible to students (Shulman, 1986, 1987). The National Board for Professional Teaching Standards (NBPTS, 2004) also underscores the importance of pedagogical content knowledge within their five core propositions as a foundational component of what teachers should know and be able to do. NBPTS, established in 1987, outlines five core propositions that accomplished teachers should demonstrate. These core propositions are: Teachers are committed to students and their learning, teachers know the subjects they teach and how to teach those subjects to students, teachers are responsible for managing and monitoring student learning, teachers think systematically about their practice and learn from experiences (NBPTS, 1987). The core propositions that contribute to pedagogical content knowledge represents knowledge that is uniquely the province of teachers and their own special form of professional understanding (Shulman, 1987 p. 8). Cochran (1992) asserted that pedagogical content knowledge is the ‘‘knowledge that makes science teachers rather than scientists’’ (p. 4). Professional learning must be developed within classroom practice (Van Driel, Beijaard, & Verloop, 2001).

Williams (2002) suggests that teachers need to be jointly involved with researchers in developing pedagogical content knowledge rather than expecting teachers to translate remote research findings to their own teaching. Jenkins (2000) argues that since teaching is such a complex activity, generalizations drawn from educational research are often too board and general to be of help in a specific classroom situation. Additionally, it has been found that placing research knowledge within the reach of teachers is important, but more important is placing the research knowledge within the conceptual reach of teachers (Kennedy, 1997 p. 7). Teachers tend to be receptive of research that closely conforms to their beliefs and values. When research differs from their beliefs, the practices of teachers tend to be very difficult to change (Pajares, 1992; Richardson-Koehler, 1987).

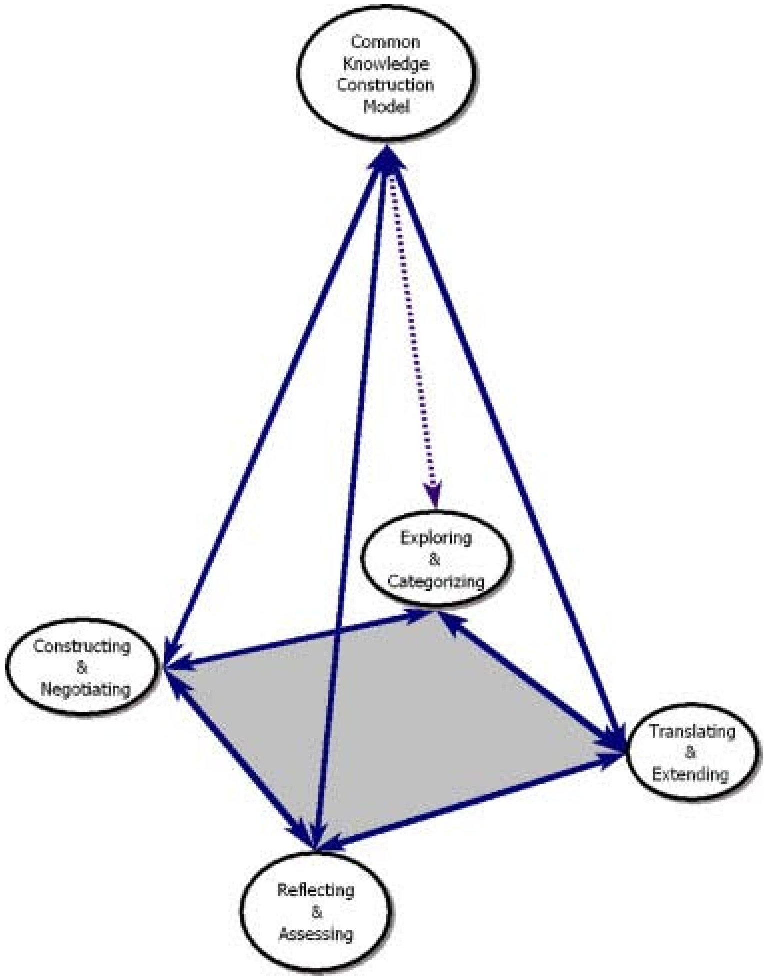
Professional Learning Over Time. Empirical evidence shows that effective professional learning is sustained over time and is best situated within a community that supports that learning (Darling-Hammond, 1997**;** Loucks-Horsley et al., 2010). The argument is that teachers like students learn over time and it is equally important to include regular follow up support, which has been described as an “indispensable catalyst of the change process” (Schiefter, Russell, & Bastable, 1999, p. 30). For example, professional development may begin with intensive education and training during one, two, or three weeks or one month. However, subsequent work-shops and site mentoring during the school year are important for teacher change (Ebenezer et al., 2011).

In a study by Supovitz and Turner (2000), at least 80 hours of professional development are needed before a statistically significant relationship can be identified between professional development experiences and changes in teaching practices. Sustained professional development provides the opportunity for collaboration of teachers. Science education research indicates that increased student achievement is directly proportional to the length and the type of professional development over time (Cohen & Hill, 2000; Loucks-Horsley et al., 2003). Teacher professional experience creates a community of learners and promotes growth. Sustained professional development improves the performance of all students.

Engaging Teachers in Immersive Practice. Teachers must be immersed in the content and context of the learning environment over time. Teachers should be provided opportunities to reflect about their practice within a teacher community of learning in the same way we ask students to construct understanding within social groups (Vygotsky, 1978). Designing appropriate teacher learning experiences should be matched with their daily classroom experiences. Anchoring teacher professional learning in the context of their work is important for meaningful collaboration and optimal pedagogical learning in order to meet the diverse learning and instructional needs of students in today’s classrooms. To understand the complex process of teaching, it is necessary to understand the knowledge teachers develop and use. It is critical to acknowledge the complex nature of teaching and to underscore the beliefs that underlie a teacher’s actions. To discern teacher beliefs and actions, it is important to describe the model the teacher used to implement a lesson sequence on acids and bases. Thus, I turn to the intellectually caring Common Knowledge Construction Model (CKCM).

Intellectually Caring Common Knowledge Construction Model

The CKCM for teaching and learning was developed by Ebenezer and Connor in 1998. The CKCM is rooted in phenomenography, the variation theory of learning (Marton, 1981; Marton & Booth, 1997). The CKCM consists of four interactive phases of teaching and learning as represented by Figure 1: (a) exploring and categorizing, (b) constructing and negotiating, (c) translating and extending, and (d) reflecting and assessing.



Culture – Culture Pedagogy

Figure 1. The Common Knowledge Construction Model (Ebenezer et al., 2010. Modified to include culture-culture pedagogy)

The CKCM affords students intellectual freedom to propose, assess, revise, and shape ideas about natural and socio-scientific phenomena. These characteristics of the CKCM signify the aspects of care that general theorists advocate in the literature (Gay, 2010; Hull, 1997; Littky, 2004; McCroskey, 1992; Noddings, 2005).

Each phase of the CKCM reflects pedagogy of caring. Therefore, the present discussion of the various phases of the CKCM explicitly links to pedagogical aspects of caring (Ebenezer et al., 2010; Ebenezer & Connor, 1998). While the goal of CKCM curriculum design and pedagogy is to emulate the inquiry practices and processes of the scientific community, the burden of reaching all students in learning science with care is an even greater goal. This goal has been set to reach those students of science who often have been neglected. Caring, demonstrated in the classroom, calls for a learning environment that accommodates conditions, contexts, activities, and structures that promote, nurture, and support reasoning practices among students. Such practices promote a learning community with which students can identify (Honig & McDonald, 2005; National Academy of Sciences, 2002; Noam, Biancarosa, & Dechausay, 2003).

