1-1-2015

Using The Instructional Congruence Model To Change A Science Teacher's Practices And English Language Learners' Attitudes And Achievement In Science

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USING THE INSTRUCTIONAL CONGRUENCE MODEL TO CHANGE A SCIENCE TEACHER'S PRACTICES AND ENGLISH LANGUAGE LEARNERS' ATTITUDES AND ACHIEVEMENT IN SCIENCE

by

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DISSERTATION

Submitted to the Graduate School

of Wayne State University,

Detroit, Michigan

in partial fulfillment of the requirements

for the degree of

DOCTOR OF PHILOSOPHY

2015

MAJOR: CURRICULUM & INSTRUCTION
(Science Education)

Approved By:

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Advisor Date

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DEDICATION

This research project is dedicated to my former students and co-workers at Riverside Academy West, who shared in many wonderful years of my teaching career, and who provided the impetus to grow and go farther than I ever thought I could.

ACKNOWLEDGEMENTS

I would like to acknowledge the following people for their support and assistance through the entire process of this dissertation:

- The participating teacher and subjects of this study for their generosity in sharing their classroom experience.
- To my parents, siblings, husband and children for their unwavering support in this journey.
- To my dissertation committee, Professors Maria M. Ferreira, Ava Zeineddin, David Grueber, Justine Kane and Robert Arking for their time, interest and feedback in my research and writing. Special thanks to my research director and committee chair, Dr. Maria M. Ferreira who has provided so many opportunities to encourage my growth and learning; especially for her competent advising, and for her esteemed example as a mentor.
- Gratitude to my family and friends for believing in me.
- Profound appreciation to the doctoral learning community and to the Research Design and Analysis Unit at Wayne State University, and my classmates for sharing the process.

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CHAPTER 1

INTRODUCTION

The ultimate goal of education is to prepare students to succeed in their schooling and to be effective contributors to society and the workplace. In her book, *Releasing the Imagination: Essays on Education, the Arts, and Social Change,* Maxine Greene (1995) confirms that education is geared toward economic competitiveness and mastering technology, further acknowledging that, "The difficult task for the teacher is to devise situations in which the young will move from the habitual and the ordinary and consciously undertake a search" (p. 24). It is the noble mission of educators to ensure students are ready for life outside school that demands good decision-making skills. Typically, students who are ill-equipped with the necessary language and skills face more difficulties socially and economically.

In 1983, the United States National Commission on Excellence in Education emphasized, through its publication of *A Nation at Risk*, the need to reform classroom practices since the U.S. schools fail to prepare students to effectively use in the workplace the knowledge attained in mathematics, science, and technology. Later in 1996, the National Research Council (NRC) released the *National Science Education Standards* (NSES) stressing that the emphasis in science had been on acquiring factual knowledge rather than being engaged in the processes of science. Since then, there has been an increased emphasis on using inquiry-based science approaches as the central strategy for teaching science.

The National Science Education Standards' focus on inquiry use in science instruction (NRC, 1996) was based on research results showing that inquiry improves student achievement, attitude, and process skills (Shymansky, Kyle, & Alport, 1983; Shymansky, Hedges, & Woodworth, 1990).

Teaching science as inquiry is particularly effective with underrepresented populations such as English Language Learners (ELL) because it facilitates the development of students' vocabulary (Fellows, 1994; Haury, 1993). The use of inquiry assists ELL students in moving closer to scientific understanding as they build their language skills (Fellows, 1994). Inquiry use along with the language support that ELL students receive normally translates into higher academic achievement (Lee, Deaktor, Hart, Cuevas & Enders, 2005).

Problem Statement

Research indicates that the number of English Language Learners (ELL) in public schools has been increasing at a fast pace. ELL refers to students who have recently immigrated to the U.S. or U.S. born students who live in a household where English is rarely spoken. The US Department of Education mandates placing ELL students in an appropriate grade level according to their age. However, often guidance counselors and teachers prefer to place ELL students in classes suited to their academic level to best meet their educational needs. The 2002 No Child Left Behind Act placed additional challenges on schools by demanding that the academic progress of special student populations, including ELL students, be monitored and their level of academic proficiency measured.

Because the number of limited English proficient and immigrant students is continuously on the rise, there is a similar increase in their needs for language support to help them achieve academically.

Research indicates that the traditional educational paradigm has been ineffective in meeting the needs of the increased diversity of the US student population (Banks, 2001). The Lee and Fradd's (1998) framework of instructional congruence provides science teachers with a framework that can be used to increase their ELL students' opportunities to acquire information and learn in meaningful ways. According to Lee and Fradd (1998), mediating the nature of academic content with students' language and cultural experience creates instructional congruence and makes science content meaningful and relevant for different learners. Therefore, by integrating literacy and science, achievement is promoted in both areas.

Research Objectives and Questions

The goal of this study was to examine the effects of the instructional congruence model on a teacher's instructional practice teaching English Language Learners (ELL) in an urban school in the Detroit area. The study also examined the impact of the instructional congruence model on the students' attitudes and achievement in science. The following research questions guided this study:

1. What changes in attitudes towards science are evident in ELL students after experiencing the instructional congruence model in a science unit?

2. What changes in ELL students' achievement are evident during a science unit taught using the instructional congruence model?
3. What changes in a teacher's practices and views on the nature of science are evident while adapting the instructional congruence model in a science unit?

Significance of the Study

The instructional congruence model provides teachers a practical guide to address ELL students' needs by combining language and science components in order to create harmony between the student's language, experiences, and schooling. Since cultural congruence is the basis of the instructional congruence model, most of the previous work related to the instructional congruence model involved teachers who shared their students' language and culture. In this study, however, the instructional congruence model was used with a teacher of a different culture, background and language from his students. To the present, the model has been tested with Hispanic students only. No use of the instructional congruence model is reported on any other population in the US. Abroad, the instructional congruence model has been tested on students in Indonesia. Additionally, none of the studies on the instructional congruence model have included high school students of Middle Eastern (Arabic) descent. Therefore, this study adds to the growing body of research related to practices in science education that produce higher achieving and well-rounded students, particularly those from ELL backgrounds.

CHAPTER 2

THEORETICAL FRAMEWORK

The terms English Language Learners (ELL) and Limited English Proficiency (LEP) are used interchangeably to refer to students who have recently immigrated to the U.S. or to U.S. born students who live in a household where English is rarely spoken. Non-English-Language Background (NELB) is still another term that has been used to describe such students, whose difficulties with the English language may include understanding, speaking, reading, or writing, which hinder their achievement on state assessments. Such students have difficulties achieving in a classroom where the instructional language is English, and therefore have fewer opportunities to fully participate in the instructional process and later in society (U.S. Department of Education, 2013). For the purpose of this study the term ELL will be used to denote students in any of the aforementioned categories.

The National Clearinghouse for English Language Acquisition & Language Instruction Educational Program (NCELA) is responsible for documenting the growth of the ELL population and school enrollment. Using the 2002-2003 school year as a base, NCELA identified 4,340,006 ELL students attending public schools. In the 2007-08 school year 4.7 million students were identified as ELL, constituting about 10 percent of the total student enrollment. In the 2008-2009 school year over five million English Language Learners from grades pre-K through12 were enrolled in US public schools, maintaining the 10% representation. These data show a 7% increase between the 2002-03 and 2009-10 school years in the number of ELL students in grades K-12. This increase might be the result of better reporting, which has also led to a decrease in the gap of identified versus served ELL students by Title III-funded language instruction educational programs. For example, in the 2002-03 school year, 4,340,006 students were identified as ELL/LEP but only 3,639,219 were served. Some estimate that by 2030 the number of ELL students could account for 25-40% of all students in k-12 schools (Garcia, 2002).

Regardless of the difficulties ELL students face in US schools, the Department of Education mandates placing these students in appropriate grade levels according to their age. However, guidance counselors and teachers prefer to place students in classes suited to their academic level to best meet their educational needs. The 2002 *No Child Left Behind Act* placed additional demands on schools, teachers, and guidance counselors related to meeting the needs of ELL students in order to help them attain academic proficiency. Because the numbers of ELL students are on the rise, there is a similar rise in their needs related to additional language support and resources to help them achieve academically. Of particular concern to this study is the Arab American community in Michigan. According to the U.S. census this community grew by more than 65% between 1990 and 2000, more than doubling the population since 1980. According to the Arab America website, more than 80% of Arab Americans reside in Wayne, Oakland and Macomb counties and one-third of the city of Dearborn residents claim Arab heritage (www.arabamerica.com).

Unfortunately, the traditional educational approaches used in most schools do not appear to be effective in meeting the needs of the increased diversity of the student population (Banks, 2001). ELL students need learning environments that facilitate acquisition of academic content while attaining literacy in a second language (Cummins, 1984; Thomas & Collier, 2002; Wong-Fillmore & Snow, 2000).

Addressing the needs of ELL students

Educators have attempted to assist ELL students by removing them from general education classrooms and placing them in special education classes to receive language assistance (Gersten, 1996). May schools have used this approach due to the lack of resources and appropriate programming options (Mehan, Hertwick, & Meihls, 1986). According to Frattura and Capper (2007), removing students from regular classes fragments their instructional experience, decreases their sense of belonging in school, and leads to lower achievement. Fierros (2002) adds that ELL students are frequently taught in unnecessary isolation where teachers typically use manufactured remedial materials (Gersten, 1996; Ruiz et al., 1995). Collier and Thomas (2004) point out that if ELL students are isolated for longer periods of time, they will eventually fall behind academically and "must make more than one year's progress every year to eventually close the gap" (p. 2).

The 2002 *No Child Left Behind Act* held educators in general, and teachers in particular, accountable for the success of their students using standardized test scores. Fry (2007) analyzed the 2005 nationalized test scores and found that one in three ELL student in fourth grade was behind in math achievement, compared to their native English speaking peers. The gap was even higher in reading. Fry noted that as time passed, the gap widened and suggested removing ELL students from ELL classes as soon as they are ready to work independently.

Students' understanding of academic content, attitude, and motivation are important factors affecting their achievement. For teachers to effectively reach ELL students they must: (1) create an environment conductive to learning, (2) use appropriate strategies to meet their needs, and (3) build their general and content-specific academic vocabulary. Teachers need to be equipped with the skills and tools needed to teach science to their ELL students. Some of the identifiable skills of successful science teachers of ELL students include their ability to communicate effectively with students and to engage their families (Gándara, Maxwell-Jolly & Driscoll, 2005; Moll, Amanti, Neff & González, 1992). Effective teachers also help ELL students make connections between content and language, and support their communication and social interaction (Facella, Rampino & Shea, 2005). Additionally, ELL students gain a deeper understanding of science concepts when they are guided through multisensory explorations that repeatedly expose them to keywords, use visual clues, and use definitions in context (Husty & Jackson, 2008). Finally, measuring student achievement may take different forms; yet, no matter what alternative assessments teachers use, all assessments must show increase in student knowledge and better understanding of the science concepts.

High-quality materials designed to meet the current science education standards are difficult to find. Kesidou and Roseman (2002) conducted a study to examine how well nine widely used science programs supported the attainment of key scientific ideas specified in the national science standards. Teams of teachers and research specialists in teaching and learning reviewed the materials and concluded:

> Programs only rarely provided students with a sense of purpose for the units of study, took account of student beliefs that interfere with learning, engaged students with relevant phenomena to make abstract scientific ideas plausible, modeled the use of scientific knowledge so that students could apply what they learned in

> everyday situations, or scaffolded student efforts to make meaning of key phenomena and ideas presented in the programs. (p. 522)

Furthermore, Barba (1993) reported that students were taught science using materials not relevant to their language and/or culture in the 57 observed bilingual/bicultural classrooms in southwestern United States. Traditionally, science instruction has relied on artifacts and cultural examples that are often unfamiliar to non-mainstream students (Barba, 1993).

Culture and Student Learning

Students who live in a culture different than their own often receive multiple or perhaps opposing messages. Eisenhart (2001) provided an accurate description of the students' reactions as they attempted to fit in with the rest of the student population:

> Living at the juncture of different traditions, these individuals must make sense of their lives by crossing, blending, negotiating, or transcending the boundaries of tradition…they develop behaviors and attitudes in practice that deal directly with the challenges of being "mixed," "different," or simply, "oneself. (Eisenhart, 2001, p. 19)

A number of factors effect ELL students' educational experiences and learning. Culture, for example, influences the way in which students interact with the teacher and receive information (Stewart & Benson, 1988). Hvitfeldt (1986) reported that cultural variables influence students' preferred learning modes, verbal interaction patterns in the classrooms, and students' concept acquisition. Culturally harmonious variables used in a science classroom include variables such as instructional language, level of peer interaction, level of interactivity with instructional materials, culturally familiar elaboration and context, and preferred instructional mode (Barba, 1993).

The importance of student classroom discussions was stressed by Gee (1997) and divided into four types: *design and debate, anomaly talk, everyday speculation talk,* and *explanation talk. Design and debate* discussion takes place when students are discussing how to set up an experiment and whether what is used appropriate. This type of classroom discussion is related to the procedure and limited to how to conduct a research experiment. The second type of classroom discussion, *anomaly talk,* refers to a discussion of unexpected results in a science experiment. It does not include building connections between scientific ideas and concepts. The third type of classroom discussion, *everyday speculation talk*, uses everyday language and experiences to refer to the processes students learned. The downfall of this type of talk is the possibility of students deviating from the science concepts and process into other, non-related conversations. The final type of classroom discussion in Gee's (1997) categories is *explanation talk. Explanation talk* is often unused by students due to the fact that they have not yet developed their scientific literacy. When used, students try to make sense of science through explaining.

Using the student's native language as the instructional language in the classroom builds the child's self-esteem (Cohen, Lotan & Catanzarite, 1990) and, as confirmed by Pitman (1989), aids in English language development, facilitates content area acquisition, and improves the student's attitudes towards school. Cohen, Lotan and Catanzarite (1990) reported that content area acquisition was further enhanced by peer tutoring. Peer tutoring is an effective way to fill in the gap and create clear understanding of concepts for bilingual students. According to Watson (1991), students prefer peer tutoring environments to large group instructional situations; they profit from peer tutoring and cooperative group work in terms of attitude change, cognitive growth, and self-esteem.

Culturally familiar examples and elaborations present a powerful tool in concept acquisition. These include using culturally familiar objects, examples, analogies, environments and contexts (Watts, 1986). According to Barba (1993), “Culturally familiar examples and elaborations append new learning to existing schema. Cued recall in one’s native language serves to activate prior knowledge and to allow students to connect new knowledge to existing schema” (p. 1058). Interaction with instructional materials also increases bilingual students’ attitudes towards science and their learning of conceptual or declarative knowledge (Cohen et al., 1990). Thus, science activities and experiments help develop students’ problem solving skills; a social as well as academic component in their preparation to become active participants in today’s society.

Instructional Congruence Framework

Educators have been promoting high academic standards for students from Non-English-Language Background (NELB) for a long time. Lee and Fradd (1998) introduced the instructional congruence framework as a model for the underserved, yet rapidly growing population of NELB. The instructional congruence framework is proposed as “a way of making the academic content accessible, meaningful, and relevant for diverse learners (e.g., NELB students)” (Lee and Fradd, 1998, p. 12). Instructional congruence is an agreement or harmony between the language, experiences, culture and the child’s science school experiences. The model is based on the belief that if students’ cultures are reflected in the science instruction, effective science education is more likely to be achieved. The instructional congruence framework serves as a "conceptual and practical guide for improving instructional materials development, classroom practices, teacher training, and student achievement" (Zain et. al., 2010, p. 42). The aim of instructional congruence is to help students develop their language skills and understanding of science by using scientific inquiry practices and engaging them in scientific discourse (Luykx & Lee, 2007). Even though there are many strategies to teach students science, the instructional congruence model is the only coherent model for teaching science to ELL students.

Integrating science and literacy. Traditionally science teaching focused on knowledge attainment and habits of mind. Knowledge attainment manifested itself in terms of students' ability to memorize facts related to a set amount of science information. Habits of mind involved understanding the values and attitudes related to science in addition to the world view of science. Integration of subjects during science instruction was rarely used. Over the years however, views about science teaching and learning changed. Currently, science knowledge includes knowing science, doing science and talking science. In this new model of science instruction, employing language is an essential part of science learning. Language is used to construct understanding in science, communicate procedures and inquiries in science, and make informed decisions (Yore, 2004). In the conceptual framework of instructional congruence, science and literacy are integrated and emphasized. Academic and social discourse and cultural understanding are key elements in the language component of the model. In this framework, cultural congruence is evident in the interaction of students and their teacher using a shared language and culture (Saunders et al., 1992; Tuyay et al., 1995).

Key elements of instructional congruence. Teachers' instructional practice must contain key elements as they attempt to establish instructional congruence in their science classes (Lee & Fradd, 1998). Teachers need to know (a) who their students are, (b) how they acquire their literacy and English-language proficiency, (c) what the nature of science is, (d) what kind of language and cultural experiences students bring to the learning process, and (e) how to enable and guide students in their journey to understand science. According to Gutiérrez and Rogoff (2003) teachers' familiarity with their students' "individual's background experiences, together with their interests, may prepare them to knowing how to engage in particular forms of language and literacy activities, …" (p. 22).

However, becoming familiar with each of their student's cultural and language backgrounds poses a challenge to educators working in schools with a very diverse student body. Ethno-linguistic diversity in the U.S. generally identifies five major categories: White, Black, Hispanic, Asian, and American Indian. However, each one of these categories includes students who speak different languages and have different cultural experiences. For example, within the "White" category, students could be from Brazil, Canada, Latin America, Europe, and the Middle East. While some people within the "White" category speak English as their native language, others do not. Therefore, identifying students using the five ethno-linguistic categories might not be very useful when trying to implement the instructional congruence model, unless educators examine closely each student's particular culture.

When students learn science through inquiry, language is used to do science, know science, and talk science. As a result, in this type of learning environment it is not sufficient for students to be able to speak, listen, and read and write English. Learning science in this environment further requires that students know how to observe, analyze, predict, and present information effectively whether in oral or in written form. In such educational contexts children develop their social as well as academic language.

Posner and colleagues (1993) report that prior knowledge and personal experiences play key roles in acquiring new knowledge. Identifying relevant experiences can play a major role in linking what students already know with what they are expected to learn because the knowledge ELL students bring to the learning process may differ from that of mainstream students (Atwater, 1994).Teachers' awareness of the variety of cultural and linguistic experiences among their students is necessary for them to understand how different students may approach science learning. Providing the students with opportunities to talk science is a recommended step in the journey of science learning. It helps students access their prior knowledge, develop their current understanding of ideas, and learn new knowledge.

Teacher's role in the instructional congruence model. Congruence between the nature of science and the language and cultural experiences of students is a needed component in order to promote science learning for ELL students (Lee & Fradd, 1998). Driver and colleagues (1994) explain that the central role of a teacher is to mediate between the students' world and the world of science. In the instructional congruence model, teachers must understand and appreciate the students' language, cultural experiences, and current science knowledge in order to relate science concepts to students' background experiences. Tikunoff (1985) added that in establishing instructional congruence, teachers can build on students' background experiences while promoting new ways of understanding and communicating about academic subjects. Fradd and colleagues (1997) reported that after teachers became confident and knowledgeable of the specific science content, they began to establish instructional congruence by relating their students' experiences to promote both science learning and language development.

To effectively instruct students using the congruent teaching framework, teachers must have knowledge of both the academic disciplines and student diversity (Lee & Fradd, 1998; Moje, Collazo, Carillo & Marx, 2001; Warren, Ballenger, Ogonowski, Rosebery & Hudicourt-Barnes, 2001). Identifying the rich experiences and resources students bring to the science classroom serves as the basis or prior knowledge in preparing instruction for a particular population of students. Luykx and Lee (2007) add:

> The aim of instructional congruence framework is not to lower expectations for non-mainstream students, nor to adjust curricular content so as not to conflict with students' home cultures. Rather, it is to guide teachers in recognizing students' prior linguistic and cultural knowledge and the relation of this knowledge to scientific content and practice. Such consideration of each student's "starting points" will help teachers to map out more effective paths for leading students toward scientific understanding and practices. (p. 426)

Instructionally congruent teaching requires that teachers make connections between academic subjects and the students' cultures and languages in order to develop congruence between them. This may be established by engaging students in meaningful, challenging and relevant content and instructional activities. By linking the content to the students' interests and experiences, teachers help activate the students' prior knowledge especially when they use familiar vocabulary. Teachers may also choose visual images to assist students in acquiring new information as the core instruction is provided in Standard English.

Instructional Behaviors and Tools in the Instructional Congruence Model

The first step in preparing effective instruction is to identify students' needs. The characteristics of effective teachers' instructional style include language proficiency, cultural knowledge, and linguistic knowledge combined with positive teacher attitude and competencies (Clark & Perez, 1995). Effective teachers reach their ELL students by communicating clear directions, pacing lessons, making jointly determined decisions, providing immediate feedback, monitoring students' progress, instructing in the students' native language, employing dual language methodology, integrating students' home culture and values and implementing a balanced coherent curriculum (Baker, 1997). The science education community agrees that rigorous standards supported by effective teaching and quality curricula result in more learning and translate into higher achievement level. Even though there are many strategies, such as inquiry use, to teach students science, the instructional congruence model is the only coherent model for teaching science to ELL students.

Inquiry use. Lack of communication in a science classroom may result in students not having confidence in their ideas or findings (Lemke, 1990). Typically, such students run back to the teacher for the “right answer” when they are faced with any uncertainties. It is the teacher’s responsibility to create opportunities for students to develop basic skills and understandings in science. When students design their own experiments and carry them out, not only do they develop confidence in their findings, they are also able to defend their results. Ideally, inquiry science teaching addresses the importance of communication in science through the vocalizing and writing of students’ ideas, science thinking, and critical analysis (Lemke, 1990).

Driver and colleagues (1994) reported that several scholarly groups had researched students’ conceptual change as a result of implementing inquiry instruction. Learners’ reasoning skills and logical thinking were used as part of applying inquiry to convince the students to change their existing science ideas. The intentional planning of activities showed students the flaws in their previous knowledge and the hands-on activities convinced them of accurate information by highlighting correct ideas and concepts. In other instances, the whole curriculum was employed to change the students’ conceptual thinking. For example, in reporting on the effectiveness of curriculum developed by Anderson and colleagues, Fellows (1994) found that students (a) added new principles or theories to their conceptual schema, (b) organized their schema around more central concepts, and (c) moved closer to scientific understanding. Along the same lines, Shymansky and colleagues (1983, 1990) reported an improvement in students’ achievement, attitude, and process skills in some areas of science as effects of a new science curriculum. Finally, Ford and colleagues (2000) demonstrated that students displayed sophisticated understandings of light as a result of combining guided inquiry and specially designed texts.

Adopting the science inquiry teaching approach assists in increasing students' understanding and achievement. Students' academic growth is typically assessed through standardized tests. If the test scores do not reflect improvement, it is assumed that not enough growth in knowledge was acquired. Lee and colleagues showed that incorporating science and literacy through the use of science inquiry, results in significant increases on all measures of science and literacy for students from diverse languages and cultures (Lee, Deaktor, Hart, Cuevas & Enders, 2005). Haury (1993) summarized the benefits of inquiry science teaching:

1. Generally enhances student performance, particularly lab skills;
2. Fosters scientific literacy and understanding of science processes;
3. Fosters vocabulary knowledge and conceptual understanding;
4. Develops critical thinking;
5. Develops positive attitudes towards science, and;
6. May be particularly valuable with underrepresented populations.

Questioning techniques. It is human nature to inquire about phenomena through questioning. Questioning techniques increase teacher-student interactions and stimulates productive thinking of ELL students. In her study, *Teacher Questioning in Science Classroom*, Chin (2007) showed how teachers may shape student thinking and construct scientific knowledge using questioning techniques. Classroom talk serves as character and knowledge builder at the social and linguistic levels. Chin described the different questioning approaches that stimulate productive thinking and compared teacher questioning in both the traditional and constructivist/inquiry teaching settings. Teachers in the traditional setting applied the Initiate-Response-Evaluate (IRE) model of questioning to evaluate student knowledge, followed a planned agenda, praised correct answers and considered themselves as the authoritative figure in their classrooms. In comparison, in the constructivist/inquiry model, teachers facilitated assessment of knowledge by eliciting and directing student thinking, adjusting the questioning per the students' input, engaging them by holding them responsible for their own thinking, and encouraged the students as they became decision makers or experts on specific topics.

Teachers must consider carefully the three components of questioning (context, content, and responses & reactions to questions) since they are the coaches that guide and direct their students' thinking in one way or another. Their purposeful questioning is oriented around various thinking forms to reach different kinds of learners at the same time. The questioning approach is not an easy task since it demands having highly qualified skilled teachers. Such approach requires that teachers prepare a series of questioning sequences to guide students in understanding the curriculum material and preparing for examinations whether at the school or state level.

Teacher and Students' Attitudes Toward Science

Attitude or the feelings a person has about an object and/or subject is based on his/her knowledge and belief about that object/subject (Kind, Jones & Barmby, 2007). This knowledge may lead a person to take a particular action (Barmby, Kind & Jones, 2008). Attitudes differ from moods and emotions; attitudes are evaluative judgments formed by the person (Ajzen, 2001; Crano & Prislin, 2006). Researchers have examined the changes in teacher attitudes and beliefs about science. Lee (2004) conducted a study to examine the patterns of change in beliefs and practices of six elementary Hispanic teachers working with grade four students. The changes included modifications of existing teachers' beliefs and willingness to undergo changes as a reflective and generative process characterized by full understanding of ideas and not blindly following procedural routines. Initially, gaps existed in the teachers' knowledge of science and science instruction. At the onset of the study, teachers lacked confidence, depended more on the textbooks, and gave little attention to hands-on activities. Even when teachers conducted science activities, the focus was on the procedures of the activities. Through training, teachers' lack of confidence gradually dissipated and was substituted by enhanced understanding and improved learning in science. The hands-on activities and experiments employed created "meaningful contexts for both oral and written communication" (Lee, 2004, p. 80).

Teachers must know about their students' experiences and prior knowledge to the same extent as they do about their language and culture. In a study by Lee (2004), the changes in teacher-student communication level proceeded from general greetings and basic knowledge to actual use of examples from the students' language and culture during lessons. Thus, teachers' social talks with their students were employed to enhance science understanding. Teachers' misconception that delivering whole group explicit instruction meets the cultural congruence component of teaching soon changed as they learned more about the instructional congruence model. Teachers realized the importance of involving students when it comes to attaining their own knowledge. Teachers encouraged students to take initiative, promote autonomy and individual work. They also stressed to students the importance of questioning what they saw to ensure understanding and increase their interest level in the subject.

Lee and Fradd (2001) summarize four important features of instructional congruence. These features are: Promoting student learning in both science and literacy, integrating knowledge of students' languages and cultures with the nature of science, providing "subject-specific'' pedagogies that consider the nature of science content and scientific inquiry, and extending personal constructivism to sense making in the contexts of students' languages and cultures. The development of an "adequate understanding of the nature of science" or an understanding of "science as a way of knowing" continues to be convincingly advocated as a desired outcome of science instruction (American Association for the Advancement of Science, 1989). Helping students develop informed conceptions of NOS is a perennial goal of science education. This goal has gained renewed emphasis in current national science education reform documents (Abd-El-Khalick, 2001). K-12 students and teachers have not attained the desired NOS understandings (Lederman et al., 2002). The goal of NOS lessons is for students to experience how scientists search for answers. Clough (2006) describes NOS instruction as a process through which learners proceed through a conceptual change.

The two main approaches for teaching NOS are the implicit approach and the explicit/reflective approach. Khishfe and Abd-El-Khalick (2002) conducted a study to compare the two approaches and found that students in the explicit group achieved substantially more improved views of most of the target NOS aspects compared with those in the implicit group. Some of the instructional elements emphasized include: providing students with opportunities to analyze their activities from within a NOS framework, mapping connections between these activities and those of scientists, and making conclusions about scientific epistemology. Simply put, an explicit-reflective approach emphasizes student awareness of certain NOS aspects in relation to their learning activities, and student reflection on these activities. Reflective journaling and discussions encourage students to express themselves in a way that uncovers their thinking and understanding of issues and situations.

The explicit/reflective NOS instruction approach may be integrated with problem-based lessons. The advantage of this, as discussed by Clough (2006), is that when students learn NOS within a contextual framework, they are less likely to exit instruction with dualistic thinking of NOS tenets. Gallucci (2009) integrated case studies early in a semester and documented that such integration can be the foundation for understanding NOS throughout the semester. She used "The Dragon in My Garage" story that elicited some interesting discussions on that first day of class. Gallucci reported that students generally agree by the end of that class that a scientific hypothesis must be tested in some way in order to prove or disprove it. If a hypothesis is testable, we must be able to collect evidence to support or reject it. This is what makes science a unique way of knowing.

The 5E Instructional Model is one of the approaches that has been used to teach students the nature of science. The model was developed in 1980 by Biological Sciences Curriculum Study and consists of the following phases: Engagement, exploration, explanation, elaboration, and evaluation. In the engagement phase, educators access the learners' prior knowledge and engage them in a new concept. Through the use of short activities, teachers promote curiosity and elicit prior knowledge. They attempt to make connections between past and present learning experiences and organize students' thinking toward the learning outcomes of current activities. In the exploration phase, teachers attempt to identify students' current misconceptions, processes, and skills to facilitate conceptual change.

Understanding of the nature of science is a key component of science teachers' instructional practice as they establish instructional congruence in their science classes (Lee & Fradd, 1998). To assess a person's views about the nature of science (NOS), various questionnaires had been developed and adapted. The Views of Nature of Science Questionnaire (VNOS) has three versions: A, B and C. All versions are open-ended and each questionnaire aims to elucidate participants' views about several aspects of "nature of science" (NOS). Lederman and O'Malley (1990) developed VNOS-A which is composed of seven items. Abd-El-Khalick (1998) developed Views of Nature of Science Questionnaire, Form B (VNOS-B) which assesses participants' views of the tentative, creative, inferential, empirical, and theory-laden NOS, and the functions of and relationship between theories and laws. The VNOS Form C (VNOS-C) (Lederman, Abd-El-Khalick, Bell & Schwartz, 2002), was modified and expanded from previous versions. "In addition to assessing respondents' views of the NOS aspects targeted by the VNOS-B, the VNOS-C also aims to assess views of the social and cultural embeddedness of science and the existence of a universal scientific method" (Lederman, Abd-El-Khalick, Bell & Schwartz, 2002, p. 509). Thus, while VNOS–B is composed of seven items, the VNOS–C has three additional items for a total of ten items. The participants' responses about the NOS are classified as naïve or more informed views.

Students' attitudes towards science change throughout their different years of schooling. A lot of studies have examined students' attitude development in science, leading to questions regarding the kind of changes in students' attitudes that take place during their elementary and secondary education. Whether student attitudes towards science decline at the elementary school level (Murphy & Beggs, 2001; Pell & Jarvis, 2001; Simpson & Oliver, 1985), stay stable (NAEP, 1978; Yager & Yager, 1985) or change from primary to secondary levels or within the secondary years (George, 2000, 2006; NAEP, 1978; Simpson & Oliver, 1985; Yager & Yager, 1985), it is important to realize that science educators' goal is to create a positive change in their students' attitude towards science. After all, students who start with more positive attitudes towards science experience a slower drop over time (George, 2000, 2006). Researchers have found that adapting the instructional congruence model produces favorable results in terms of changes in students' attitudes in the US and abroad (Luykx & Lee, 2007; Zain, Samsudin, Rohandi & Juosh, 2010). The researchers used the "Attitude Toward Science" survey to detect the students' mindsets about science in different contexts. The survey includes many dimensions based on different meanings of science and in which context these occur.

Summary

Lee and Fradd (1998) introduced the instructional congruence framework to address the needs of the continuously growing population of English Language Learners (ELL). The integration of science and literacy in this instructional model helps to make the academic content relevant and meaningful for the underserved ELL students. In this model teachers assume the role of mediators in order to create congruence between the nature of science and the language and cultural experiences of their students. Teachers' awareness and sensitivity about issues of language and culture is enhanced when they are trained in the instructional congruence model. The goal of creating higher expectations for non-mainstream, non-western students is facilitated by engaging students in meaningful, challenging and relevant content and instructional activities. By linking the academic content to the students' interests and experiences, teachers activate the students' prior knowledge, elicit and direct their thinking, and increase their understanding of science. As a result, students' attitudes towards science are improved and their academic growth is enhanced.

CHAPTER 3

METHODOLOGY

Research Design

This study used a quasi-experimental, single-group, pretest-posttest design, and a mixed method approach in data collection and analyses. McMillan and Schumacher (2006) describes a quasi-experimental design as a quantitative research design whose purpose is to determine cause and effect when there is direct manipulation of conditions. In a quasi-experimental design a "treatment" is used in order to impact certain variables, without random assignment of subjects to either the treatment or control groups. In this study no control group was used. Instead, the treatment (implementation of the instructional congruence model) was used with the same group of students. Similar data collection measures were used before and after the implementation of the instructional congruence model.