Phase 1: Exploring and Categorizing. Phenomenography is an experiential perspective. It embodies a relational view of conceptions of a phenomenon – a relationship between the conceptualizing individual and the conceptualized phenomenon. It describes the possible variations in relational conceptions that individuals hold for a phenomenon. In this phase, there is no strong concern for the developmental mechanism that created that variability. Thus, phenomenography may be used as an inquiry tool to generate conceptions of a natural phenomenon. Rather than the first order questions that simply asks what something is, second-order questions is used in order to explore students' conceptions. Second order questions allow the individual to take ownership of the learning situation and make meaning of the phenomenon being studied. Usually one or two highly related <u>everyday</u> tasks are used to explore students' conceptions. To explore students' ideas of acid-base concepts, for example, they may be shown a picture of a factory with gases coming out of the smokestacks while it is also raining. The teacher asks second-order questions based on the following scenario: What sense do you make of this picture? Can you see what is happening? More complex questions might be as follows: What do you think happens when gases and water mix? How might the combination of gas and water affect the environment?

When emotional connections are made to an environmental issue through an activity, students have the opportunity to demonstrate caring practices and value what they are learning. To simulate scientific practice, students are provided with opportunities to explore multiple ideas. In doing so, students begin to understand that science is an attempt to explore and explain natural phenomena. Students' ideas are interpreted with much intellectual empathy, not judged for rightness or wrongness, as would occur in a diagnostic or deficit models such as Chi and Roscoe (2002) and Posner et al. (1982).

Found in the pool of students' expressions are personal ideas with inter- and intra-variations. The teacher/researcher identifies and develops commonalities in meanings into "phenomenographic categories" (Marton & Booth, 1997; Marton & Tsui, 2004). This step also denotes the aspect of caring for a student because the CKCM does not focus on an individual student or the task itself. The student is not individually responsible for the meaning that is made, or the student is not set aside based on his or her meaning, or student is not classified low medium or high achiever. The teacher/researcher focuses on the relations that students collectively make about the phenomenon. This means no relational meaning is attached to an individual student. The collective meanings in the form of categories of description are ways of denoting the researcher's interpretations of students' conceptions of a phenomenon. These descriptive categories are exposed to all students in class with the purpose of helping all students to own the collective meanings. As a community of student researchers, students subject their proposed ideas to tests. They collect data, look for evidence, and through a process negotiation make evidence-explanation connections.

According to Ebenezer et al. (2010), taking class time to explore all students' personal ideas of a science phenomenon with tasks that represent their experience, interpreting those ideas, and categorizing those ideas with intellectual empathy before beginning a sequence of lessons symbolizes “pedagogical care” (Hull, 1997). As a result, caring is shown and felt in the classroom according to McCroskey’s (1992**)** notion of caring. In phase one, a first attempt is made to reach all students, including the majority/minority, privileged/under privileged, culturally rich/poor, and regular/alternative education students within the dynamics of urban education. Caring for all students and the need to be cared for are human needs that have been reinforced by Littky (2004). McCroskey (1992) has pointed out that it is not simply a matter of caring that counts; rather, it is the perception of caring that is critical. Students perceive teacher caring when teachers demonstrate a genuine capacity to see situations from students’ perspectives and experience how they feel as well as the ability to comprehend students’ ideas, feelings, and needs. Pedagogical caring and learners’ perceptions of caring are built into the CKCM. Students enter into the construction and negotiation phase with the confidence that their teachers care for them, respect their values, and respect their ideas.

Phase 2: Constructing and Negotiating. Phase 2 consists of constructing and negotiating meaning. Students share their personal ideas in class so that peers can evaluate the merits of these ideas in an open forum through a process of construction and negotiation. Exposing their conceptions to the teacher and peers for critical inquiry is a sign of strength, not weakness. Scientific explanation based on students’ conceptions occurs in this phase. Students must recognize that teachers believe they are capable of constructing and negotiating knowledge. Simply telling or providing students with structured knowledge does not suffice. Providing a learning environment of caring is probably one of the most influential factors that must be established to support the development of scientific knowledge for all students (Gay, 2010). This author believes when teachers attend to their students and care about who they are and how they are performing, it creates an environment that enhances a students' desire to learn and succeed academically. The CKCM provides a framework to support teachers in demonstrating this level of caring.

In Phase 2 of the CKCM, students construct and negotiate understanding through discourse in the comfort and nuances of diverse learners. As students critically analyze and engage in discourse with each other and the teacher in the classroom community, they continue to expose their conceptual variations. In response, the teacher encourages, guides, and pushes students to participate in a community of inquirers generating and validating conceptions of scientific ideas. Students then see themselves as establishing credibility and taking responsibility for the knowledge they have mutually constructed. The teacher encourages students to communicate their scientific understanding using the multi-modal representations with which they are comfortable. This level of engagement and care is important for all students, particularly those who are disadvantaged. Their self-esteem and confidence may have been eroded over time, resulting in a lack of academic success in traditional schools. By maintaining high expectations and simultaneously demonstrating caring practices that reinforce students, the teacher is showing students they are cared for as people and valued, which is tremendously important for students in alternative education settings. During Phase 2 of the CKCM, students who are "in the cradle of care" are nurtured by a "caring teacher" who recognizes that constructing and negotiating meaning will require students to be vulnerable. This confirmation and encouragement of care encourages the students to engage in conversations that expose and challenge their ideas because they are secure in the caring environment and caring structure created by the teacher.

Through the experiences students encounter in Phase 2, they become aware of how they construct scientific knowledge and how conceptual change occurs. Students recognize that conceptual change occurs when they question their original conceptions based on everyday contexts and submit their ideas to critical thinking processes, inquiry, and peer review. Students also realize that collaborative time and effort are required as well as empathy towards fellow learners when formulating scientific ideas. Furthermore, teachers understand that if students show “situational interest” (Swarat, Ortony, & Revelle, 2012) in learning science, conceptual change may be facilitated. Teachers build meaningful bridges from the students’ cultural values to the culture of science. Teachers continually monitor and adjust the lesson sequence for future instruction based on their sense-making of students’ evolving conceptions and understandings.

Phase 2 of the CKCM manifests caring by creating a learning environment in which students clearly perceive that the teacher cares and supports discursive practice. As teachers engage students in dialogue, they learn about their needs, working habits, interests, and talents. Teachers gain valuable ideas from students about their understanding and then use that knowledge to build meaningful and targeted lessons along with plans for individual student progress. In these ways, the CKCM inspires authentic caring teachers to increase their own competence to support student conceptual change.

Phase 3: Extending and Translating. Phase 3 of the CKCM helps students extend and translate their knowledge. Gay (2010) has described one of the tenets of culturally responsive caring as action provoking. During the third phase of the CKCM, teachers ask students to extend and translate their understanding. Students recognize and remain in a learning environment that fosters caring, but now they are asked to extend their thoughts into actions. In Phase 3, students use their ideas to identify issues that impact their own lives and the lives of others.

In this phase, students work collaboratively and cooperatively with empathy for each other’s ideas, processes, and values while exploring community-based socio-scientific issues.