Research Context and Participants

This research was conducted in a charter school in the Detroit area. The school serves a community made mostly of Middle Eastern families. In general these families live on government assistance programs or the head of the household works at a local business where Arabic is the main spoken language.

The school serves around 500 students in grades 6-12, most of them from low socioeconomic families with very limited education. Many students are either newcomers or first-generation immigrants from the Middle-East. The student to teacher ratio in the school is (22.6). The ethnic makeup of the student population in the school during the year

2013-2014 was 92% White (from the Middle East), 3% Hispanic, 4% African American and 1% Other. Classes are segregated by gender, which might account for the almost 2:1 ratio of females to males. Separate-gender classes represent a traditional preference of parents in the Arabic-speaking communities. Eighty nine percent of the students receive free lunch and three percent qualify for reduced-price meals. Forty nine percent of the middle school students and 53% of the high school students were identified and served as English as a Second Language (ESL) students.

The participants in this study were an all-female class of 24 students and their science teacher whose native language and culture were different from most of his students. The participating science teacher was a US born, white, non-Hispanic male, with a secondary teaching certificate in science (grades 6-12), and two years of teaching experience.

Data Collection

This study employed a mixed-method approach to data collection and analysis. A mixed method is best when researching questions that require a variety of data sources. "With mixed-method designs, researchers are not limited to using techniques associated with traditional designs, either quantitative or qualitative" (McMillan and Schumacher, 2006, p. 27-28). In this study, quantitative data collection included paper-and-pencil tests used to measure student achievement and attitudes before and after the implementation of the instructional congruence model. Qualitative data were collected through classroom observations and videotaping, as well as the teacher's responses to the VNOS questionnaire. The researcher assumed the role of a complete observer and used the video recordings to analyze the interactions that took place among ELL students and between them and their teacher during science instruction. Garcez (1997) stresses the use of videotaping of naturally occurring "encounters to investigate in minute detail what interactants do in real time as they con-construct talk-in-interaction in everyday life" (p. 187).

Pre-intervention. Data collection in this study began with classroom observations of the participating teacher's current practices during a science unit (2 weeks) using Luykx and Lee (2007) instrument (Appendix D). Videotaping was used to collect data on the frequency and types of teacher-student interactions (speaking, listening and turn-taking) and types of science discussion based on Gee's (1997) categories (*design and debate, anomaly talk, everyday speculation talk,* and *explanation talk*).

Student attitudes toward science were measured before the implementation of the instructional congruence model using a 4-point Likert-type survey (1=strongly disagree to 4=strongly agree) developed by Barmby, Kind and Jones (2008). However, for this study the neutral category was deleted. As a result, this survey used a 4-point instead of the original 5-point (Appendix A). The attitudinal survey was used to assess students' mindsets about science in different contexts involving:

- Learning science in school
- Activities and experiments in science
- Science outside of school
- Importance of science
- Self-concept in science

- Future participation in science

Students were provided with sufficient time and assistance to fill out and interpret the content of the survey as needed. Student achievement was measured using all the teacher assessments related to that unit of instruction (e.g., tests, quizzes, homework, lab reports, etc.).

The teacher's views on the nature of science (NOS) was measured before and after the implementation of the instructional congruence model using Views of Nature of Science Questionnaire, Form C (VNOS-C), developed by (Lederman, Abd-El-Khalick, Bell & Schwartz, 2002). The VNOS Questionnaire (Appendix B) was used to assess teacher's understandings of the various aspects of the nature of science (tentativeness, creativity, observations and inferences, empirical basis, subjectivity, and theory-laden NOS, the functions of and relationship between theories and laws, social/cultural embeddedness of science and the existence of a universal scientific method. The teacher's pre and post-intervention responses to the VNOS questionnaire were classified as naïve or more informed views based on the descriptions set by Lederman, Abd-El-Khalick, Bell and Schwartz's (2002) intervention study (Appendix F).

During and post intervention. Data in the form of classroom observations and video-taping were collected during the implementation of the instructional congruence unit. Throughout the research process, the teacher was encouraged to discuss and check with the researcher regarding any issues including:

- aspects of the congruence model with which the teacher felt comfortable
- aspects of the model with which the teacher was struggling

- areas of the model in which the teacher needed additional training

At the completion of the unit student attitudes toward science were once again measured using Barmby, Kind and Jones (2008) survey. The teacher's views on the nature of science were measured again using VNOS-C at the completion of the study. Student achievement was once again measured using all the unit assessments, as well as their literacy level at the completion of the unit.

Data Analysis

T-tests were used to determine any significant changes in student achievement and attitudes toward science as a result of the implementation of the instructional congruent model. Statistical significance was established at $p<0.05$. Prior to running the t-tests, the scores of the survey items 6, 7, 8, 12 and 21 needed to be reversed. For example, item number six in the student attitudinal survey reads as: "Science is boring." A student who strongly agreed with this statement circled choice four. This item has a negative meaning related to science therefore it needed to be reversed to reflect choice four as the most positive choice to the question. Then, the average of pre and post context scores was calculated and used to run the t-test. Six t-tests were performed on the attitudes towards science survey, one on each context (see Appendix L).

Analysis of the data from classroom observations was done through coding using Luykx and Lee (2007) categories related to the instructional congruence model to determine changes in the teacher's practice as a result of being trained in the model.
Each scale in this observational instrument summarizes particular student and teacher behaviors necessary to the establishment of instructional congruence. There are five rating

scales for each component (Appendix D and E) based on the frequency of an activity and the number of students engaged. The components are placed within three categories or constructs: Constructs of science learning, constructs based on students' linguistic and cultural knowledge, and constructs that bridge the two domains (see Table 8). Particular guiding questions were addressed in each component using a scale of 1-5 (see Appendix E and Table 8)

Data collected through videotaping focused on student and teacher communication interactions (speaking, listening and turn-taking), student engagement in scientific discourse, and student English language development and literacy before and after the use of the instructional congruence model. Analysis of these data involved coding using Gee's (1997) categories of classroom talk (*design and debate, anomaly talk, everyday speculation talk, and explanation talk*) to determine: (i) Whether such interactions occurred in culturally congruent ways (whether students' cultural experiences and examples were integrated in instruction, and the extent to which students' home language was used to enhance understanding). (ii) Student engagement in scientific understanding, inquiry, and discourse. (iii) Student development of English language and literacy in terms of reading and writing activities in the science lessons, use of grammatical and graphic convention to enhance students' use of standard English, and adaptations of communications (verbal, gestural, written, and graphic) to enhance understanding.

Data collected from the VNOS-C questionnaire was used to classify the participant's views about the aspects of NOS. The VNOS–C assessed the teacher's views of the empirical, tentative, functions of and relationship between theories and laws, creative and imaginative, inferential, theory-laden, social and cultural embeddedness of science. A pre/post response table was created and answers to each question were entered to be later analyzed. The NOS aspects were classified as naïve or more informed views based on the responses provided by the participant and using the illustrative examples of responses to VNOS Items by Lederman and colleagues' 2002 study (Appendix F).

Teacher Training on the ICM

After collecting data on students' attitudes and achievement in science and their teacher's views on the NOS and instructional practices, the participating teacher was trained on the use of the instructional congruence model including understanding the nature of science. Teacher training along with unit preparation was accomplished over a period of 10 weeks, 1 hour a week (Table 1). Teacher training was divided into three stages: Presentations on instructional congruence framework and NOS, assigned readings and discussions, and general culture lessons/conversations including a list of Arabic commonly used words.

Table 1

Teacher Training and Assignments

Name of Assignment	Date	Duration
Instructional Congruence Framework Presentation	Friday Oct 3	1 hour
Nature of Science Presentation & Lee and Fradd (1998)	Wednesday Oct 8	1 hour
Buxton, Lee, and Santau (2008)	Wednesday Oct 15	1 hour
Lee (2004)	Thursday Oct 23	1 hour

Luykx and Lee (2007) & Tables used for evaluation	Wednesday Oct 29	1 hour
Cultural Congruence & List of Arabic words	Wednesday Nov 5	1 hour
Zain and colleagues (2010)	Tuesday Nov 11	1 hour
Preparing a science unit and lesson plan templates	Thursday Nov 20	1/2 hour
Lesson planning (Initial)	Friday Nov 21	1/2 hour
Lesson planning	Friday Nov 28	1 hour
Lesson planning	Tuesday – Friday, Dec 2-5 (15 minutes each)	1hour

Teacher training stage one. In stage one of the process used to train the science teacher, a power point presentation was used to introduce the teacher to the instructional congruence framework and reinforce his views on the nature of science through presentations followed by discussions. The instructional congruence power point presentation started with the fact that Lee and Fradd (1998) introduced the instructional congruence framework as a model for the underserved yet rapidly growing population of Non-English-Language Background (NELB). They further proposed it as "a way of making the academic content accessible, meaningful, and relevant for diverse learners" (Lee and Fradd, 1998, p. 12). I pointed out how the instructional congruence model served as a guide in teaching and helping students to understand science through developing their scientific inquiry practices and engaging them in scientific discourse (Luykx & Lee, 2007). In this presentation, I emphasized how science teaching changed overtime from knowledge attainment and habits of mind to knowing science, doing science and talking science. After explaining the importance of integrating science and literacy in this model, I listed the five key elements of the instructional congruence model that each teacher needs to know. As they attempt to establish instructional congruence in their science classes, teachers need to know (a) who their students are, (b) how they acquire their literacy and English-language proficiency, (c) what the nature of science is, (d) what kind of language and cultural experiences students bring to the learning process, and (e) how to enable and guide students in their journey to understand science. Next, I highlighted the teacher's role and recommended instructional behaviors such as inquiry use and questioning techniques. One of the slides of the instructional congruence power point presentation referred to the aim of this framework as best stated by Luykx and Lee (2007):

> The aim of instructional congruence framework is not to lower expectations for non-mainstream students, nor to adjust curricular content so as not to conflict with students' home cultures. Rather, it is to guide teachers in recognizing students' prior linguistic and cultural knowledge and the relation of this knowledge to scientific content and practice. Such consideration of each student's "starting points" will help teacher to map out more effective paths for leading students toward scientific understanding and practices. (p. 426)

In the nature of science (NOS) presentation, first I introduced the concept of nature of science and its definition by different scholars. Next, I highlighted the renewed emphasis of the science education documents on NOS in addition to the reasons of why students need to understand NOS. The presentation touched on how NOS includes the process of science, that is the scientific enterprise or "context of discovery" and scientific knowledge which is the "context of justification." The eight aspects of NOS (empirically based, human inference, creativity, subjectivity or theory-laden, culturally and socially embedded, tentative, imaginative and relationships between scientific theories and laws) were explained in details. I also introduced the two main NOS teaching approaches (implicit and explicit) and the finding that students in the explicit group achieved substantially more improved views of most of the target NOS aspects compared with those in the implicit group as explained by Khishfe and Abd-El-Khalick's (2002) study. Suggested instructional strategies to assist students in building more informed views about NOS aspects included: Using problem-based lessons, integrating case studies and adapting the BSCS 5E instructional model. The last slide in the NOS power point presentation read as: Current reform documents in science education (e.g., American Association for the Advancement of Science [AAAS], 1989; National Research Council, 1996, 2000) recommend that teachers help students to not only develop conceptual understandings and integrated skills that are central to making sense of scientific knowledge and engaging in scientific inquiries, but also to internalize understandings related to the nature of science (NOS).

Teacher training stage two. The next stage in the teacher's training involved discussions and readings to raise the teacher's awareness and sensitivity about issues of language and culture that are required by the instructional congruence model. Stage two covered the following assigned readings: Lee and Fradd (1998), Buxton, Lee, and Santau (2008), Luykx and Lee (2007), Lee (2004), Zain and colleagues (2010) and Cultural Congruence in Instruction (Chapter 8 of Raising Black Students' Achievement through Culturally Responsive Teaching by Johnnie McKinley). The participating teacher received a hard copy of each reading ahead of time and was instructed to read it so it could be further discussed during the training session. A typical session in stage two included: Summary of the reading's key points, description of the study's contexts and participants, stating results and reviewing discussions. Comments, questions and feedback were welcomed during any of the sessions. What follows is a summary of the key findings in each of the assigned readings.

The Lee and Fradd (1998) article emphasized the importance of reaching out to non-main stream science learners by creating a harmony between the student's culture and world and school science. The authors proposed a framework for instructional congruence in literacy and science and explained how the model works. Adapting the instructional congruence framework makes science more meaningful to students from diverse backgrounds. This article also identified the teacher's role in establishing instructional congruence in his/her classroom.

Buxton, Lee, and Santau (2008) described a model of professional development intervention designed to assist teachers educating in schools with high numbers of English language learners. Third through fifth grade teachers attended workshops throughout the school year and received curriculum material. The workshops aimed to reinforce teachers' knowledge, practices, and beliefs of English language development for ELL students and to improve their science instruction in general. Additional goals of the intervention included: improving scientific reasoning, supporting mathematical understanding, preparing students for high-stakes testing, capitalizing on students' home language and culture, and improve learning in general through hands-on, inquiry-based learning experiences.

Luykx and Lee (2007) explained that the aim of instructional congruence is "to help students acquire scientific understandings, inquiry practices, and discourse by taking into account the relation of these three domains to students' home culture and language" (p. 425). To assist in the mission of measuring instructional congruence in elementary science classrooms, they developed an observation guideline that provides detailed scales thus producing numerical ratings. The scales assessed in this observational instrument are grouped into three categories: Constructs of science learning, constructs based on students' linguistic and cultural knowledge, and constructs that bridge the two domains. Constructs of science learning include: Scientific understanding, scientific inquiry, scientific discourse, and teacher's knowledge of science content. Constructs based on students' linguistic and cultural knowledge include: Diversity of cultural experiences and materials and students' home language in regular classrooms. Constructs that bridge the two domains are: Scientific authority and linguistic scaffolding to enhance meaning. Luykx and Lee emphasized the need to structure classrooms to permit students to construct scientific knowledge by activating prior cultural and linguistic experiences. This is accomplished by teachers who are not only knowledgeable of academic discipline but of student diversity as well.

Lee (2004) examined patterns of change in six elementary teachers' beliefs and practices as they adapted the instructional congruence model as a way of teaching. This study concluded that "teacher learning and change occurred in different ways in the areas of science instruction, students' language and culture, English language and literacy instruction, and integration of these areas in establishing instructional congruence" (p. 65). Lee also reported that adapting instructional congruence is a gradual process that demands formal training, collaboration among teachers, extensive support and continuous teacher reflection. The overarching goal of making science meaningful and relevant to the students' lives was the guiding force behind this article. The author described specific ways on how the teachers changed their beliefs and practice and summarized how to relate those beliefs and practice to the instructional congruence model.

Zain and colleagues' (2010) study measured students' attitudes toward science after adapting the instructional congruence model. Students' attitudes toward science were measured prior and post intervention. Teachers received training on the instructional congruence framework before a unit was taught using the new model. Students once again took the "Attitudes Toward Science" survey to note any changes. Zain and colleagues reported that using instructional congruence in science education promoted students' attitudes toward science. The study further recommended science educators integrate science learning with science related experiences outside school.

Cultural Congruence in Instruction is chapter eight of McKinley's book *Raising Black Students' Achievement through Culturally Responsive Teaching*. This chapter has four sections titled as: Meaningful, complex instruction; scaffolding instruction to home culture and language; responding to student traits and needs; and culturally relevant curriculum materials. McKinley provides teachers with a list of strategies on how to implement each category (Appendix G). Under each category, I explained the different strategies and demonstrated with examples what teachers may do to achieve the desired outcome.

Teacher training stage three. A few meetings were scheduled during which we just talked about the students' culture in general. The teacher asked questions related to particular Arabic terms that students often used in class (e.g. haram) and we had a discussion regarding similarities between the American and the Arabic cultures. I also provided the participating teacher with a list of terms/statements and their Arabic transliteration using the female way of speech (Appendix H). The teacher practiced the proper pronunciation of the words and paid special attention to phrases such as thank you (shokran lekey), you are welcome (ahlan wa sehlan) and please (min fedlikee).

Unit preparation. After teacher training was concluded, we started developing a science instructional unit that followed the instructional congruence model. The title of the unit was "Electricity" and it was composed of three lessons and a "Jeopardy Buzzer Activity." Each lesson in the unit included: Content and Language Objectives, National Standards and Michigan High School Content Expectations (MI HSCEs), Vocabulary Link, Reading Strategy and a Student English and Arabic Vocabulary List that included pronunciation of terms. All teaching and assessment materials along with the grading rubrics were included. Special emphasis in each lesson was placed on the criteria required by the instructional congruence model. The literacy component of the instructional congruence model was stressed in the "Vocabulary Link" sections, "Reading Strategy" sections, "Student English and Arabic Vocabulary List" and "Writing in Science" assignments.

Literacy Components. Extra effort was placed on the "Language Objectives" sections of the lessons to include language components and to expose students to as many concepts as possible within the post-intervention two week period. Table two lists the language objectives for each lesson as well as the Jeopardy Buzzer Activity in the "Electricity Unit".

Table 2

Electricity Unit Language Objectives

Assignment/Activity Name	**Language Objectives**
Lesson 1:	
Key Concepts	Name, analyze, determine, describe, explain
Flashlight Activity	Compare and contrast, infer and predict
Reading Strategy	Identify main ideas
Guided Notes	Fill in the blanks, choose correct response, determine if true or false and write a short answer
Writing in Science	Organize ideas and explain
Semantic Web	Write or draw
Timeline of Lighting Technology Presentation	List, name, describe, introduce, give examples, identify types, and relate to own experience
Lesson 2:	
Key Concepts	Identify, give examples, identify factors and causes, and relate different components
Reading Strategy	Predict
Guided Notes	Fill in the blanks, choose correct response, determine if true or false and write a short answer
Writing in Science	Compare and Contrast
Ohm's Law Practice Problems	The 3-Step Method: Read & Understand, Plan and Solve, and Look back & Check
Lesson 3:	
Key Concepts	Analyze and compare circuit diagrams, solve equations, and describe devices and procedures
Reading Strategy	Relate Text and Visuals
Guided Notes	Fill in the blanks, choose correct response, determine if true or false and write a short answer
Writing in Science	Write Math Word Problems
Problem Solving Practice	The 3-Step Method: Read & Understand, Plan and Solve, and Look back & Check
Al-Sabbah's Presentation	List, name, describe, introduce, recognize, appreciate, and give examples

Jeopardy Buzzer Project	Work in groups, design, construct, sketch diagram, and answer post activity questions

In the "Vocabulary Link" sections, three different vocabulary-building techniques were used. One approach used to assist students to recall and use more vocabulary included telling them what the root of the word was and its origin. For instance, the root word for electricity comes from "amber," a Greek word referring to a substance that is easily charged. Therefore, electricity deals with charges. Another vocabulary link approach used included constructing a vocabulary knowledge rating chart. This technique required students to make a chart with four columns labeled as: Term, can define or use it, have heard or seen it, and don't know it. Using this chart, students rated their knowledge of each term at the beginning of a reading section then re-rated themselves as they read the section. The third vocabulary link approach adapted is referred to as LINCS. Students were asked to: List the parts of the vocabulary they knew; Imagine what a term might look like and how the terms might fit together; Note a reminding sound-alike word; Connect the terms to something they know; and finally Self-test where students quiz themselves.

Three different reading strategies were chosen for the three sections taught in the electricity unit. In lesson one, students were instructed to use the table below and write the main ideas for each topic as they read. The predicting reading strategy, which was used in lesson two, required students to write the probable meaning of a phrase prior to reading about it. Then, after they had read the section, if the prediction was unclear, incomplete or incorrect, students should write down what the phrase actually is. Relating text and visuals was used in lesson three where students had to list three things about circuits as they studied a blue print of a complete house circuit (see Appendix I).

Table 3

Reading Strategy (Identify Main Ideas)

Topic	Main Idea
Electric Charge	An access or shortage of electrons produces a net electric charge.
Electric Forces	b.______________________________ ______________________________
Electric Fields	b.______________________________ ______________________________
Static Electricity	c.______________________________ ______________________________

For each of the three lessons in the electricity unit, a table was created to display the English word, its pronunciation, and its Arabic meaning. Table 4 lists the new vocabulary terms used in lesson one of the electricity unit.

Table 4

Lesson 1 English and Arabic Vocabulary List

English Word	Pronunciation	معاني مفردات الدرس (الجزء الأول)
Electric charge	Ih-lek-trik chahrj	شحنة كهربائية
Electric force	Ih-lek-trik fohrs	قوة كهربائية (الجذب أو التنافر)
Electric field	Ih-lek-trik feeld	حقل كهربائي

Electrical circuit	Ih-lek-tri-kuh l sur-kit	دارة أو دائرة كهربائية
Induction	In-duhk-shuh n	انتقال الشحنة بدون لمس
Law of conservation of charge	Law of kon-ser-vey-shuh n of chahrj	قانون المحافظة على الشحنة الكهربائية

"Writing in Science" was another approach to address the literacy component of the instructional congruence model. In the first assignment, students were asked to write an explanatory paragraph to list the series of events that may cause a person to receive a shock due to touching a door knob on a dry winter day. The teacher suggested the use of a flowchart to organize ideas before writing the paragraph. Lesson two's "Writing in Science" assignment required students to write a paragraph comparing and contrasting insulators and conductors and the ways in which they might be used. Students received a hint stating: "Identify materials that are good insulators and materials that are good conductors." In the final "Writing in Science" assignment, students were required to write three mathematics problems based on the electric power equation used in section three of the electricity unit. Each problem required solving a different variable: Power, voltage and current. Students were asked to answer the questions themselves and came up with the solution to their own problems.

Guided note-taking was also used in the electricity unit. Students received a worksheet containing multiple choice, true or false, fill in the blanks, and short answer items. Guided note-taking was one of many activities in which students used the three language components of speak, write, and hear. Another activity that involved students using the three language domains was semantic web. A semantic web with the word electricity was placed at its center and projected on the screen (see Appendix J). Students were asked to work in pairs and write or draw all word, phrases or concepts related to electricity.

The Jeopardy Buzzer Activity (see Appendix K) required students to work in groups of 3-4 students to design and construct a working buzzer system that would be used during future review games. Each group received the same materials (batteries, wiring, button, buzzer, and box). Requirements included using the required materials to create a working buzzer. Group members had to sketch the electrical wiring diagram of their buzzer in their notebooks. An example of the electrical wiring diagram showing the two types (parallel and series circuits) was included. Group members were also required to answer the post activity questions in their notebooks. Post lab questions and grading rubric were also supplied on the activity sheet.

Cultural Components. Two main presentations were given related to the cultural component of the "Electricity Unit:" Timeline of Lighting Activity and Hasan Kamel Al-Sabbah presentations. The Timeline of Lighting Activity was used as an introduction to the "Electricity Unit" at the start of Lesson 1. It listed the main items used throughout history to provide light. Oil lamp was the first form of light used. It was invented around 4500 B.C. Candles were invented around 3000 B.C. and were used to provide light and heat as well as to keep time. The next lighting device was invented by Muhammad ibn Zakariya Razi in 900 AD. In the presentation, types of kerosene lamps (flat wick, central tabular wick, and kerosene lanterns) and description of each were provided. Bas lighting was produced in 1792, carbon-thread incandescent lamp in 1879, frosted light bulbs in 1925, fluorescent light bulbs in 1991, sulfur lamps in 1994 and finally LED screw-in lamp was introduced in 2011. During this presentation, the teacher introduced his students to different devices and items and asked students to relate them to their experiences. For example, the teacher and his students spoke of lamps used in camping trips.

The second major culture presentation was titled “Hasan Kamel Al-Sabbah.” This cultural piece was used at the start of lesson 3 to introduce students to major contributors form Arabic descent to the field of electricity. Hasan Kamel Al-Sabbah was an electrical and electronics research engineer, mathematician, and inventor. Sometimes he was referred to as Camil A. Sabbah. He was born in Lebanon in 1885. Al-Sabbah was a professor of mathematics before he traveled to the United States in 1921. He received a master’s degree in 1923 from the University of Illinois then he became a researcher at the Engineering Laboratory of General Electric Company in New York. Al-Sabbah received 43 patents covering his work including innovations in television transmission. He was engaged in work related to television, motors, and circuits for use with rectifiers. Al-Sabbah’s inventions in electricity had a great impact on the development of 20th Century technology. Al-Sabbah’s dream was to generate and power solar cells to produce enormous amounts of energy to transform the Arabian Desert.

Al-Sabbah died in an automobile accident at Lewis near Elizabeth Town, N.Y. on March 31, 1935. His inventions and patents have greatly contributed to development of applied technology in the entire world. Al-Sabbah was recognized and appreciated in the world of technology.

Ethics and Protection of Participants

The study began only after permission was obtained from WSU's Human Investigations Committee, which included permission from the school's administration and informed consent from the teacher, each student, and the student's parent or legal guardian. The data in both paper and videotape were kept in a locked file cabinet only accessible to the researcher. The video tapes were transcribed and then destroyed. Quantitative data were presented in aggregate form and when necessary pseudonyms were utilized for reporting data pertaining to specific participants

CHAPTER 4

RESULTS

The results of this study are organized around the three research questions: (1) Impact of the instructional congruence model (ICM) on student attitudes toward science, (2) impact of the ICM on student achievement, and (3) impact of the ICM on the science teacher's practice and views on the nature of science.

Impact of the ICM on Students' Attitudes Toward Science

Student attitudes toward science were measured before and after the implementation of the instructional congruence model using a 4-point Likert-type survey (1=strongly disagree to 4=strongly agree), developed by Barmby, Kind and Jones (2008). All 24 students finished the pre and post surveys in 20 to 30 minutes and were provided with assistance interpreting the content of the survey when requested. The attitudinal survey assesses students' mindsets about science in six different contexts: (1) Learning science in school, (2) activities and experiments in science, (3) science outside of school, (4) importance of science, (5) self-concept in science, and (6) future participation in science. Each context was assessed using five to eight questions (see Appendix A).

Table 5

Mean Changes in Students' Attitudes Toward Science Contexts

		Mean	Mean Change
Learning science in school	Pre	2.7569	.36806*
	Post	3.1250	

Self-concept in science	Pre	2.7321	.32143*
	Post	3.0536	
Activities and experiments in science	Pre	3.2969	.15625
	Post	3.4531	
Science outside of school	Pre	2.7292	.18056
	Post	2.9097	
Future participation in science	Pre	2.4750	.18333
	Post	2.6583	
Importance of science	Pre	2.9250	.32500*
	Post	3.2500	

*$p < 0.05$

As results on Table 5 indicate, the means of all six contexts related to student attitudes toward science experienced and increase post intervention. However, the difference between the means was only statistically significant for three of the domains: *Learning science in school* (e.g., “we learn interesting things in science lessons;” “I look forward to my science lessons;” “I like science better than most other subjects at school”); *self-concept in science* (e.g., “I get good grades in science;” “I learn science quickly;” “Science is one of my best subjects”); and *importance of science* (e.g., “Science and technology is important for society;” “Science and technology makes our lives easier and more comfortable;" "There are many exciting things happening in science and technology").

Impact of the ICM on Students' Achievement in Science

Student achievement was measured using all the teacher assessments related to that unit of instruction (e.g., tests, quizzes, homework, lab reports, etc.). Students' grades in the "Forces and Energy Unit" (pre-intervention unit) ranged between 18 and 100% (range = 82). The average performance was at 70% which is a C- according to the school's grading scale. The class's median was 73% and its mode (most often occurring grade) was 86%. For the "Electricity Unit" (post-intervention unit), the students' overall performance ranged between 66% and 100% (range = 34). The average performance (mean) was 88% which is a B+ grade. The class's mode was 94. A t-test comparing student grades in the pre and post intervention units indicated a statistically significant difference in means $t(23)=6.455$, $p<0.001$. These results indicate that the instructional congruence model was very effective in increasing student achievement in science.

Impact of the ICM on Teacher's Views on Nature of Science

The VNOS-C questionnaire was used to determine changes in the science teacher's views on the nature of science. The VNOS–C assessed the teacher's views of the empirical, tentative, functions of and relationship between theories and laws, creative and imaginative, inferential, theory-laden, social and cultural embeddedness of science. The teacher's pre and post intervention responses in each of these categories of the questionnaire were coded as naïve or more informed using the examples of responses provided by the developers of the questionnaire ((Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002). (see Appendix F).

As reported in Table 6, the teacher experienced changes in his views about the nature of science in three areas: (1) the general structure and aim of experiments, and (2) inference in relation to theoretical entities in science, and (3) the imaginative and creative nature of science.

Table 6

Teacher's Views on NOS

NOS Aspect	VNOS-C Item #	Teacher's Pre Views	Teacher's Post Views	Change in Views
Empirical NOS	Item 1	Informed view	Informed view	NO
General structure and aim of experiments	Item 2	Naïve view	Informed view	Yes
Tentative NOS	Item 3*	Naïve view	Naïve view	NO
	Item 6	Informed	Informed	NO
Difference and relationship between theories and laws	Item 6	Informed	Informed	NO
Nature and functions of scientific theories	Item 5	Informed	Informed	NO
Creative and imaginative NOS	Item 8	Naive	Informed	Yes
Inferential NOS	Item 4	Informed	Informed	NO
Inference in relation to theoretical entities	Item 7	Naive	Informed	Yes
Theory-laden NOS	Item 9	Informed	Informed	NO
Social and cultural embeddedness of science	Item 10	Informed	Informed	NO

*Lederman used item number three to note changes in the tentative NOS aspect yet the participant displayed informed views about it in answering question number six.

Empirical and tentative NOS. In answering the first question about what science is, the participating teacher explained that science is observation and questioning the physical world. "In order to scientifically study a subject you must be able to observe and experiment," he added. As for what makes science different from other disciplines of inquiry (e.g., religion, philosophy), the response was that other disciplines rely on ideas that cannot be proven or disproven. In the post-intervention survey, he explained that science is about "How" not "Why." He further expanded that science is designing experiments, trial and error, and discovery. It's not about memorization of facts; it's more of a way of thinking and doing things rather than just a subject in school. Science is a way to discover new things and make sense of them. Thus, as for the empirical nature of science, the teacher's pre and post-intervention responses display the informed view about this aspect of the nature of science.

The third question in VNOS-C questionnaire asks whether the development of scientific knowledge require experimentation. Lederman used this question to assess the teacher's views about the tentative NOS. The teacher's pre and post responses to the development of scientific knowledge question appear to indicate that the teacher adopted the naïve view which assumes that science does not exist without scientific procedure (based on experiment). In fact, the teacher proposed that scientific knowledge can be attained through experiments that can be modified in the quest for knowledge. Lederman et al. (2002) used item number three to note changes in the tentative NOS aspect. The participating teacher continued to have naïve views about tentative NOS in item number three yet he displayed informed views about it in answering question number six.

The following statements were taken from the pre NOS survey in answering the sixth question. Theories are described as “the currently best ideas” by the participating teacher, and “they are subject to change. The Earth was once thought to be the center of the universe but it was disproven.” After all, the purpose of learning theories is “to stay current and to improve them. Science needs to evolve and this can’t happen unless we learn.” As for the post survey, he added the fact that “scientists find out they’re wrong all the time.” As a result, scientific knowledge is tentative, durable, subject to change and self-correcting. Based on evidence displayed in pre and post answer to item number 6, and assuming that the participating teacher interpreted question number three from a different perspective that intended by Lederman and colleagues (2002), I would report that the participating teacher’s views about tentative NOS were informed at the start of study; therefore, no change is documented in the tentative NOS aspect at the conclusion of the study.

Structure and aim of experiments. The teacher displayed a more naïve view when asked about the structure and aim of experiments. He described it as “a process that is used to try to discover how something works.” At the conclusion of the study, the participating teacher continued to define an experiment as “a step by step procedure that is followed” yet he added that experiments may be used to “prove a claim.” He gave an example to clarify his views. “You want to prove plants need light to grow so you set up an experiment with one in light and one in dark. Record measurements and report data to try and prove that yes they do need light.” This example demonstrated the view that an experiment is a “controlled way to test and manipulate the objects of interest while keeping all other factors the same" which is what Lederman et al. (2002, p. 514) described as a more informed view of the aim of experiments. Furthermore, he demonstrated an acceptable view regarding the validity of observationally based theories and disciplines.

Relationship between theories and laws. In terms of differences and relationship between theories and laws (question 5 in the VNOS-C), the teacher showed informed views in the pre-intervention survey about this aspect as he described a law as a "phenomenon that can't be changed or disproven." He gave the Law of Gravity as an example and explained that "objects attract other objects; we don't know why but it happens." As for theories, he labeled a theory as a "currently best idea since a theory had been tested over and over and not disproven." For example, he added, "the Theory of Relativity states that space is curved and it bends due to gravity. This can't be disproven and as of now, it is a great idea and has been tested so we use it for now." The proceeding explanation confirms that the teacher understands the nature of scientific theory (in terms of other people's ideas can be proven) and the functions of scientific theory (of how theories represent the framework for further research and advance knowledge).