Encouraging students to collaborate in making responsible decisions and taking collective action is crucial for all students in science classrooms. In this phase, students are nurtured to develop a critical-thinking disposition through scientific inquiry and problem solving. Personal responsibility from students is elicited via a reflective process based on their values. Therefore, these types of concerns and issues that they value and for which they will be responsible, will emerge as a result of the caring environment and meaningful discourse (Noddings, 1992). Students must also perceive that the responsibility they are demonstrating is acknowledged and that their insights are understood, shared, and valued. The CKCM supports a social, intellectual, and ethical progression from (a) self-centeredness to (b) ethical partnerships to (c) ethical caring/support to (d) ethical decision making at a global level. Through school-community partnerships, all students can experience an ethically caring environment that enables them to make intellectual decisions and take action in community affairs (Ebenezer, Kaya, & Ebenezer, 2011). These authors believe that by ushering deprived students into the scientific community of practice through community partners, they are pointed to STEM higher learning and STEM careers.

Phase 4: Reflecting and Assessing. The fourth phase, reflecting and assessing, is integral to exploring and categorizing students' conceptions, constructing and negotiating shared common knowledge, and translating and extending students' understanding of science concepts into the study of personal and socially relevant scientific and socio-scientific issues. Traditional assessment options, such as fill-in-the-blank items, multiple-choice questions, true/false questions, and matching questions, require students to regurgitate information and provide "the right answer." These methods do not serve as effective assessment practices for conceptual change inquiry teaching and learning, especially when that teaching and learning environment underscores aspects of caring. In the conceptual change inquiry process, assessments should measure how students explore, expose, revise, or reject their conceptions based on evidence and explanation. Measurement should track the small steps that students take to understand difficult science concepts and make conceptual changes. Assessments should determine how effective teaching has been in terms of initiating conceptual change, identifying which concepts need to be further explored, and clearly observing how students use the understood concepts. This assessment information is necessary to design, conduct, and evaluate scientific and socio-scientific inquiries that have personal and social relevance. Measuring these processes of learning continuously and reflectively is vital. Teachers and students both need to engage in formative assessments that enable students to consider *how* they know *what* they know regarding "knowledge claims communicated in science" (Ruiz-Primo & Furtak, 2007, p. 64).

Caring is manifested in this phase when students engage in experiences that confirm *what they know* and, perhaps just as importantly, *how they know* a concept. Noddings (2009) has suggested that teachers should care about not only the knowledge goals for which students are striving but also the ways that students go about achieving these goals. The use of formative assessments is one way that teachers and students can measure continuous and reflective learning. Encouraging and confirming, as highlighted by Noddings (1992), is an integral part of the assessment process.

Research Objective and Question

The objective of this article is to narrate a story of a chemistry teacher's classroom practice in an alternative high school classroom. The research question is as follows: How does a chemistry teacher's classroom practice look while enacting the CKCM acid-base lesson sequence in an alternative high school classroom?

Methods

Bonnie’s developing story of professional learning is situated within three contexts of the researcher. First is my own experience and use of the CKCM as I engaged in my doctoral studies with the developer of the CKCM. Second is my drive to introduce the National Board Take One! to my school district. Third, is the teacher involvement with the National Board Take One! These three contexts have a bearing on Bonnie’s developing story. I will first narrate how I came to situate myself in Bonnie’s developing story based on my own personal learning.

Researcher’s Convictions with the CKCM

My story began five years ago when I invited faculty members from local universities and colleges to share their curriculum and instruction research and expertise at our District Professional Development Day. This was a contractual day set aside for teachers to engage in professional learning. The goal was to have a spectrum of district staff and guest presenters lead sessions for all levels and all content areas taught in the District! On this occasion, I invited Jazlin Ebenezer, Professor of Science Education, College of Education, Wayne State University. I was aware of Ebenezer’s NSF-funded multi-year technology project through my doctoral course work with her. Soon I learned that although technology is an area of her research, she is known among her international colleagues in science education for translating theory into practice. For example, one teaching and learning model that Ebenezer developed is called the *Common Knowledge Construction Model* (CKCM) (Ebenezer & Connor, 1998). She rooted this model of teaching in the *variation theory of learning* (Marton, 1981; Marton & Booth, 1997; Marton & Tsui, 2004.) The CKCM anchored in the variation learning theory was the focus when Ebenezer addressed the secondary science teachers in my district at the 2007 District-wide Professional Development day. I was impressed with the response by our teachers. I realized what she shared had much intellectual and emotional appeal to the teachers. Consequently, I felt the need to learn more about the CKCM and adopt it for my own doctoral research.

I soon learned that the CKCM was being used internationally, and had been for several years. I read her methods books (Ebenezer & Connor, 1998; Ebenezer & Haggarty, 1999) and was pleased that my beliefs and thinking about teaching and learning were aligned with the persuasions of the CKCM. I was impressed with the underpinning philosophies and the design of the CKCM because it embraced a non-judgmental posturing for students as they explored and exposed their ideas. This non-judgmental posturing was also evident when ideas were subjected to testing by the classroom community of science learners. Students changed their ideas not because they were "misconceptions," rather they were able to distinguish between their everyday contextual talk and science classroom talk. Also, what intrigued me was the relational conceptual change emphasis that promoted empathy for teaching and learning. This, I knew, was an approach that would reach the often uncared for learners. Prior to my exposure to the CKCM, I was intrigued with the inquiry models, such as the 5 E model **(**Bybee, 1989) and the learning cycle (NRC, 1999) that were advocated by different science educators and researchers. Although these simple inquiry models provide an anchor on science teaching and learning for beginning science teachers, these should be replaced with a more challenging model such as the CKCM that deals with complexities of science learning. The notion of intellectual empathy sets the CKCM apart from the inquiry models and the other conceptual change models based on Piaget's learning theory of *assimilation* and *accommodation* (Ebenezer et al., 2010).

Researcher's Commitment to the National Board Take One!

As the Associate Superintendent for Instruction of the Northwood School District, I am responsible for the leadership of all P-12 curriculum and instructional initiatives and programs.

My continued quest is to identify sound teaching methods that will support teachers with providing exemplar teaching to the students they encounter each day. In our district, as with many urban districts, we have provided a variety of professional learning experiences for teachers to enhance their practice. However, I had not witnessed evidence-based strategies of teaching and learning strategies practiced in the classrooms as often and as richly as it should have been occurring. Three years ago, I learned more about the National Board for Professional Teaching Standards full certification program and its relatively new professional development program, Take One!—an introduction to the portfolio assessment required of all National Board Candidates (NBPTS, 2011). I learned that Take One! was designed for teachers who are interested in studying their practice, but not ready to commit to the full certification program. This was just what I felt our teachers needed. I knew of the National Board Certification, but how could I inspire a large number of teachers to commit to a huge professional learning process was my quest. At that time the school district did not have any Nationally Board Certified teachers and many were not interested because they felt it was an elite program and the district offered no incentive for the huge investment of time to complete the full certification program. However, Take One! did not require teacher commitment to the entire NBPTS full Certification program. I believed I could create a momentum in the district to facilitate and support improved professional practice by embracing Take One!

The Take One! professional development program facilitates teachers to work independently and in small study groups, learning from one another as they critically discuss, analyze, and reflect on their practice. Therefore, I contracted with two National Board Certified Teachers from another school district, to support a small cadre of teachers to pilot completing Take One! The Take One! process involves each teacher videotaping a 15 – 20 minute lesson and writing a 10 to 15 page analytical reflective paper describing several factors related to classroom instruction based on evidence grounded in the video recording of a lesson.

The teacher consultants provided professional development to our Take One! teacher cadre over a six-month period. Teachers met after school and the learning addressed (a) introduction to and requirements of Take One!; (b) the five core propositions and how they look in a teacher's classroom; (c) thinking and writing styles – analytical, reflective and descriptive writing; (d) unpacking the NBPTS standards; (e) architecture of accomplished teaching and lesson planning; (f) video-recording lesson enactments; (g) and reflective practice – an analysis of the video recorded lesson. Teachers found the Take One! sessions valuable. The district initiative was compelling to teachers. Little did I foresee, that the successful completion of the pilot implementation of Take One! would develop from a small group of 15 teachers to 170 teachers during the following school year deciding to engage in this professional learning. I asked each principal to use Take One! as a professional development model to engage the staff in his/her building in order to improve pedagogical practice.

Teacher's Involvement with the National Board Take One!

It was during the second year of the District implementation following the pilot that Bonnie became involved with Take One! She recognized it as a valuable process for improving her classroom practices. During the second year, with the number of teachers now engaged in the process, video-recording lessons became a priority and Bonnie was part of this group. Reflecting on her practice and sharing her reflections with others became an important element of professional learning. I was thrilled that this was happening with Bonnie and throughout the district with teachers Pk-12.

It was at this period in time that three important commitments converged to move forward with my doctoral study: (a) Bonnie's commitment to engage in Take One!—She saw a profound value in using this process beyond the scope of Take One! to inform and improve her practice. (b) Bonnie's commitment to the Common Knowledge Construction Model—She was compelled to share with me how the model "spoke" to her and that she wanted to try using the model in her classroom. (c) My commitment to complete my doctoral program under the advisement of Professor Ebenezer and use the Common Knowledge Construction Model as the theoretical framework.

To begin change, Bonnie took the opportunity to teach a chemistry course to her alternative high school students. Although she was certified to teach chemistry, she had never taught this course. Bonnie looked for vehicles to support the much needed learning to best serve her alternative high school students that she chose to study with for the preparation for her National Board Take One!. National Board Take One! and the CKCM opened new pedagogical beliefs and practices to support the chemistry curriculum she taught to the alternative high school students.

A strength Bonnie brought to our professional conversation was the unreserved commitment to reflect on her practice. It was both our commitments to meet the intellectual needs of our alternative high school students in the chemistry class. It was our desire to conscientiously provide this group of African American alternative high school chemistry learners the depth of intellectual care that the CKCM portrays. It was our vision to ensure that this group of chemistry learners were provided with premiere chemistry education by a teacher who cared about their learning. It was also our belief the potential for excellence existed among all learners in this chemistry course.

Both the researcher’s and teacher’s context of research provided a rich learning experience for our conversation. The conversations were anchored in our mutual experiences as educators, and the dialogues concentrated on the teacher’s experience of implementing an acid-base lesson sequence using the CKCM.

Data Collection

Data collection is summarized in Table 15. Data sources consists of teacher video-recordings of her classroom enactments of the acid base lesson sequence; verbatim transcripts of the audio-recordings of the teacher-researcher discourse of alternative high school students' learning based on the video-recordings of the enactment of CKCM acid-base lesson sequence; construction of narratives of the video-recordings by the researcher; the verbatim transcripts of the teacher interviews by the researcher; and a personal paper sent by the teacher to the researcher via e-mail attachment. These data sources provided ample evidence for the researcher to write a story about Bonnie through her own voice.

Table 15

Data Collection Summary

Teacher's Data Collection	Researcher's Data Collection
Qualitative Data	Qualitative Data
<u>Video-recordings</u> of classroom lesson enactments <u>Writing</u> a personal paper about her experience	<u>Audio-recordings</u> of the teacher-researcher discourse based on the teacher's video-recordings <u>Audio-recordings</u> of the teacher's interview by the researcher

Data Analysis

The researcher reviewed all of the data from the various sources. Based on the teacher's reflections about her alternative high school students' learning, she narrated a story called Professional Learning of Bonnie: Pedagogical Care, Comfort and Confidence.

Professional Learning of Bonnie: Pedagogical Care, Comfort and Confidence

Students coming to NSA are often saddled with judgments about their potential in life, their academic capability and their capacity to change. Many of the students who attend NSA come with many rich experiences that may not always be rich academically. Bonnie teaches chemistry to these students at NSA. This is a story about Bonnie, a narration of her professional learning. The story is based on evidence gathered from video-recordings of her classroom interactions with students and conversations between her and the "Other" about teaching and learning. Bonnie's professional learning characterizes care, comfort, and confidence—all revolving around her pedagogical practice when she enacts the CKCM acid-base lesson in her classroom with alternative high school students at NSA.

Care

There is a great need to establish a caring relationship with students who are troubled. To care for these often uncared for students that come to NSA, Bonnie and I decide to adopt the CKCM to teach her alternative high school chemistry students. This is because we both are convinced that the notion of caring is a hallmark of the CKCM. Caring is portrayed when Bonnie attempts to explore students' conceptions at the beginning of the CKCM acid-base lesson sequence. Bonnie uses everyday activities that are part of their experiential world.

The practice of exploring students' ideas is different for Bonnie and it is different for her students. Bonnie reflects on her students' experience of exploring their ideas:

> *This is the first time most of my students have been interviewed to elicit their thoughts on chemical concepts. During the process of exploring my students' ideas, my students were often looking for my approval for their answers. One of my female students is seeking approval. She made eye contact with me quite a few*

times. She sort of looked to me for approval at times when she was not sure about providing a response. I had the sense that she was looking to me for some type of help and support.

It is not unusual for these students not to trust their own answers because day after day these students come to her classroom with very low confidence. So it was not surprising that these students who lacked confidence in themselves sought teacher affirmation.

Taking the time to have extended conversations with students about their ideas was new to Bonnie but proved to be a worthwhile experience for her because she became aware of her students' ideas. As Bonnie reflected on this experience, she realized how much more information she was able to gather about her students' understanding of the concepts than any other pre-assessments she conducted. Bonnie takes the ideas that students' expressed during the exploration phase, categorized these ideas, and constructed a matrix connecting students' ideas to the state chemistry curriculum. She designed, developed, and enacted the acid-base lesson sequence with the assistance of the CKCM developer. With respect to teaching students based on their ideas, Bonnie stated: "In the CKCM, she [Bonnie] learned how important it was to connect the experiences and ideas of the students to content understandings that would eventually unfold and crystallize in the minds of students."

Bonnie and I discussed the work of Geneva Gay often as we traversed the realities of responsive teaching related to the CKCM. Gay (2010) stated that teachers who are exhibiting caring practices and where students feel the teacher is attending to their personal intellectual needs in a non-judgmental way consistently create a climate that makes students more willing to participate in learning tasks and accomplish higher levels of achievement. Watching Bonnie's lesson enactment, it was often observed how she encouraged her students to do their work. She also appreciated the humble steps students took to meet her expectations. One thing evident in every video of Bonnie’s classroom teaching was her commitment to the students and their learning. In a video segment, Bonnie was seen discussing with a student the lab results and possible explanation. She asked the student specific questions, such as “What is causing the color change?” When the student answered correctly, she praised him and asked him to continue. She then moved to another student on the other side of the table to discuss her understanding of the concept. Although Bonnie was naturally a caring person, it was through her reflections with the “Other” and writing a personal reflective paper that Bonnie began to bring care for her students, their ideas, and their learning to the foreground.