Since theories are described as "the currently best ideas" by the participating teacher, they are subject to change. The Earth was once thought to be the center of the universe but it was disproven. After all, the purpose of learning theories is "to stay current and to improve them. Science needs to evolve and this can't happen unless we learn." The prior statements were taken from the pre NOS survey in answering the sixth question. As for the post survey, he added the fact that "information and technology change and that leads to new experiments and new data. Scientists find out they're wrong all the time; they have to change in order to be improved." As a result, scientific knowledge is tentative, durable, subject to change and self-correcting. This conclusion is evident in the teacher's pre survey and became more enhanced with information and technology advancement. The teacher's view may be classified as informed views that improved by the time he took the post survey.

Inferential NOS. Items 4 and 7 in the VNOS-C survey were used to access the participant's views about the inferential nature of science. Question number four in VNOS-C reads as:

> Science textbooks often represent the atom as a central nucleus composed of protons (positively charged particles) and neutrons (neutral particles) with electrons (negatively charged particles) orbiting that nucleus. How certain are scientists about the structure of the atom? What specific evidence, or types of evidence, do you think scientists used to determine what an atom looks like?

In answering VNOS-C item 4, the participating teacher explained that scientists inferred the structure of the atom based on what they know thus far. In the pre and post survey responses, the teacher displayed the informed view on how evidence may be indirect and may relate to things that cannot be observed directly. He further explained that "scientists have some evidence like the bending of waves and charged particles which is due to the location of protons and electrons. I believe they have a solid idea which will be the accepted idea until new findings come along."

Item number 7 addressed inference in relation to theoretical entity in science. It referred to the current science textbooks' definition of species "as a group of organisms that share similar characteristics and can interbreed with one another to produce fertile offspring," and asked about the certainty scientists have about their characterization of what a species is and the specific evidence they used. In answering VNOS-C 7, the teacher's initial views about species were based on studying evolution which has led to an understanding of what a species is. He added, "The similar characteristics are the traits that evolve in a population. When a group of organisms evolve, they are different. Breeding is also part of it. Dogs don't breed with cats and so forth. This most likely caused the idea of a species." The teacher's pre survey response was naïve since he hinted that the different approaches such as trial and error and genetic testing were used to ascertain what a species is. In the post intervention survey, the participating teacher showed an informed view as he acknowledged that species is a human creation and it categorizes things in a convenient framework. He explained that scientists "use the term to describe these groups of animals rather than trying to determine what it is." Therefore, as for the NOS aspect related to inference and theoretical entities, the teacher's views changed from the naïve version to the more informed views.

Creative and imaginative NOS. The teacher displayed naive pre survey views about creative and imaginative NOS. Question number 8 in VNOS-C survey asked if scientists use their imagination and creativity during their investigations as they try to find answers to the questions they put forth. In the pre survey response, the teacher wrote: "Scientists use their imagination when they are planning the experiment and when they are analyzing the data." He displayed the naïve view as he added that no creativity is involved during the data collection stage but, before and after data collection, scientists use imagination to envision what they will do and how to make sense of their results. A change is noted in the post intervention NOS survey as the teacher changed his view regarding the use of imagination during data collection. “Things happen and you need to be able to adapt. You can’t just give up if it doesn’t work; use your imagination and try something new until it works,” he explained. At the conclusion of the study, the teacher came to the realization that imagination and creativity are essential for the formation of ideas and explanation of observed results and thus had informed views about the creative and imaginative NOS.

Theory-laden NOS. Item number 9 in the VNOS-C questionnaire inquires about the reasons for scientists to have different conclusions regarding the dinosaur’s extinction even though they have access to and use the same set of data to derive their conclusions. In his interpretation of the different conclusions, the participating teacher commented, “I tend to believe that both likely caused the extinction of the dinosaurs and many other organisms. They all have the same data so they both are possible causes. Why not both?” He further elaborated, “it’s more of a case of one group of scientists finding an alternative and researching so that they can say “this is another possibility” rather than “we are right and the others are wrong.” According to this explanation, the theory-laden pre- and post-survey NOS view owned by the teacher is ranked as highly informed views. The idea that scientists may think differently and interpret findings based on their own education and background constitutes the more informed view about theory-laden nature of science and acknowledged by the teacher in his response.

Social and cultural embeddedness of science. Question 10 in the VNOS-C questionnaire distinguished between the claim that science is infused with social and cultural values versus science is universal. It asked the person taking the survey to take a stand and to defend his/her answer with examples. In his response to this question, the participating teacher replied,

> I believe the idea of science and experimentation is universal but it is practiced in different cultures in different ways. Religion is a big part of that. I know that Christians are anti-evolution, so I believe that certain scientific ideas can be altered by the members of a certain culture.

As a result, the teacher clearly believes that science is about facts yet it could be influenced by culture. By giving the example about acceptance of theory of evolution, the teacher acknowledged that different factors in culture and society influence the acceptance of scientific ideas. This represents the more informed view of science social and cultural embeddedness pre and post intervention.

Impact of the ICM on Teacher's Instructional Practices and Communication

Data from classroom observations was analyzed using Luykx and Lee (2007) categories related to the instructional congruence model to determine changes in the teacher's practice as a result of being trained on the model. Each scale in this observational instrument summarizes particular student and teacher behaviors necessary to the establishment of instructional congruence. There are five rating scales for each component (Appendix D and E) based on the frequency of an activity and the number of students engaged. The components are placed within three categories or constructs: Constructs of science learning, constructs based on students' linguistic and cultural knowledge, and constructs that bridge the two domains (see Table 7). Particular guiding questions were addressed in each component using a scale of 1-5 (see Appendix E and Table 7)

Table 7

Observational Constructs, Components, and Questions Addressed

Construct Name	Components	Questions Addressed
Constructs of science learning	Scientific Understanding	To what extent do students demonstrate a deep understanding of science concepts and link these to real-world phenomena?
	Scientific Inquiry	To what extent do students engage in investigation/ experimentation or higher-order thinking, as opposed to simply receiving or reciting information or performing routine procedures?
	Scientific Discourse	To what extent is classroom discourse developed to create or negotiate shared understandings of science as opposed to limiting students to short, fill-in-the-blank answers?
	Teacher's Knowledge of Science Content	How accurate and comprehensive of the teacher's mastery of the science content of the lesson?
Constructs based on students' linguistic and cultural knowledge	Diversity of Cultural Experiences and Materials	To what extent are students' cultural experiences and materials integrated in science instruction?
	Students' Home Language	To what extent is students' home language (other than English) used to enhance understanding in regular (non-bilingual) classrooms?
Constructs that bridge the two domains	Scientific Authority	To what extent is the authority for determining the validity of scientific arguments or answers shared by students and teacher, rather than relying on teacher or text as the sole legitimate sources of scientific authority?
	Linguistic Scaffolding to Enhance Meaning	To what extent does the teacher tailor his or her level and mode of communication, aiming at slightly above students' level of linguistic competence?

Pre and post mean changes related to each component under the three constructs were recorded in Table 8. Ten pre and ten post intervention entries were averaged into a single number labeled as pre and post. The mean change reflects the pre mean value subtracted from the post mean entry. As indicated in Table 8 and Figure 1, there was an increase in the use of every component from pre to post intervention. A t-test was performed for each component of the constructs related to the teacher's instructional practices (see Appendix M). Results indicate that the difference between the means was statistically significant for: scientific understanding, scientific inquiry, scientific discourse, teacher's knowledge of science content, diversity of cultural experiences and materials, students' home language, and scientific authority. The only component that had its significance greater that 0.05 was linguistic scaffolding to enhance meaning (at 0.06). These results indicate that the teacher's instructional practices were very effective in teaching science.

Table 8

Mean Changes in Constructs of Teacher's Instructional Practices

	Mean		Mean Change
Constructs of science learning			
Scientific Understanding	Pre	3.65	1.03*
	Post	4.68	
Scientific Inquiry	Pre	1.73	2.64*
	Post	4.37	
Scientific Discourse	Pre	3.45	1.3*
	Post	4.75	
Teacher's Knowledge of Science Content	Pre	4.1	0.85*
	Post	4.95	

Constructs based on students' linguistic and cultural knowledge			
Diversity of Cultural Experiences and Materials	Pre	1	1.65*
	Post	2.65	
Students' Home Language in Regular Classrooms	Pre	1.45	1.7*
	Post	3.15	
Constructs that bridge the two domains			
Scientific Authority	Pre	3.27	1.5*
	Post	4.77	
Linguistic Scaffolding to Enhance Meaning	Pre	4	0.33
	Post	4.33	

*$p < 0.05$

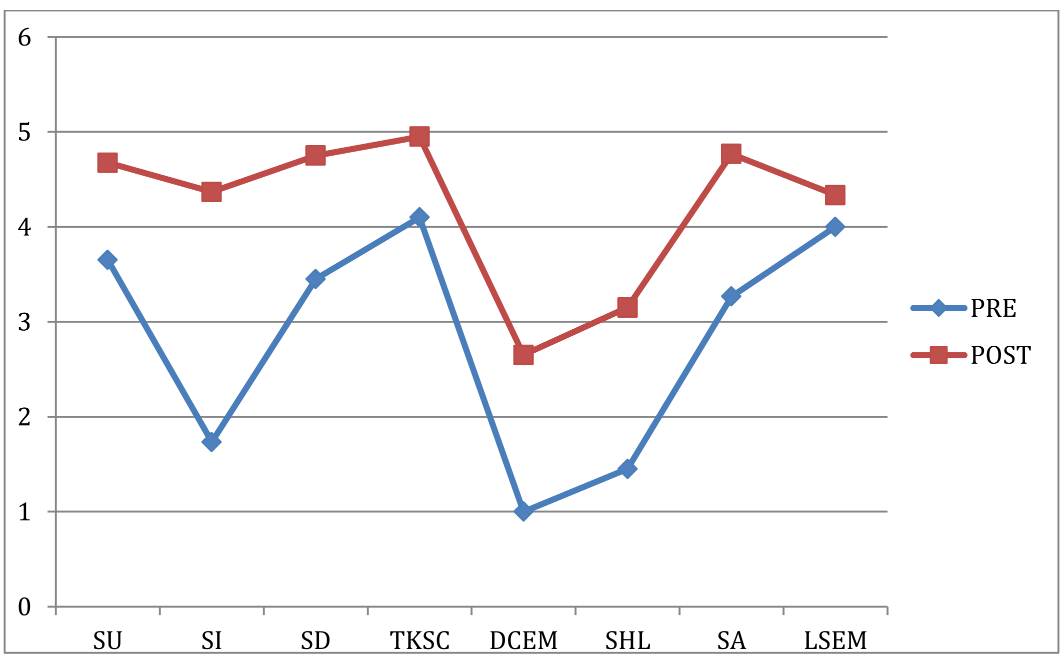


Figure 1. Teacher's pre and post instructional practices upon using the instructional congruence model. SU refers to scientific understanding, SI for scientific inquiry, SD for scientific discourse, TKSC for teacher's knowledge of science content, DCEM for diversity of cultural experiences and materials, SHL for students'

home language in regular classrooms, SA for scientific authority, and LSEM stands for linguistic scaffolding to enhance meaning.

As shown in Table 8, the largest mean change was observed in Scientific Inquiry (2.63). This component was measured by noting the level of use of scientific inquiry routines (always, primarily, less, lower or least times), evidence of science inquiry use (none, scripted investigation, or non-scripted investigation), and higher order thinking displayed by the students as a group (none, some, many, or most students). The smallest change between pre and post means was recorded in the area related to Linguistic Scaffolding to Enhance Meaning entry (0.33). Each of these categories is discussed in more detail in the sections that follow.

Constructs of science learning. The constructs of science learning are: Scientific inquiry, scientific discourse, scientific understanding, and teacher's knowledge of science content. The construct of science learning has to do with knowing, doing, and talking science. It definitely does not refer to the simple transmission of the scientific content from the teacher to the students. Scientific learning is a process in which students understand the "big ideas," formulate their hypothesis, design investigations, draw conclusions, and communicate findings. Figure 2 reflects an increase in every construct related to science learning from pre to post use of the instructional congruence model. The largest increase is evident in science inquiry (from 1.73 to 4.37). The most increase is evident in the science inquiry construct of science learning. The teacher provided his students with ample opportunities to increase their scientific understanding and thus enhance scientific discourse through scientific inquiry. For example, the teacher demonstrated how charge transferred by friction using balloon as he rubbed it against his hair. Another example used was the flashlight activity which introduced students to the idea that current consists of moving charged particles.

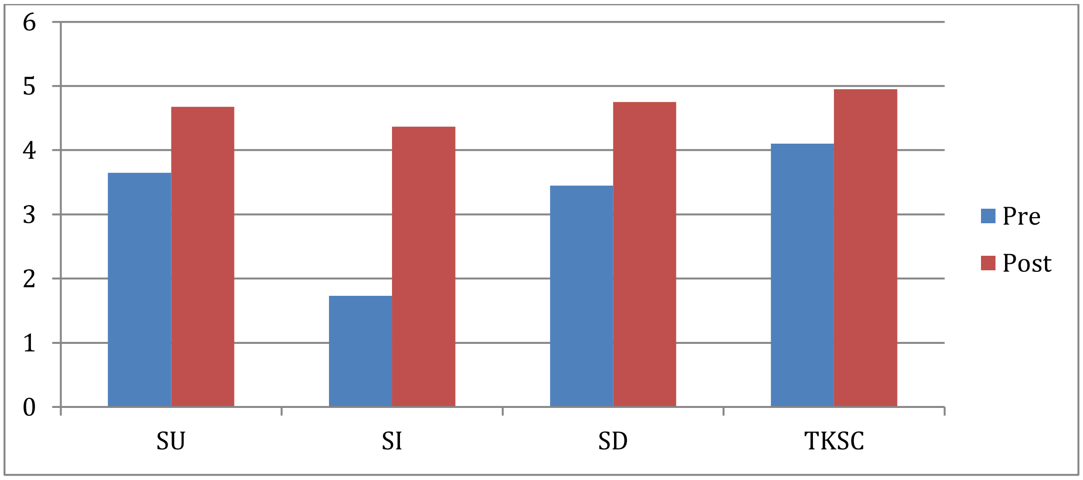


Figure 2. Changes in teacher's use of constructs of science learning. SU refers to scientific understanding, SI for scientific inquiry, SD for scientific discourse, TKSC stands for teacher's knowledge of science content,

Constructs based on students' linguistic and cultural knowledge. Two components make up the constructs based on students' linguistic and cultural knowledge: Students' home language and diversity of cultural experiences and materials. The students' home language refers to whether the teacher uses the students' home language in instruction and/or invites and encourages students' home language use. A scale of 1 reflects that neither the teacher uses nor invites/encourages students to use their home language in a regular classroom. The highest scale of this component is teacher's language use at 10-20% and teacher's encouragement of peer interaction. The diversity of culture experiences and materials uses a scale of 1 if there is no mention of cultural experience and no use of cultural material. A score of five means the teacher provided a variety of examples of cultural experience where students volunteered to share their cultural experiences and materials. As shown in Figure 3, a mean change of 1.7 is evident for the two components of this construct.

By adding the cultural component in the post intervention unit, students had the opportunity to share their cultural experiences. For example, as the participating teacher covered the "Timeline of Lighting Technology" presentation, students spoke of kerosene lamps still used in some homes for lighting purposes. They further related kerosene lamps to the decorations taking place in some Arabic countries at the onset of the fasting month. Additionally, the student home language use among themselves was encouraged by providing students with numerous group/work in pair activities related to the lesson.