Comfort and Confidence

For many of her students, school is their safe haven. It is the one place that is normal for them. Teachers may be the only adults in their life that make time to communicate with them about their intellectual and emotional concerns and needs. It was important for Bonnie that students perceive she valued their experiences and their perspectives. Bonnie also understood the importance of not shutting them down by being judgmental of what they knew or did not know upon entering her classroom. Taking the time to help them through the learning process was vital to Bonnie.

The relational conceptual change of the CKCM was beginning to make sense to Bonnie. She understood the need for building strong intellectual and emotional relationships with her students. But building the bridge to establish the relational conceptual change process was something she had not experienced in other pedagogical models. Bonnie realized valuing and entering students’ intellectual world with a caring disposition created a different sort of learning. Bonnie expressed that she had a new understanding of the importance and value for connecting with students intellectually and emotionally. Intellectual and emotional connections seem to facilitate the development of student comfort and confidence. Bonnie was beginning to become comfortable in “letting go” of some control in the classroom and turning the responsibility for learning to the students and allowing them the opportunity to construct understanding. This release of teacher responsibility was what she believed supported her students’ independence.

Although Bonnie was intrigued with the idea of creating a relational conceptual change process, became very excited about it, and understood the value, at moments she struggled with the issue of time in relation to content coverage as she enacted the CKCM. She, like many teachers, had a pre-conceived idea of exactly where she should start her instruction and how much she needed to accomplish by the conclusion of a time period. Such expectations are often imposed on teachers by the State Standards or Benchmarks and mandated assessments for core content areas, which includes science. Teachers are measured by these standards and we both express a desire to see our accountability system value equally the growth component related to student learning.

Our common inclination was the need to engage students actively in deep thinking about their ideas and understandings. To facilitate student understanding, a teacher needs to be comfortable in asking probing questions. This is not easy because the teacher requires a deep understanding of the subject matter and methods to establish a community of inquiry in the classroom for the construction of knowledge through a social process. Bonnie expressed how valuable the video-recordings were as she reflected on her actions. She emphasized that video-recordings of her teaching practice and reflecting on it were vital for her professional learning and development. Bonnie admitted that she learned a lot by implementing the CKCM over two years – from the spring of 2010 to the fall of 2011. Bonnie emphasized that it was during the second attempt that she understood more about the nature of asking questions. In Bonnie's words:

The first time I would ask questions and the kids would answer and that was about all. It did not lead to deep thinking. In terms of the exploration, definitely a big difference this time around, there was more thinking involved on the students' part and on my part. During the first trial I thought a 15 minute interview was a lot, however, during the second trial one of my interviews went over an hour. What I realized was that as time progressed there was a certain kind of comfort I experienced. I saw one set of questions lead to other questions and a certain way of thinking. As the kids were thinking, there was more verbalization in terms of how they were thinking. It prompted me to ask additional questions for information, clarity and elaboration while I taught lessons bases on their ideas.

Bonnie highlighted two fundamental pedagogical issues: a way of asking questions and a way of thinking. In regard to asking questions, prior to the enactment of the CKCM, Bonnie emphasized how she would ask questions and students would simply answer and she moved on. The difference now, is that Bonnie is thinking about posing a chain of questions that explores understanding of a particular concept. In regard to thinking, Bonnie pointed out students' involvements in deep thinking and their verbalization increased Bonnie's comfort and confidence in the areas of posing questions and enabling students to verbalize their ideas.

In the context of the Mystery Solutions inquiry activity, Bonnie found comfort and confidence in "letting go" of some control in the classroom and returning the responsibility to students as they engaged in constructing new ideas and understandings. The Mystery Solutions inquiry activity was the fourth lesson in the lesson sequence on acids and bases. The students were given asked to identify a selection of unidentified substances as either being an acid or base. Bonnie asked the students to share their ideas and develop an experimental design to organize their thinking and procedures for doing the Mystery Solutions activity. The students were given a range of mystery solutions and indicators for testing the pH. Moving to each group, Bonnie made sure each group was creating their own experimental design, testing, making observations, and recording their observations.

Bonnie stopped to speak with a student who seemed to be stuck in the process of experimentation. She gave suggestions for ways to begin testing and using curiosity as a means of finding out the unknown substances. Bonnie suggested that the student used what she knew to infer and that she would not tell her anything else. Bonnie wanted this student to build confidence in doing the experiment herself.

Next, Bonnie sat with an individual student who seemed to be having difficulty with testing. The student seemed more comfortable, more engaged as Bonnie worked with him. Bonnie coached him to make sure he was fully observing the pH strip and the reactions. It is important to note this was done quietly and without fanfare. She had spent most of the time with this student, reminding and making sure he wrote down all of his observations.

Bonnie approached another young man and noticed that he did not make the connection. So she suggested to him, “Okay, let me try this. How do you know you have an acid?” The student was able to correctly note the color. Then Bonnie asked another question, “Now what other substances produced the same color when tested using the indicator?” The student and the group now made the connection and used that line of questioning to test each substance. To bring the back the conversation full circle to the group, Bonnie asked them to “have some discussion.” The students began new discussions based on their findings.

The above episodes reiterated Bonnie's comfort in teaching chemistry. Bonnie reflected on another important issue that caused a shift in her thinking. This issue involved the awareness of "wait time" for student responses. To come to the realization that all students would not respond immediately, and that if they did not respond immediately it did not mean that they did not know or would not respond is a learning moment for Bonnie. Bonnie asserted in one of our conversations that she simply was not fully aware of the implication of "wait time" until now. She knew the theory of "wait time" (Budd-Rowe, 1974), however, it was only now that she was experiencing it. Bonnie shared that she too needed to release the feeling that something was wrong when there were "empty moments." When no student was responding, Bonnie was now of the understanding that there were likely several students in the process of "thinking" and indeed taking a few extra moments to formulate their responses. Because students were accustomed to moving on for lack of time to think, they too felt uncomfortable with the length of time given to them to think through an answer. Bonnie described how she was changing. She felt much more comfortable with providing time for students to think. Bonnie commented on how she now takes the time to think through her responses to students. She was more conscious of the comments to students that may have been judgmental regarding student responses.

The episode that I described now portrays Bonnie's interactions with her students. Bonnie arranged to take her students to a chemistry laboratory at the local university to conduct titration activity because she did not have access to a laboratory at NSA. In the days prior to the laboratory learning activity, she developed the concept of neutralization in class. She asked the students, "What do they get if they combine an acid and a base?" There was silence. The students did not answer. After prompting, a student answered, "Salt and H20." Bonnie asked about the chemical reactants. A student answered, "Hydroxide." Bonnie requested the same student to answer the question concerning the combination of an acid and a base. The student, in attempting to bypass the teacher's question, stated, "Oh never mind." Bonnie encouraged the student to answer the question when she stated, "No, no, no, go ahead, go ahead." The student seemed afraid to answer the question. She directed the student's attention to the board and stated, "It's on the board." After a moment, looking at the board, the student responded, "HCl". Bonnie then asked, "What does HCl stand for? She did not spell it out and the rest of the class stayed silent. Bonnie asked if they had their handout with the names of chemicals on them. There was a smattering of affirmative mutters. Then Bonnie stated, "Hydrochloric acid. Does that sound familiar to you?" One student responded, "Oh yeah."

Bonnie now attends to the other reactant in the neutralization reaction between hydrochloric acid and sodium bicarbonate. She states, "Just like we have hydrochloric acid, what would be the name of the base?" One female student whispers, "Bicarbonate." The student does not appear to be very confident about her answer and Bonnie, who is speaking, does not hear her. The rest of the class is silent. Bonnie then follows up this question with, "Well what do you see up here that could possibly be a base and what clues do you have that could tell you it is a base?" To Bonnie's question cue, one student guesses, "Water? Maybe, Sodium?" Another female student chimes in: "It turns paper blue, and it is a bicarbonate. I already said that three times." Students speak softly, probably because of lack of confidence.

Subsequently, students do independent seat work. Bonnie visits students individually and discusses the lesson**.** After seeing students struggle on their own, she suggests that they work as a group**.** However, Bonnie later realizes that the students are socializing instead of concentrating on the task. When Bonnie and I observe other lessons in the video, students are not as socially engaged. This leads Bonnie and me to discuss students' social behavior in their group work. It becomes very clear to us that the students are not confident with the content. Often times, when students are not confident with the content they do not engage in their activity. The tendency is to resort to something that is more comfortable. If the students had been more confident with the content as is the case with group work in the titration lab, the students would have concentrated on the assigned work. Students' disengagement in group work enables Bonnie to understand more than ever before the importance of forging conceptual links for her students.

As the lesson sequence unfolds, students become more confident. The discourse is more focused on the task and understanding of the concepts. The students begin to make conceptual connections. They become more serious with learning. As confidence increases, students demonstrate less dependence on Bonnie. Student non-dependence on the teacher parallels Bonnie's gain in comfort and confidence in teaching chemistry to these students. Bonnie develops pedagogical practices that support student thinking and inquiry. In Bonnie's words:
"I am comparing my experimental group with my control group. I am also reflecting on my first trial in the spring to what we are doing now. I am recognizing things I am thinking about now that I was not thinking about last year. I understand more about engaging students in inquiry."
Bonnie agrees when I mention that this unfolding of understanding about teaching does not happen overnight.

As time progresses, Bonnie observes the students develop greater dependency on themselves and form a more peer interdependency. This is truly evident at the end of the lesson sequence with the titration activity. It is exciting to see students' willingness to support each other during the laboratory experience in the video. A progression of interdependence develops with students. Note what the teacher states concerning the issue of dependence-interdependence dichotomy and the dynamics of working together:

There was a change in terms of students who were working independently. As time progressed I saw students who were developing skills for working with each other, and they kind of found it to be okay. Then there were those who were, yes, some who were leaders in the group who learned to kind of share their leadership role, and let kids who may have been somewhat passive kind of project, or interject their part or make their contribution to the learning process as a group. On one hand, I had some concerns because there was a tendency for certain kids to be too dependent on the group, and they looked to the group for consensus and just went with that. And initially, they were afraid to kind of think for themselves or commit to a particular answer. They figured that majority ruled. If the group felt that was the answer that was the answer. But then as the kids started learning how to process certain things, and draw their own conclusions, they would at least have some discussion or even sometimes in the form of a debate as to why they were going to stick with their particular response, which was good because I saw some discussion taking place among the kids. So, like I said on the one hand I could kind of see where some kids who started out being too dependent on the group learned how to be a little bit more, not so much independent, but felt confident to provide a rational if they had a different opinion about something.

Bonnie observed the transition some students made from being too dependent on her to being dependent on the members of the group. The ability of some students to be interdependent was becoming evident in the classroom during this lesson sequence. The idea that students were beginning to see the need to collaborate with each other for mutual support was very important.

This interdependence or the need for each other was often not experienced in the classroom and was an important life skill that Bonnie does not take casually.

There is much more than what I have raised above in terms of students working together in an activity. Bonnie and I discussed the importance of having students share their work orally and for other students to listen without judgment. For many of the NSA students, insecurity in expressing themselves in an open forum was based on their past experiences when they had been placed in situations where they were confronted with “put-downs.” I asked Bonnie if it appears that students become insecure when they write down something and later when someone else expresses something different, they start erasing their answers. Over time this action dissipates as students become more confident with their understanding and are comfortable expressing them openly, knowing that they and their ideas are valued and not judged. I asked Bonnie about her thoughts on the learning environment she had created. Bonnie commented that she wanted students to develop empathy for one another and engage in discourse that was meaningful and intellectual. As researcher, I was interested to knowing how this type of discourse evolved in class. Bonnie shared, “It is anchored in creating an environment for making mistakes.

> *It’s okay, no one’s going to ridicule you for being in error, and they understand that it’s a part of going through discovery. They were encouraged to rationalize a lot of things they were doing, or provide an explanation because quite a few demands were made on the kids. I could also tell that some were not accustomed to the science vocabulary. However, I still asked them to use the correct terminology, and it was okay.*

It was important for students to feel comfortable speaking in class without fear of ridicule or judgment. It is only when students take the risk to be interdependent that their confidence is enhanced and the comfort to speak increases.

As Bonnie embraced the second phase of the CKCM, she continued to create opportunities for students to share their thinking with other students. For example, in the titration activity, students worked cooperatively in pairs. The direction requires each team to repeat the process twice and the team members shared in conducting the titration activity. Bonnie noted that she plans to do more of this, where students are working with someone and at the same time, she holds each person individually accountable for engaging and understanding the process they are studying. Concurrently, she created a climate and expectation that students listened with care and empathy for each other. As students' confidence levels increased there also is a greater ability on the part of the students to work interdependently. When students are placed in an engaging environment with the expectation that the lesson is an advanced learning experience, the support and engagement among peers is visible and learning soars.

Implications

The purpose of this study was to document a teacher's reflective practice of her professional learning as she engaged in discourse with the "Other", the researcher. The context of the teacher's reflection was the enactment of the Common Knowledge Construction Model acid-base lesson sequence in an alternative high school classroom while preparing for the National Board Take One! The implication of this study is how "storytelling" can be used as a way of unpacking teacher transformation amidst complexities of classroom teaching and learning.

In this study, through storytelling, I captured the experiences of a high school teacher as she taught CKCM acid-base lesson sequence. This storytelling through the voice of the "Other" provided Bonnie an opportunity to reflect on her teaching practices and recognize changes that were occurring for her as well as changes she noted occurring with the students.

This story relates Bonnie's reflections with "the Other" based on video recordings of Bonnie's teaching and interactions with students. It was evident in the video that Bonnie had a tremendous commitment to the students and their learning. It was clear that she cared for the students and the students saw value in that caring. For Bonnie moving from less direct instruction to more facilitated learning allowed students to view her actions in the classroom as intellectual caring because she was beginning to engage in more facilitation. Moving throughout the classroom to probe and ask questions of students about their learning in small groups and individually was not new, but she saw the value in engaging in this practice much more. She was engaging and communicating with students in a nonjudgmental way and supporting their learning in a caring way. Bonnie also shared with the "Other" that enacting the first phase or Exploration Phase of the CKCM was very new for her. Taking time to have extended conversations with students about their conceptions at the beginning of the lesson sequence, valuing those conceptions and using those ideas to build the learning progression was new for her. Even though she described the process as new and different, she shared that it was a very worthwhile and valuable experience for her and the students.

Bonnie reflected on her growth in terms of facilitating student understanding and how she was engaging students in deep thinking about their work. She felt comfortable in engaging in this practice that evolved over time. Bonnie explained that it was only after initiating the second trial that she had a gestalt in understanding of what was needed to ensure her efforts with facilitating deep understanding was actually occurring. It was clear from Bonnie that care, comfort and confidence were three important elements needed as she changed her practices to support deeper understandings for students. The process of reflection through conversation with the "Other" solidified her thoughts related to her practice and student learning.