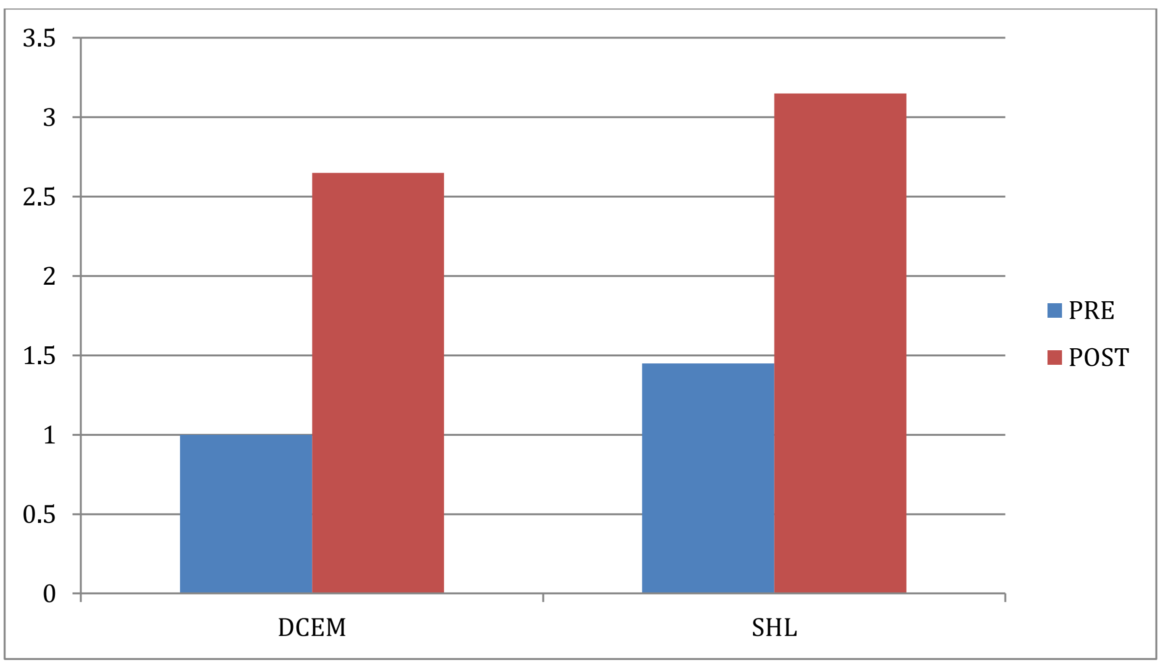


Figure 3. Changes in constructs based on students' linguistic and cultural knowledge. DCEM stands for diversity of cultural experiences and materials and SHL refers to students' home language in regular classrooms.

Constructs that bridge the two domains. Two constructs bridge the two domains between scientific learning and students' linguistic and cultural experiences: Scientific authority and linguistic scaffolding to enhance meaning. The scientific authority construct has three main components: Source of information, teacher's role, and student-teacher shared authority. The scientific authority component rates a classroom as 1 if: The source of information is the teacher or text, the teacher's role is to answer questions and there is no shared authority with students. On the other hand, a rating of 5 describes a classroom where students' consider themselves a reliable source of information, they share authority with the teacher, and the teacher's role is to guide students to explore learning and provide instrumental support. For scientific authority, a pre intervention score of 3.27 changed to a post score of 4.77 resulting in a change in means of 1.5.

In the post intervention unit on electricity, most students considered themselves as a dependable source of information. Few consulted other classmates and teacher. This is partially due to the repeated exposure to lessons' concepts using different methods. Students became more confident in their skills and the teacher's role changed from answering questions to questioning students and providing instrumental help as needed. The participating teacher would answer students' questions with a question to direct their thinking in a particular path. He made extra effort to hold himself back from providing the answer right away. Authority was shared among students and their teacher during the electricity unit.

Linguistic scaffolding to enhance meaning focuses on the extent to which the teacher changed his verbal communication to enhance students' comprehension and understanding of science. Linguistic scaffolding takes into consideration the teacher's level of communication with the students and the variation of forms of communications used in the classroom. A rating of 1 represents an inappropriate teacher level of communication where it is either too high or too low, it has no variation in forms, and it does not accommodate students with different levels of proficiency. A rating of 5 describes a teacher who, most of the time, communicates at or slightly above the students' level of communication and uses a variety of communication types (verbal, gesture, written, and graphic). The pre intervention mean score for the teacher's linguistic scaffolding was 4, which changed to 4.33 post intervention. When asked what he meant, the participating teacher would rephrase the statement and use different words to illustrate meaning. Most students were able to provide linguistic scaffolding to their classmates as well. They would translate particular terms to each other, clarify concepts, and correct each other's language errors.

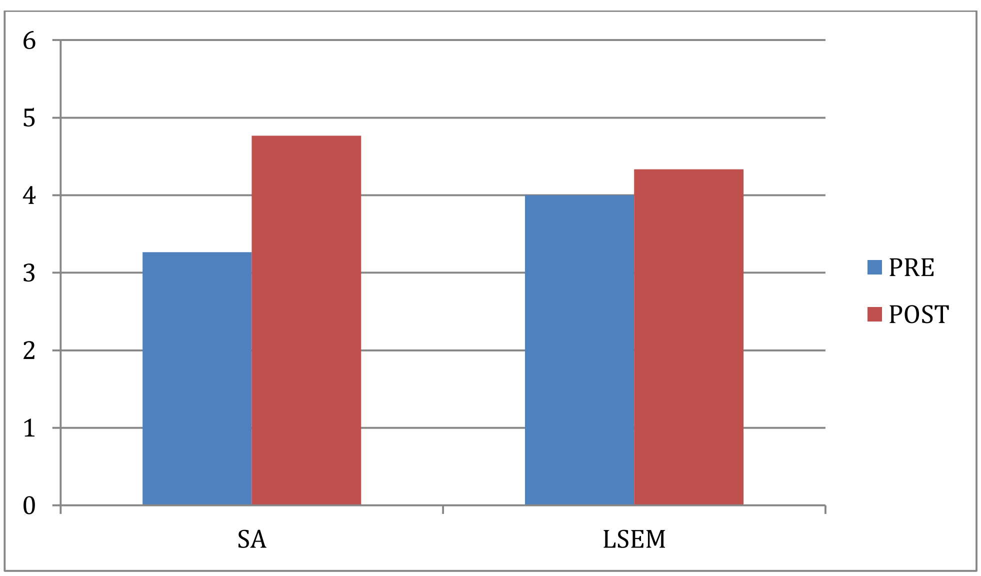


Figure 4. Changes in constructs that bridge the two domains. SA stands for scientific authority, and LSEM refers to linguistic scaffolding to enhance meaning.

Scientific Discourse in the Classroom

Data collected through videotaping focused on students and teacher's communication interactions (speaking, listening and turn-taking), students' engagement in scientific discourse, and students' development in English language and literacy before and after the use of the instructional congruence model. Analysis of these data used Gee's (1997) categories of classroom talk (*design and debate*, *anomaly talk*, *everyday speculation talk, and explanation talk*) to determine: (i) Whether such interactions occurred in culturally congruent ways (whether students' cultural experiences and examples were integrated in instruction, and the extent to which students' home language was used to enhance understanding). (ii) Student engagement in scientific understanding, inquiry, and discourse. (iii) Student development of English language and literacy in terms of reading and writing activities in the science lessons, use of grammatical and graphic convention to enhance students' use of standard English, and adaptations of communications (verbal, gestural, written, and graphic) to enhance understanding.

The frequency and types of communication interactions between students and their teacher were noted during pre and post intervention over a 10 day period (see Tables 9 and 10).

Table 9

Pre-Intervention Totals of Classroom Discussion Categories

		Design/Debate				**Anomaly Talk**				**Everyday Speculation Talk**				**Explanation Talk**			
		Verbal	**Gesturing**	**Written**	**Graphic**	**Verbal**	**Gesturing**	**Written**	**Graphic**	**Verbal**	**Gesturing**	**Written**	**Graphic**	**Verbal**	**Gesturing**	**Written**	**Graphic**
Teacher-Student	**Speaking**	3	0	0	0	0	0	0	0	0	0	0	0	351	8	21	14
	Listening	3	0	0	0	0	0	0	0	2	0	0	0	85	0	0	0
	Turn-Taking	3	0	0	0	0	0	0	0	0	0	0	0	63	0	0	0
Student-Teacher	**Speaking**	3	0	0	0	0	0	0	0	2	0	0	0	96	1	14	2
	Listening	3	0	0	0	0	0	0	0	0	0	0	0	308	0	0	0
	Turn-Taking	0	0	0	0	0	0	0	0	0	0	0	0	66	0	0	0
Student-Student	**Speaking**	0	0	0	0	0	0	0	0	1	0	0	0	42	0	8	0
	Listening	0	0	0	0	0	0	0	0	1	0	0	0	41	0	0	0
	Turn-Taking	0	0	0	0	0	0	0	0	1	0	0	0	37	0	0	0

Table 10

Post-Intervention Totals of Classroom Discussion Categories

		Design/Debate				**Anomaly Talk**				**Everyday Speculation Talk**				**Explanation Talk**			
		Verbal	**Gesturing**	**Written**	**Graphic**	**Verbal**	**Gesturing**	**Written**	**Graphic**	**Verbal**	**Gesturing**	**Written**	**Graphic**	**Verbal**	**Gesturing**	**Written**	**Graphic**
Teacher-Student	**Speaking**	18	0	0	0	0	0	0	0	7	5	0	0	399	1	21	6
	Listening	13	0	0	0	0	0	0	0	12	0	0	0	136	0	0	0
	Turn-Taking	13	0	0	0	0	0	0	0	7	0	0	0	124	0	0	0
Student-Teacher	**Speaking**	13	0	0	0	0	0	0	0	12	0	0	1	152	0	0	0
	Listening	18	0	0	0	0	0	0	0	8	0	0	0	374	0	16	0
	Turn-Taking	13	0	0	0	0	0	0	0	7	0	0	0	110	0	0	0
Student-Student	**Speaking**	23	0	0	0	0	0	0	0	16	2	0	2	101	0	21	0
	Listening	23	0	0	0	0	0	0	0	16	0	0	0	101	0	7	0
	Turn-Taking	23	0	0	0	0	0	0	0	15	0	0	0	90	0	0	0

Each type of classroom talk (*design and debate, anomaly talk, everyday speculation talk, and explanation talk)* was analyzed using the four types of communications (verbal, gesture, written and graphic) in addition to the forms of interaction (speaking, listening and turn-taking). Types of interactions (teacher-student, student-teacher, and student-student) were noted as well. The changes in pre and post means are provided in Table 11.

Table 11

Mean Changes in Verbal Communications

	Mean		Mean Change
Explanation Talk			
Teacher to Student	Pre	49.9	16
	Post	65.9	
Student to Teacher	Pre	47.0	16.6
	Post	63.6	
Student to Student	Pre	12.0	27.3
	Post	29.3	
Design/Debate Talk			
Teacher to Student	Pre	0.9	3.5
	Post	4.4	
Student to Teacher	Pre	0.6	3.8
	Post	4.4	

Student to Student	Pre	0.0	7.0
	Post	7.0	
Everyday Speculation Talk			
Teacher to Student	Pre	0.2	2.4
	Post	2.6	
Student to Teacher	Pre	0.2	2.5
	Post	2.7	
Student to Student	Pre	0.3	4.4
	Post	4.7	

Explanation talk. According to Gee (1997), explanation talk is often used by teachers when new lessons are introduced and explained. The verbal form of teacher-student interaction in the explanation talk was the highest total of all entries at 351 for pre and 399 for post intervention (Tables 9 and 10). The written component of teacher-student interaction claimed the second place (21 pre and post) then graphic (14 pre and 6 post) and finally gesturing at pre score of 8 and post of 1). The descending order of verbal, written, graphic, and gesture totals is true in all the observations made in the study.

Explanation talk was the most used form of classroom discussion categories. It was used to introduce new materials, re-explain existing concepts, analyze and correct misconception and re-affirm correct responses.

Design/debate talk. Design/debate talk is concerned with procedures and limited to how to conduct a research experiment (Gee, 1997). Verbal interactions only took place in the design/debate talk. Student-student interaction headed the list at a total of 70 and a tie between teacher-student interactions and student-teacher interactions (44) was noted in the post intervention data (Table 10). As for the pre intervention data, teacher-student interactions totaled 9, student-teacher interactions totaled 6 and no student-student interactions were recorded (Table 9). Therefore, student-student verbal interactions have the highest mean change of 4.4, student-teacher interactions have a mean change of 2.5, and teacher-student interaction has the lowest mean change at 2.4 (see Table 11).

Over 80% of the tallies of the student-student interactions in the design/debate talk were accumulated due to the "Jeopardy Buzzer Activity." Students were instructed to use the provided materials to create a working buzzer. They were also required to sketch out the electrical wiring diagrams used to create the buzzer. The decision whether the design involved a series or parallel circuit was debated and the wiring diagram reflected it. Question three in the post lab questions required students to think further ahead before answering it in their science notebooks. It asked about what would be needed in order to add a light bulb that lights up when the button is pressed and how could this be done. Most of the remaining tallies came from the "Flashlight Activity". So, the nature of these activities made the design/debate talk mandatory to proceed further with the activities.

Everyday speculation talk. Everyday speculation talk uses everyday language and experiences to refer to processes students learned. Student-student verbal interactions have the highest mean change at 7.0 (pre=3 and post=47), student-teacher interactions have a mean change at 3.8 (pre=2 and post=27), and teacher-student interaction has the lowest mean change at 3.5 (pre=2 and post=26) (see Tables 10-12). The verbal mode of communication was the only documented form of communication in the pre-intervention data (see Table 10), whereas in the post intervention about 95% of the communications were verbal (see Table 11).

The majority of everyday speculation talks' tallies were accumulated during three activity days: Home circuitry activity, how electric shocks happen activity, and semantic web/flashlight activity days. Students in these occasions used everyday language to refer to concepts they learned. Students related text and visuals in the home circuitry activity. They were instructed to work together (as pairs or in groups) to list three things about circuits. As for how electric shocks happen activity, students were required to write an explanatory paragraph and to list the series of events they may cause a person to receive a shock from a metal doorknob on a dry winter day. Volunteers read aloud those paragraphs in class the next day. For the semantic web activity, students worked in pairs to write or draw all words, phrases and concepts related to the term electricity.

Anomaly talk. Anomaly talk discusses unexpected results. No record of anomaly talk was present in the pre or post intervention in this study.

CHAPTER 5

DISCUSSION, CONCLUSION, AND IMPLICATIONS

This chapter provides a discussion of the results presented in the previous chapter and their implications. This discussion is organized around the three research questions that framed the study.

Impact of the ICM on Student Attitudes Toward Science

The "Attitude Towards Science" survey was used to examine changes in student mindsets about science in different contexts. Results indicate that teaching science using the instructional congruence model improved students' attitudes in all contexts, particularly in the areas of contexts of learning science in school, self-concept in science and the importance of science. Positive changes in student attitudes toward science were expected given that an important aspect of the teacher training in the instructional congruence model included the integration of inquiry-based activities (Lee & Fradd, 2001). The teacher provided his students with ample opportunities to increase their scientific understanding and thus enhance scientific discourse through scientific inquiry. For example, the "Jeopardy Buzzer Activity" ignited the students' interest in science as they built their own buzzer to use during the test review. Other activities such as the "Flashlight Activity" and "Balloon Activity" used items familiar to students to confirm scientific findings such movement of charged particles and transfer of charge by friction. As a result, students were exposed to more hands-on/minds-on activities during the unit employing the instructional congruence model approach.

Data from the classroom observations showed increased student interest in learning science as the instructional congruence model was adapted. These findings support those of other studies in the US and abroad indicating that adapting the instructional congruence model improves student attitudes (Luykx & Lee, 2007; Zain, et al., 2010).

Another important aspect of the teacher's training was the integration of aspect of the student culture and language so students could make connections between their personal experiences and what they were learning in science (Lee & Fradd, 1998; Moje et al., 2001; Warren et al., 2001). Students' language was incorporated as the students were provided with each lesson's vocabulary terms, their pronunciation, and Arabic translation. Many literacy components were used in teaching the electricity unit. For example, for each lesson, there was a vocabulary link, reading strategy, and writing in science component among many others. The cultural components of the instructional congruence model were also integrated in the electricity unit. The "Timeline for Lighting Technology" and "Hassan Kamel Al-Sabbah" presentations also captured the students' attention and increased their interest in the topic at hand. They were delighted to know that a famous person sharing the same culture as they did, such as Hassan Al-Sabbah, had made major contributions to science that are recognized worldwide.

Impact of the ICM on Students' Achievement in Science

The Lee and Fradd's (1998) framework of instructional congruence provides science teachers with a framework that can be used to increase their ELL students' opportunities to acquire information and learn in meaningful ways. According to Lee and Fradd (1998), mediating the nature of academic content with students' language and cultural experience creates instructional congruence and makes science content meaningful and relevant for different learners. Therefore, by integrating literacy and science, achievement is promoted in both areas.