Bonnie and I discussed the idea of dependence versus independence often and in this study we both understood that these two ideas are actually interdependent. In teaching and learning we must have students that are independent thinkers, however it is equally important for these independent thinkers to appreciate and value the social process for learning. The interdependence that students in the classroom must have to learn from each other through discourse was evident as the lesson sequence progressed. Bonnie recognized the importance of this element and especially for students who pride themselves on being independent and not needing anyone to support or assist them. However, what Bonnie and the students together experienced was the importance in needing each other and supporting each other in this process.

Through this study, the new ideas and learning experiences were unpacked and the results were presented in a story format. Examining this rather new avenue for teacher professional learning is important. Using storytelling as the venue for representing teacher reflection and transformation is bound to transform other teachers.

CHAPTER 5

CONCLUSIONS OF THE STUDY

Introduction

This study is a trilogy of articles with a common framework--Intellectual Caring Common Knowledge Construction Model (CKCM; Ebenezer et al., 2010). The teacher (Bonnie) in this study designed and enacted CKCM acid-base lesson sequence with African American alternative high school students. The study is anchored on student conceptual change and achievement, teacher practical arguments and professional learning. The study focuses on the impact of the CKCM on Bonnie's own practice and improving her students' learning. After summarizing all three articles, I present the summary of each article consecutively:

The study of teaching and learning during this period of translating ideals of reform into classroom practice enables us to better understand student-teacher-researcher symbiotic learning. In line with this assumption, the purpose of this study is threefold: (a) observe the effect of the Common Knowledge Construction Model *(*CKCM), a conceptual change inquiry model of teaching and learning, on African American alternative high school students' conceptual change and achievement; (b) observe the shift in teacher's practical arguments; and (c) narrate the voice of the "Other" about teacher professional learning. This study used retrospective data from a mixed-method approach consisting of phenomenography, achievement, practical arguments, and storytelling. The data sources include audio-recordings of a chemistry teacher's individual interviews of her students' prior– and post-intervention conceptions of acids and bases; results of Acid-Base Achievement Test (ABA-T); video-recordings of a chemistry teacher's enactment of

CKCM acid-base lesson sequence; audio-recordings of teacher-researcher reflective discourse using classroom video-clips; teacher interviews; and teacher and researcher personal reflective journals.

Summary of Article One

The purpose of the first article was to study the effect of an intellectually caring conceptual change model on African American alternative high school students' conceptual change and achievement in a unit on acids and bases. A mixed-methods approach using retrospective data was utilized. Data secured from the teacher were the audio-recordings of her prior- and post-intervention individual interviews with students and the results of the students' prior- and post-intervention Acid Base Achievement Test (ABA-T). The audio-recorded interviews were transcribed verbatim. Two research goals were identified for this study – and that is, conceptual change and its effect on achievement. The two research questions formulated were: (1) What conceptual changes were evident for a group of urban alternative high school students, when immersed in the CKCM-based acid-base lesson sequence? (2) Does the CKCM acid-base lesson sequence significantly improve urban alternative education students' achievement compared to (a) pre and post-interventional teaching; and (b) traditional teaching?

The significance of this study is that it may be helpful in assisting other teachers and researchers who are looking for a caring teaching and learning model that addresses the needs of an alternative school. The study also may be used by other science teachers to gain insight on students' prior conceptions of acids and bases along with an evidence based CKCM acid-base lesson sequence for other teachers and curriculum developers to adopt or adapt based on their academic contexts. The theoretical framework for this study includes the following (a) conceptions of teacher caring related to pedagogy and (b) the intellectually caring common knowledge construction model. The qualitative results for this study provided evidence in three chemical concepts: acids, bases and neutralization. Based on the descriptive categories the study observed the following trends (1) changes in the number of categories of description; (2) shift in language use from everyday talk to chemical talk; and (3) development of hierarchy of chemical knowledge. The quantitative results for the study provide support that the students' knowledge of acids and bases improved significantly following the intervention of the CKCM. The implications for the study are three-fold: (a) a caring conceptual change model for the unreached mind; (b) empathetically listening to alternative students' simple chemical talk and making it sophisticated; and (c) the use of the CKCM for alternative students' conceptual change and success in a traditional achievement test.

Summary of Article Two

The purpose of second study is to elicit, appraise, and reconstruct a chemistry teacher's practical arguments as she engages in discourse with a researcher after enacting a unit on acids and bases in an alternative high school chemistry classroom using the *Common Knowledge Construction Model* (Ebenezer et al., 2010). The data for this study consisted of audio-recorded discourse between the chemistry teacher and the researcher as they reflected on the video recordings of the chemistry teacher's lessons on acids and bases. The research question posed for this study is as follows: What practical arguments arise when a chemistry teacher dialogues with a researcher about her enactment of the CKCM acid-base lesson sequence in an alternative classroom context? The study is significant in two ways (a) a narrative of one chemistry teacher's practical arguments about teaching a group of alternative high school students on acid-base lesson sequence may provide insights that may inspire and inform other science teachers to engage in practical argumentation with the expert "Other" for their own professional learning;

and (b) a chemistry teacher's conversations with a researcher using video-clips add another piece of research evidence to the literature on reflective practice through practical argumentation for teacher professional learning. The theoretical frameworks for this study are: (a) teacher practical arguments, and (b) the Common Knowledge Construction Model.

The professional learning consisted of coaching by a university expert and facilitated by the expert "Other", the researcher of the study. The researcher engaged the teacher on focused reflective dialogues with her about the enactment of the CKCM acid-base lesson sequence. Throughout the professional learning, it was important for the researcher to keep four elements in mind as the study was enacted: (a) the professional learning needs to occur over time to support the reflective process (b) the professional learning needed to be in the context of the school and classroom where the teacher taught (c) the professional learning has a focus on the content and pedagogy to support sound teaching and learning practices (d) the professional learning supports the assessment of teacher's beliefs and values in order to support the change expected. These elements were integrated into the process for each phase of the study. The findings of this study are discussed in the contexts of three science activities, namely, (a) Mystery Solutions Activity, (b) Titration Activity, and (c) pH Activity. The discourse between the teacher and the researcher, the "Other," gave rise to several practical arguments related to issues on teaching and learning. During the teacher-researcher discourse, the practical arguments on divergent issues that the teacher raised indicate the following major shifts: (a) inadequate preparedness to adequate preparedness; (b) low confidence to high confidence; and (c) surface learning to deep learning. The study implies that engaging teachers with the expert "Other" to elicit and appraise practical arguments in order to reconstruct is a valuable reflective practice for teacher change in thought and action. For this purpose, there should be mutual trust between the teacher and the “Other”.

Summary of Article Three

The third article narrates a story about the experiences of a teacher as she reflects on her professional learning over a period of several months, based on teaching urban African-American students in an alternative high school using the Common Knowledge Construction Model (Ebenezer et al., 2010). Developing a story is an essential process for capturing the richness and complexities of studying teacher practice. The theoretical framework for this study is comprised of two complementary conceptual models: (a) teacher professional learning; and (b) the Common Knowledge Construction Conceptual Change Model (Ebenezer et al., 2010).