The results of this study support previous research related to the relationship between the use of the instructional congruence model and student achievement in science. In this study, inquiry use mediated science learning and facilitated student understanding, thus resulting in great achievement (Lee & Fradd, 2001). The inquiry-based activities provided students with opportunities to do science, talk science, and hear science (Luykx & Lee, 2007; NRC, 1996). Students were able to master concepts by doing activities that promoted their interest in science learning. Building a “Jeopardy Buzzer Activity,” for example, required students to use the provided items, choose the type of circuit (parallel versus series), sketch out the electrical circuit diagram, and answer post lab questions. The “Flashlight Activity” was yet another opportunity where students tested changing the order of the batteries and check which order allowed the flow of charge for the flashlight to work. Activities of different types were fun, challenging, and designed to reach learners at different levels.

Research indicates that teaching science as inquiry is particularly effective with underrepresented populations such as English Language Learners (ELL) because it facilitates the development of students’ vocabulary (Fellows, 1994; Haury, 1993). The use of inquiry assists ELL students in moving closer to scientific understanding as they build their language skills (Fellows, 1994). Providing students with the Arabic translation of the lessons’ vocabulary terms was one way to assist students in understanding the meaning of the terms. Additionally, bringing students closer to scientific understanding was the ultimate goal of activities such as: the semantic web, writing in science, vocabulary reinforcement strategies, math links, and reading strategies.

Science learning was developed as students and their teacher participated actively in classroom tasks. On a daily basis, the teacher directed students' attention to displayed lesson's objectives. The teacher ensured that students were on task whether it was opening activity time, direct instruction time, independent practice/small group work, or closure and checking for understanding time. Raising questions that encourage students to think was a norm in the classroom. The teacher used activities that focused on student discovery and creativity to keep them interested. As learning was connected to real world situations, students asked questions and defined problems in search of answers. Teacher's demonstrations such as rubbing the balloon to prove that charge is transferred by friction and the mini home circuit were employed to enhance understanding as well.

Students constructed explanations and designed solutions based on planning procedures, carrying out investigations, analyzing data and interpreting results. These approaches guaranteed that the teacher and the text were not the sole source of information. Instead, students interacted with each other and exchanged ideas. This way, students were not only required to provide evidence of their thinking, but to respond to the reasoning of others. They also had opportunities to practice word problems working either independently or with a partner. When appropriate, manipulative and technology use was incorporated into the electricity unit. The teacher constantly checked for understanding, validated information and expectations through oral explanation, written models, steps and/or examples. Students were given the opportunity to ask clarifying questions so they could build clear understanding of science concepts. Student participation increased in the electricity unit as students became more attentive and engaged, which resulted in greater achievement. As pointed out by Lee et al. (2005), inquiry use along with the language support that ELL students receive normally translates into higher academic achievement.

Impact of the ICM on Teacher's VNOS

The American Association for the Advancement of Science (1989) advocates developing an "adequate understanding" about the nature of science or understanding that science is a "way of knowing" as an outcome of science instruction. The goal of helping students develop informed conceptions of NOS in science education has gained renewed emphasis in current national science education reform documents (Abd-El-Khalick, 2001). However, K-12 students and teachers have not attained the desired NOS understandings (Lederman et al., 2002). For that reason, training of the teacher on the NOS was mandatory so he could build informed views on the various aspects of NOS and in turn facilitate student understanding of the nature of science. The goal of NOS lessons is for students to experience how scientists search for answers. After all, Clough (2006) describes NOS instruction as a process through which learners proceed through a conceptual change.

Understanding of the nature of science is a key component of science teachers' instructional practice as they establish instructional congruence in their science classes (Lee & Fradd, 1998). The teacher's views on the nature of science (NOS) were measured before and after the implementation of the instructional congruence model to note the effects of teacher training on the teacher's views. During the training, different definitions of NOS were introduced, the components were mentioned, teaching approaches were covered, and the aspects of NOS were explained in details. In the last slide in the NOS power point presentation, I re-emphasized that current reform documents in science education (e.g., National Research Council, 1996) recommend that teachers should help students to develop conceptual understandings and integrated skills, engage them in scientific inquiries, and assist them to internalize understandings related to the nature of science (NOS). As a result of the rich and intensive data presented to the teacher, his views on every item measured were at the informed level by the end of the study.

The results of this study support the assertion that the teacher's views on the nature of science became more informed, particularly in the areas of: views about general structure and aim of experiments, creative and imaginative NOS, and inference in relation to theoretical entities in science. In his views about structure and aim of experiments, the participating teacher changed his description of an experiment from "a process to figure out how something works" to "a step-by-step procedure to prove a claim." A change was noted in the post survey answer about creative and imaginative NOS as the teacher added that creativity and imagination were used during data collection as well as in the planning and analyzing data stages. As for the NOS aspect related to inference and theoretical entities, the teacher's views changed from pre naïve version related to using different approaches to group species to the informed view explaining that scientists use such terms to group organisms. The mentioned modifications and enhancements in the teacher's views were the result of careful analysis of the VNOS-C questionnaire items using Lederman's et al. (2002) as a reference and searching for clues in all responses. However, in other areas of the NOS such as: empirical NOS, tentative NOS, differences and relationships between theories and laws, nature and function of scientific theory, inferential NOS, theory-laden NOS, and social and cultural embeddedness of science, the teacher already had informed views at the onset of the study. As a result, no changes were experienced in these areas.

Impact of the ICM on Classroom Communication Interactions

Effective instruction, using the congruent teaching approach, requires teachers to have knowledge of both the academic disciplines and student diversity (Lee & Fradd, 1998; Moje et al., 2001; Warren et al., 2001). Effective instruction begins with teacher's identification of student needs. The characteristics of effective teachers' instructional style include language proficiency, cultural knowledge, linguistic knowledge combined with positive teacher attitude and competencies (Clark & Perez, 1995). Effective teachers may reach their ELL students through communicating clear directions, pacing lessons, making jointly determined decisions, providing immediate feedback, monitoring students' progress, instructing in native language, employing dual language methodology, integrating students' home culture and values and implementing a balanced coherent curriculum (Baker, 1997).

The results of this study support the assertion that the teacher's use of the instructional congruence model lead to greater interaction and communication among the students and between the students and the teacher. As students engaged in inquiry activities and the teacher used questioning techniques to help students make connections among science concepts, the students became more curious and were more willing to share their ideas among themselves and with their teacher. Their increased interest in science accounted partially for the increased communication interactions. The increase was evident as the participating teacher: Encouraged students' home language use in the classroom by requiring students to word in pairs or small groups, incorporated culture into the lessons, and listened to them as they voluntarily shared their cultural experiences.

For example, as the teacher listed the different inventions in the "Timeline of Lighting Technology" presentation, many students commented that kerosene lamp is still in use in some Arabic countries where electricity is cut off on regular basis (due to shortage in fuel, destruction of electricity power plant,…). Others linked the kerosene lamp to the start of the fasting month because the picture/drawings of lamps are used for decoration purposes. During the same presentation, as the teacher spoke about the invention of candles as a source of lighting, a few students decided to speak of another cultural use of candles. They debated that scent candles are of great importance especially "when my mother makes fish," one student said. More interactions were the result of students viewing themselves as a source of information capable of: Answering questions, correcting each other's errors, and clarifying concerns of their own peers. For example, when one student said: "Ms. L. is on the door," another student replied, "she is at the door, not on the door!"

Conclusions

The main goal of this study was to improve the attitudes and achievement of a group of ELL students and to note changes in teacher's practices after training the teacher on the instructional congruence framework. Teacher training was specifically designed to teach the participating teacher how to use the instructional congruence framework in science instruction and to help him develop informed views on NOS. The results of this study indicated that student achievement increased significantly and students' attitudes improved in all contexts. At the conclusion of the study, all teacher's views on NOS were at the informed level; the teacher's instructional practices improved, and classroom interactions among the students and between the students and teacher increased greatly.

These results suggest that the instructional congruence model is rather effective with the group of students in this particular context. Thus, using the instructional congruence model in science education has a great potential for reaching different learners, improving students' attitudes about science, increase students' achievement in science, enhance teacher's views on NOS, and improve science education in general. The findings of this study support the findings of other researchers indicating that adapting the instructional congruence model produces favorable results in terms of changes in students' attitudes toward science in the US and abroad (Luykx & Lee, 2007; Zain et al., 2010). However, unlike previous work related to the instructional congruence model, this study involved a teacher of a different culture, background and language from his students. Additionally, it included 24 high school students of Middle Eastern (Arabic) descent. Therefore, this study adds to the growing body of research related to practices in science education that produce higher achieving and well-rounded students, particularly those from ELL backgrounds. A model such as this one has significant potential for meeting the needs of the growing population of ELL students and the goals of reformed science education.

Limitations

This study may have been limited by the small number of student and teacher participants. The participating teacher has only two years of teaching experience and was open to all suggestions. Another limitation in this study is the fact that the researcher was also the teacher trainer on the instructional congruence model. The researcher worked with the participating teacher for an extended period of time first for training and later for co-developing the post-intervention science unit. The results of this study might have been different if the teacher training was in a group setting instead of one-on-one training. Further limitations were imposed by restrictions on the number of students who agreed to be video-taped during data collection within the teacher's classroom.

Implications

The results of this study are very promising even though it included only one participating teacher and an all-female class. These results highlight the positive impacts of using the instructional congruence model on the teacher's NOS views and classroom practice and on student's achievement level and improvement of attitudes toward science. The calls for reform of school science have grown more forceful as the country struggles to educate all its children and meet the demands of an increasingly technological society. For example, the 2002 No Child Left Behind Act demands that the academic progress of special student populations, including ELL students, be monitored and their level of academic proficiency measured. To meet the growing needs of ELL students, additional language support should be integrated in the various content areas using the practices that the instructional congruence model promotes.

The results of this study support the value of preparing teachers in the use of the instructional congruence model to teach science. The Lee and Fradd's (1998) framework of instructional congruence is a promising educational model that may help ELL students by: Providing more opportunities to acquire information, integrating science and literacy, and making learning more meaningful and relevant for different learners. As a result, teacher training institutions and school districts, particularly those serving large populations of ELL students, should consider providing pre-service and in-service teachers with professional development opportunities in this instructional model.

Need for Further Research

Further research is needed to determine the effectiveness of the instructional congruence model when used school wide and compare its impacts on a variety of student groups, including mainstream as well as underserved student populations, such as African American and Native American. Other areas of inquiry related to this instructional model might include measuring its impact of student performance on standardized tests, as well as its long-term effects as measured by student graduation rates and future career interests.

APPENDIX A: ATTITUDES TOWARD SCIENCE STUDENT SURVEY

<u>Directions</u>: Please check the response that best describes you.

1. Your Gender: ____Male _____Female

2. Your grade Level: ____9th ____10th ____11th _____12th

3. Your Ethnicity: ______ Middle Eastern ____ White (non-Middle Eastern)

______African American ____ Hispanic

______ Caucasian ____ Multiracial

4. What language do you feel most comfortable speaking? ________________________

5. What country did your parent/grandparents come from? ______________________

6. What is your favorite subject in school? _____________________________________

7. What do you plan to do after graduating from high school?

____

____

____

<u>Directions</u>: For the next statements, there is no right or wrong answer. As a result, you should circle the response that is closest to how you feel.

SCALE:

1 = Strongly Disagree
2 = Disagree
3 = Agree
4 = Strongly Agree

	Strongly Disagree	Disagree	Agree	Strongly Agree
Learning Science in school				
We learn interesting things in science lessons.	**1**	**2**	**3**	**4**
1. We learn interesting things in science lessons.	**1**	**2**	**3**	**4**
2. I look forward to my science lessons.	**1**	**2**	**3**	**4**
3. Science lessons are exciting.	**1**	**2**	**3**	**4**
4. I would like to do more science at school.	**1**	**2**	**3**	**4**
5. I like Science better than most other subjects at school	**1**	**2**	**3**	**4**
6. Science is boring.	**1**	**2**	**3**	**4**
Self-concept in science				
7. I find science difficult.	**1**	**2**	**3**	**4**
8. I am just not good at Science.	**1**	**2**	**3**	**4**
9. I get good grades in Science.	**1**	**2**	**3**	**4**
10. I learn Science quickly.	**1**	**2**	**3**	**4**
11. Science is one of my best subjects.	**1**	**2**	**3**	**4**
12. I feel helpless when doing Science.	**1**	**2**	**3**	**4**
13. In my Science class, I understand everything.	**1**	**2**	**3**	**4**

Activities and experiments in science

14. Science activities and experiments are exciting.	**1**	**2**	**3**	**4**
15. I like science activities and experiments because you don't know what will happen.	**1**	**2**	**3**	**4**
16. Activities and experiments in science is good because I can work with my friends.	**1**	**2**	**3**	**4**
17. I like doing activities and experiments in science because I can decide what to do myself.	**1**	**2**	**3**	**4**
18. I would like more activities and experiments in my science lessons	**1**	**2**	**3**	**4**
19. We learn science better when we perform activities and experiments.	**1**	**2**	**3**	**4**
20. I look forward to doing science activities and experiments.	**1**	**2**	**3**	**4**
21. Activities and experiments in science are boring.	**1**	**2**	**3**	**4**

Science outside of school

22. I would like to join a science club.	**1**	**2**	**3**	**4**
23. I like watching science shows on TV.	**1**	**2**	**3**	**4**
24. I like to visit science museums.	**1**	**2**	**3**	**4**
25. I would like to do more science activities outside school.	**1**	**2**	**3**	**4**
26. I like reading science magazines and books.	**1**	**2**	**3**	**4**
27. It is exciting to learn about new things happening in science.	**1**	**2**	**3**	**4**

Future participation in science

28. I would like to study more science in the future.	**1**	**2**	**3**	**4**
29. I would like to study science at university.	**1**	**2**	**3**	**4**
30. I would like to have a job working with science.	**1**	**2**	**3**	**4**
31. I would like to become a science teacher.	**1**	**2**	**3**	**4**
32. I would like to become a scientist.	**1**	**2**	**3**	**4**

Importance of science

33. Science and technology is important for society.	**1**	**2**	**3**	**4**
34. Science and technology makes our lives easier and more comfortable.	**1**	**2**	**3**	**4**
35. The benefits of science are greater than the harmful effects.	**1**	**2**	**3**	**4**
36. Science and technology are helping the poor.	**1**	**2**	**3**	**4**
37. There are many exciting things happening in science and technology.	**1**	**2**	**3**	**4**

APPENDIX B: VIEWS ABOUT NATURE OF SCIENCE (FORM C) TEACHER QUESTIONNAIRE

VNOS (C)

Date: / /

Instructions

- Please answer each of the following questions. Include relevant examples whenever possible. You can use the back of a page if you need more space.
- **There are no "right" or "wrong" answers to the following questions. We are only interested in your opinion on a number of issues about science.**

1. What, in your view, is science? What makes science (or a scientific discipline such as physics, biology, etc.) different from other disciplines of inquiry (e.g., religion, philosophy)?

2. What is an experiment?

3. Does the development of scientific knowledge **require** experiments?

• If yes, explain why. Give an example to defend your position.

• If no, explain why. Give an example to defend your position.

4. Science textbooks often represent the atom as a central nucleus composed of protons (positively charged particles) and neutrons (neutral particles) with electrons (negatively charged particles) orbiting that nucleus. How certain are scientists about the structure of the atom? What specific evidence, or types of evidence, **do you think** scientists used to determine what an atom looks like?

5. Is there a difference between a scientific theory and a scientific law? Illustrate your answer with an example.

6. After scientists have developed a scientific theory (e.g., atomic theory, evolution theory), does the theory ever change?

• If you believe that scientific theories do not change, explain why. Defend your answer with examples.

• If you believe that scientific theories do change:

(a) Explain why theories change?

(b) Explain why we bother to learn scientific theories. Defend your answer with examples.

7. Science textbooks often define a species as a group of organisms that share similar characteristics and can interbreed with one another to produce fertile offspring. How certain are scientists about their characterization of what a species is? What specific evidence **do you think** scientists used to determine what a species is?

8. Scientists perform experiments/investigations when trying to find answers to the questions they put forth. Do scientists use their creativity and imagination during their investigations?

• If yes, then at which stages of the investigations do you believe that scientists use their imagination and creativity: planning and design; data collection; after data collection? Please explain why scientists use imagination and creativity. Provide examples if appropriate.

• If you believe that scientists do not use imagination and creativity, please explain why. Provide examples if appropriate.