Professional learning of Bonnie’s story is developed within three contexts: The first is the researcher’s story of her experience with the developer of the CKCM. The second is the researcher’s drive to introduce National Board for Professional Teaching Standards Take One! to her school district. The third is the teacher’s involvement with the Nation Board Take One! All three contexts have a bearing on Bonnie’s developing story. The data collection includes the teacher video-recordings of the classroom enactment of the CKCM acid-base lesson sequence; the construction of narratives; the audio-recordings of the teacher-researcher discourse based on the teacher enactment of the CKCM acid-base lesson sequence; the researcher’s interview with the teacher after the enactment of the CKCM acid-base lesson sequence; and the teacher’s personal reflective paper sent to the researcher via e-mail attachment. The story is called Profession Learning of Bonnie: Pedagogical Care, Comfort and Confidence. The implication for this study is that researchers can understand that “storytelling” is a way of unpacking teacher transformation and representing that knowledge.

The overarching conclusions based on all three articles are as follows: The urban American African alternative high school students experienced relational learning because of the teacher's use of the intellectual caring Common Knowledge Construction Model of teaching and learning in a chemistry class. The teacher's practical arguments and professional learning revealed transformation in teacher thought and action. The story uncovered pedagogical care, comfort and confidence.

APPENDIX A: ACID-BASE ACHIEVEMENT TEST (ABA-T)

Directions: Do not write on this test. Record your answers on a scantron.

1. A group of scientist stumbles upon a lake found to have a basin mostly consisting of limestone ($CaCO_3$) in an area of the United States known for its problems with acid rain. The lake should have a pH of ___.
   a. 6-8 b. 2-4 c. 9-11 d. None of these

2. Hydroxides of Group 1 metals ___.
   a. Are all strong bases c. are all weak bases
   b. Are all acids d. might be either strong or weak bases

3. Strong bases produce ___.
   a. Small quantities of H^+ ions c. large quantities of H^+ ions
   b. Small quantities of OH^- ions d. large quantities of OH^- ions

4. The reaction $HCl + KOH \rightarrow KCl + H_2O$ is a ___.
   a. Synthesis reaction c. neutralization reaction
   b. Ionization reaction d. decomposition reaction

5. What is the pH of a neutral solution at 25°C?
   a. 0 b.1 c. 7 d. 14

6. A solution whose pH is 4 ___.
   a. Is always neutral c. is always acidic
   b. Is always basic d. might be neutral, basic or acidic

7. A solution whose pH is 10 ___.
   a. Is always neutral c. is always acidic
   b. Is always basic d. might be neutral, basic or acidic

8. The pH of a solution is 9. What is its H^+ ion concentration?
   a. 1×10^{-9}M c. 1×10^{-5}M
   b. 1×10^{7}M d. 9M

9. The pH of a solution is 10. What is its OH^- concentration?
   a. 1×10^{-10}M c. 1×10^{-4}M
   b. 1×10^{-7}M d. 10 M

10. Which substance doesn't conduct electricity?
   a. $C_6H_{12}O_6$ b. HCl c. H_2SO_4 d. vinegar

11. Which acid is not strong?
   a. HCl b. HCN c. HNO_3 d. H_2SO_4

12. Which one of the following is weak base?
   a. KOH b. NaOH c. NH_3 d.CH_3COOH

13. Information for three solutions are:

#1	#2	#3
pH=7	pOH=12	$[H^+] = 1x10^{-4}$

   Which one(s) of the above is acidic solution?

   a. #1 and #2 b. #1 and #3 c. #3 d. #2 e. #2 and #3

14. When performing an acid-base titration, which procedure would NOT introduce an error into the experimental results?
   a. Adding an unmeasured amount of water to the carefully measured acid sample which is being titrated.
   b. Failing to rinse the burettes with the appropriate reactants after cleaning and rinsing with water.
   c. Failing to remove bubbles of air from the tips of the burettes before beginning the titration.
   d. Using an indicator that changes color at a pH considerably removed from the pH at the equivalence point of the titration.

15. Which one of the following is not a property of acid solutions?
   a. Solution tastes sour.
   b. Solution is a good conductor of electricity.

c. The [H^+] can be 10^{-2}M in solution.
d. React with Mg to produce H_2 gas.
e. Solutions turn litmus blue.

16. Determine the pH range of the salt produced in the following reaction:
$NaOH + H_2SO_4 \rightarrow Na_2SO_4 + H_2$
a. 1 b. 2-6 c. 7 d. 8-13 e. 14

17. You are working for the Environmental Protection Agency (EPA). Which supply in your stockroom would you use to neutralize acid from a car battery?
a. NaOH b. HNO_3 c. HC_2H_3O d. $Al(OH)_3$

18. The unit of measure used to express the concentration of an acid or base is ___.
a. mL b. M c. mole d. g

19. Which piece of lab equipment would give you the most accurate pH of a substance?
a. Litmus paper b. pH paper c. pH probe d. phenophathalein e. universal indicator

20. Which statement best describes your understanding of acid-base chemistry?
a. I’ve seen some of this information before.
b. I’ve seen a lot of this information; I just forgot how to do it.
c. Most of the questions I’ve never seen before.

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ABSTRACT

CONCEPTUAL CHANGE AND SCIENCE ACHIEVEMENT RELATED TO A LESSON SEQUENCE ON ACIDS AND BASES AMONG AFRICAN AMERICAN ALTERNATIVE HIGH SCHOOL STUDENTS: A TEACHER'S PRACTICAL ARGUMENTS AND THE VOICE OF THE "OTHER"

by

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The study of teaching and learning during the period of translating ideals of reform into classroom practice enables us to understand student-teacher-researcher symbiotic learning. In line with this assumption, the purpose of this study is threefold:(1) observe effects of the *Common Knowledge Construction Model (*CKCM), a conceptual change inquiry model of teaching and learning, on African American students' conceptual change and achievement; (2) observe the shift in teacher's practical arguments; and (3) narrate the voice of "the Other" about teacher professional learning.

This study uses retrospective data from a mixed-method approach consisting of Phenomenography, practical arguments and story-telling. Data sources include audio-recordings of a chemistry teacher's individual interviews of her students' prior- and post-intervention conceptions of acids and bases; results of Acid-Base Achievement Test (ABA-T); video-recordings of a chemistry teacher's enactment of CKCM acid-base lesson sequence; audio-recordings of teacher-researcher reflective discourse using classroom video-clips; teacher interviews; and teacher and researcher personal reflective journals.

Students' conceptual changes reflect change in the number of categories of description; shift in language use from everyday talk to chemical talk; and development of a hierarchy of chemical knowledge. ABA-T results indicated 17 students in the experimental group achieved significantly higher scores than 22 students in the control group taught by traditional teaching methods. The teacher-researcher reflective discourse about enactment of the CKCM acid-base lesson sequence reveals three major shifts in teacher practical arguments: teacher inadequate preparedness to adequate preparedness; lack of confidence to gain in confidence; and surface learning to deep learning. The developing story uncovers several aspects about teaching and learning of African American students: teacher caring for the uncared; cultivating student and teacher confidence; converting dependence on teacher and self to peer interdependence.

The study outlines six implications: caring conceptual change inquiry model for the often unreached mind; developing simple chemical talk into coherent chemical explanation; using CKCM for alternative high school students' conceptual change and achievement; engaging teachers in elicitation and appraisal of practical arguments for reconstruction of beliefs; overcoming challenges in teacher practical argument research; and "storytelling" as a way of unpacking teacher transformation amidst complexities of classroom teaching and learning.

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