9. It is believed that about 65 million years ago the dinosaurs became extinct. Of the hypotheses formulated by scientists to explain the extinction, two enjoy wide support. The first, formulated by one group of scientists, suggests that a huge meteorite hit the earth 65 million years ago and led to a series of events that caused the extinction. The second hypothesis, formulated by another group of scientists, suggests that massive and violent volcanic eruptions were responsible for the extinction. How are these **different conclusions** possible if scientists in both groups have access to and **use the same set of data** to derive their conclusions?

10. Some claim that science is infused with social and cultural values. That is, science reflects the social and political values, philosophical assumptions, and intellectual norms of the culture in which it is practiced. Others claim that science is universal. That is, science transcends national and cultural boundaries and is not affected by social, political, and philosophical values, and intellectual norms of the culture in which it is practiced.

• If you believe that science reflects social and cultural values, explain why and how. Defend your answer with examples.

• If you believe that science is universal, explain why and how. Defend your answer with examples.

APPENDIX C: GEE'S CLASSROOM DISCUSSION CATEGORIES

		Design/Debate				Anomaly Talk				Everyday Speculation Talk				Explanation Talk			
		Verbal	Gesturing	Written	Graphic	Verbal	Gesturing	Written	Graphic	Verbal	Gesturing	Written	Graphic	Verbal	Gesturing	Written	Graphic
Teacher - Student	Speaking																
	Listening																
	Turn-Taking																
Student - Teacher	Speaking																
	Listening																
	Turn-Taking																
Student - Student	Speaking																
	Listening																
	Turn-Taking																

APPENDIX D: OBSERVATIONAL INSTRUMENT FOR LUYKX AND LEE SCALES

Scientific Understanding	1	2	3	4	5
Level of knowledge	superficial memorization	slightly superficial	mix deep & Superficial by 10-20% students	Relatively deep by 20-50% students	Consistently deep by 50-90% students
**Focus*	*none*	*little*	*generally not Sustained*	*sustained*	*sustained by more*
**Reasoning*	*not evident*	*not evident*	*few may reason*	*more may reason*	*most may reason*
**Connection between concepts*	*not evident*	*mention of concepts*	*some may connect concepts*	*demonstrated*	*demonstrated*
Comments					

Scientific Inquiry	1	2	3	4	5
**Times on Routines*	*always*	*primarily*	*less*	*lower*	*least*
**Evidence of Science Inquiry*	*none*	*scripted investigation*	*non-scripted investigation*	*non-scripted investigation*	*non-scripted investigation*
**Higher Order Thinking Displayed by*	*none*	*none*	*Some students*	*many students*	*most students*
Comments					

Scientific Discourse	**1**	**2**	**3**	**4**	**5**
***Episode Activity**	*not evident*	*shared & developed briefly*	*one episode shared & developed*	*many episodes shared & developed*	*maintained deep understanding*
***Participation level**	*none*	*<10% of students*	*20-50 % of students*	*20-50 % of students*	*50-90% of students*
Comments					

Scientific Authority	**1**	**2**	**3**	**4**	**5**
***Source**	*teacher/text*	*Teacher/peers*	*self*	*self*	*self/all share*
***Teacher's Role**	*answer questions*	*relies on students to support others*	*intervene with question then answer*	*intervene with*	*question and Instrumental help provided*
***Shared Authority**	*no*	*few Students*	*many (20-50%)*	*most (50-90%)*	*almost all*
Comments					

Teacher's Knowledge of Science Content	**1**	**2**	**3**	**4**	**5**
***Knowledge of Topic**	*multiple Inaccuracies*	*1-2 main inaccuracies during lesson*	*accurate & limited to lesson*	*accurate & relevant beyond lesson*	*beyond Adequate*
***Teacher Provide extra information**	*no*	*no b/c of shallow understanding*	*no & dismisses questions*	*beyond lesson*	*abundant*
Comments					

Diversity of Cultural Experiences & Materials	**1**	**2**	**3**	**4**	**5**
***Cultural Experience**	***no mention***	***mentioned***	***few examples***	***many examples from Diverse origins***	***variety of example***
***Cultural Material**	***not used***	***not incorporated***	***incorporated***	***important in instruction & teacher encourages sharing***	***students volunteer sharing***
Comments					

Students' Home Language in Regular Classrooms	**1**	**2**		**3**		**4**	**5**
***Teacher use students' language in instruction**	***no***	***no***	***Minimal use by teacher***	***minimal***	***10-20%***	***<10%***	***10-20%***
***Teacher allows or invite students' language use**	***no***	***invites <10% of students***	***Students not encouraged***	***invites& encourages use 10-20%***	***Students not encouraged***	***encourages peer interaction***	***encourages peer interaction***
Comments							

Linguistic Scaffolding to Enhance Meaning	1	2	3	4	5
Teacher Level of communication	***Inappropriate***	***rarely at level***	***At/slightly above at least once***	***At/slightly above much of time***	***At/slightly above most of times***
Variations in forms	***None***	***None***	***None***	***2 of 4 types of communication used***	***4 types used***
Level of student	***Low***	***<10%***	***10-20%***	***20-50%***	***50-90%***
Comments					

APPENDIX E: EXPLANATION OF LUYKX AND LEE'S (2007) OBSERVATIONAL INSTRUMENT

Scientific Understanding

To what extent do students demonstrate a deep understanding of science? To what extent is knowledge treated in a shallow and superficial manner?

For students, scientific knowledge is deep when they develop relatively complex understandings of the lesson's concepts. They also may produce new knowledge when they connect science concepts or topics to one another. In addition, they apply science concepts to explain natural phenomena or real world situations. Instead of being able to recite only fragmented pieces of information, students develop relatively systematic, integrated, or holistic understandings of the scientific content. Students may solve problems by applying knowledge to a variety of different situations and contexts.

Scientific knowledge is shallow, thin, or superficial when concepts have been taught in isolation from related ideas, personal experiences, or real world phenomena, providing students with only a surface acquaintance with their meaning. This superficiality can be due, in part, to instructional strategies, such as when teachers cover a large quantity of fragmented ideas and bits of information that are unconnected to other knowledge. Evidence of shallow understanding by students exists when they do not or cannot use knowledge to make clear distinctions, build arguments, solve problems, or develop more complex understandings of other related phenomena.

In scoring this item, observers should note that depth of knowledge and understanding refers to the substantive character of the ideas that students express as they consider scientific topics. It is possible to have a lesson containing substantively important and deep knowledge, but students fail to show understanding of the complexity or the significance of the ideas. Observers' ratings should reflect the depth to which *students* pursue the content.

Scientific Understanding

1. Knowledge is superficial because concepts are taught in isolation from related ideas, personal experiences, or real world phenomena. Students are mainly required to memorize information.

2. Knowledge remains superficial. Underlying or related concepts and ideas might be mentioned or covered, but only a superficial understanding of these ideas is evident.

3. Knowledge is treated unevenly during instruction; there is deep understanding of some scientific concepts and ideas, but superficial understanding of some other ideas. At least one idea is presented in depth and its significance may be grasped by some students (10%-20%), but in general the focus is not sustained.

4. Knowledge is relatively deep because the students provide information, arguments, or reasoning that demonstrates the complexity of one or more ideas. The teacher structures the lesson so that many students (20%-50%) do at least one of the following: sustain a focus on a significant topic for a period of time; demonstrate understanding of the connections between concepts, and between these and personal experiences or real world phenomena; demonstrate understanding of the problematic and incomplete nature of information; or demonstrate understanding by making reasoned and well-supported arguments.

5. Knowledge is consistently deep because the teacher successfully structures the lesson so that most students (50%-90%) do at least one of the following: sustain a focus on a significant topic for a period of time; demonstrate understanding of the connections between concepts, and between these and personal experiences or real world phenomena; demonstrate understanding of the problematic and incomplete nature of information; or demonstrate understanding by making reasoned and well-supported arguments.

Scientific Inquiry

To what extent do students engage in scientific inquiry?

The scale is intended to measure the extent to which students engage in scientific inquiry. There are two dimensions to this construct.
First, scientific inquiry occurs when students conduct an investigation or an experiment. Scientific inquiry involves generating questions, designing investigations and planning procedures, carrying out the investigations, analyzing and drawing conclusions, and reporting findings. Inquiry is not a linear process; instead, aspects of inquiry interact in complex ways. According to the National Science Education Standards (National Research Council, 1996, 2000), fundamental abilities necessary to do scientific inquiry at grades K-4 and 5-8 include (NRC, 1996, pp. 121-123, 143-148; NRC, 2000, p. 19):

- Asking a question about objects, organisms, and events in the environment; or asking a question that can be answered through a scientific investigation.
- Planning and conducting a simple scientific investigation.
- Using appropriate tools and techniques to gather, analyze, and interpret data.
- Using data to construct a reasonable explanation; or developing descriptions, explanations, predictions, and models using evidence.

• Communicating scientific procedures, investigations, and explanations.
• Using mathematics in appropriate aspects of scientific inquiry.

Second, scientific inquiry can be thought of as higher order thinking that involves science, i.e., thinking that goes beyond recording or reporting scientific facts, rules, and definitions or mechanically applying concepts. Scientific inquiry involves searching for patterns, making hypotheses or inferences, and justifying those with evidence. Inquiry also includes organizing, analyzing, synthesizing, evaluating, predicting, arguing, making models or simulations, and inventing original procedures. In all of these cases, the content of the thinking is science.

A lesson can be low in scientific inquiry when students' activities are limited to repeating information provided by the teacher or text, or following a scripted set of procedures that does not require them to engage in higher order thinking.

Note: Scientific inquiry might take place almost accidentally or, seemingly, as an aside to the main flow of the lesson. For example, the teacher may ask a rhetorical question whose posing, if the question were taken seriously, would provide evidence of scientific inquiry.

Scientific Inquiry

1. Students receive, recite, or perform routine procedures. In no activities during the lesson do students engage in scientific inquiry.

2. Students primarily receive, recite, or perform routine procedures. Students conduct a scripted investigation without higher order thinking. Or at some point during the lesson, students engage in higher order thinking as a minor diversion.

3. There is at least one significant activity involving scientific inquiry in which some students (10%-20%) demonstrate higher order thinking and/or conduct a non-scripted investigation. Or higher order thinking occurs sporadically.

4. There is at least one major activity in which many students (20%-50%) engage in higher order thinking and/or conduct a non-scripted investigation. This activity occupies a substantial portion of the lesson.

5. Most students (50%-90%), for most of the time (50%-90%), are engaged in scientific inquiry through an investigation and/or other activities involving higher order thinking.

Scientific Discourse

To what extent is classroom discourse developed to creating or negotiating shared understandings of science?

This scale assesses the extent to which talking is used to learn and understand science in the classroom. There are two dimensions to this construct; one involves scientific content, and the other the nature of the dialogue.

In classes characterized by high levels of scientific discourse and communication, there is considerable teacher-student and student-student discussion about the science topic. Verbal interaction is reciprocal, and promotes coherent shared understanding.

First, the talk is about science and includes higher order thinking, such as making distinctions, applying ideas, forming generalizations, and raising questions; not just reporting experiences, facts, definitions, or procedures.

Second, the conversation involves sharing ideas and is not completely scripted or controlled by one party (as in teacher-led recitation). Sharing is best illustrated when participants explain themselves or ask questions in complete sentences, and when they respond directly to previous speakers' comments.

Third, the dialogue builds coherently on participants' ideas to promote improved, shared understandings of a scientific theme or topic (which does not necessarily require summary statements).

In short, scientific discourse and communication resemble the kind of sustained exploration of content characteristic of a good seminar where student contributions lead to shared understandings.

For fourth graders, scientific discourse and communication may be composed of very short sentences. Also, students of limited English proficiency may rely heavily on their native language, or native language utterances may be incompletely translated into English. Such conversations may (but need not) result in students needing to clarify what they mean to say, perhaps with help from the teacher or another student. To score high on this scale, however, science must still be a substantial component of the ongoing dialogue.

In classes where there is little or no scientific discourse and communication, teacher-student interaction typically consists of a lecture with recitation where the teacher deviates very little from delivering a preplanned body of information and set of questions; students typically give very short answers. Because the teacher's questions are motivated principally by a preplanned checklist of questions, facts, and concepts, the discourse is frequently choppy, rather than coherent. There is often little or no follow-up of student responses. Such discourse is the oral equivalent of fill-in-the-blank or short answer study questions.

Note: The use of scientific terminology does not guarantee the existence of scientific discourse; indeed, the inappropriate use of terminology may actually interfere with the development of collective understandings and shared meanings. Scientific terms, when used, should be meaningful and appropriate, and they should help support the conversation.

In a whole class setting, students could participate in scientific discourse and communication by listening and being attentive to the conversations that take place. Students do *not* have to all take turns participating on each and every point of a lesson; such turn-taking may actually interfere with the development of shared understandings. Rather, students may selectively make comments when they have something to add. In small group settings, scientific communication is likely to be more broadly spread throughout the group. In both cases, the issue is one of balance; no one person should dominate the conversation.

Scientific Discourse

1. Virtually no features of scientific discourse and communication occur, or what occurs is of a fill-in-the-blank nature.

2. Sharing and the development of collective understanding among a few students (10% or less) or between a single student and the teacher occur briefly.

3. There is at least one sustained episode of sharing and developing collective group of students and the teacher. Or, brief episodes of sharing and developing collective understandings occur sporadically throughout the lesson.

4. There are many sustained episodes of sharing and developing collective understandings about science in which many students (20%-50%) participate.

5. The creation and maintenance of collective understandings permeates the entire lesson. This could include the use of a common terminology and the careful negotiation of meanings. Most students (50%-90%) participate.

Scientific Authority

To what extent is the authority for determining the validity of a scientific argument or answer shared by students and teacher?

This scale is to determine the extent to which the lesson supports a shared sense of authority and responsibility for validating students' scientific reasoning. When students take on responsibility for justifying their own reasoning, they develop stronger understandings of the content and are more likely to make meaningful connections across disciplinary content and/or to the real world. To score high on this scale, the teacher and students hold each other accountable for convincing themselves and each other that their reasoning is sound and that their answers are correct. Low scores are given either when the authority for determining whether something is right or wrong rests with the teacher or the text, or (as occasionally happens) when neither the teacher nor students have a means for determining whether their reasoning is scientifically valid or not.

This scale is not intended to measure students' control over the content of a lesson. The teacher still must decide what worthwhile science is and when a particular activity is not worth exploring in all of its details. In other words, the teacher makes curricular decisions; but those decisions should not undermine the sharing of scientific authority within the class.

Scientific Authority

1. For the most part, students rely on the teacher and/or text as the sole legitimate sources of scientific authority. Students accept an answer as correct only if the teacher says it is correct or if it is found in the book, and seldom challenge information from either of these sources. If stuck on a problem, students almost always ask the teacher for help. OR, there is no clear authority for determining whether someone's scientific reasoning is valid. The teacher does not indicate whether students' answers are right or wrong, becomes flustered when queried about a topic, or is at a loss as to how to find out the answer, instead of suggesting possible resources to students.

2. Students rely on the teacher and some of their more capable peers as the legitimate source of scientific authority. The teacher often relies on a few students (who are clearly recognized as being better in science) to provide the right answer when pacing the lesson or to correct an erroneous answer. As a result, other students often rely on these students for correct solutions, verification of right answers, or help when stuck.

3. Many students (20% - 50%) share scientific authority among themselves. They tend to rely on the soundness of their own scientific arguments for verification of an answer. However, they still look to the teacher as the authority for making final decisions. The teacher sometimes asks students to provide their own arguments or hypotheses (for instance, by asking them, "What do you think?" or "How do you know?"), but intervenes with the answer in an effort to speed things up when students seem to be getting bogged down in the details of an argument.

4. Most students (50% - 90%) share in the scientific authority of the class. Though the teacher might intervene when students are getting bogged down, she usually does so with a question that focuses their attention or helps them to see a contradiction that they were missing. The teacher often answers a question with a question, though from time to time she provides the students with an answer.

5. Almost all the students (90% or more) share in the scientific authority for the class. Students rely on the soundness of their own arguments and reasoning. As a rule, the teacher answers a question with a question or provides instrumental help (as opposed to just giving the answer) for students to make their own decisions. It is not uncommon to see students leaving a class still arguing about one or more scientific points in their lesson.

Teacher's Knowledge of Science Content

How accurate and comprehensive is the teacher's mastery of the science content of the lesson?

This scale indicates the extent to which the teacher has an accurate and comprehensive grasp of the science content of the lesson. While teachers are not expected to match the degree of mastery that a scientist or other specialist would have in the field, they should possess accurate information about the topic they are teaching. Their mastery of the content should be at least slightly above that expected of students upon successful completion of the lesson. Teachers should be able to answer students' questions that go beyond the bounds of the lesson, or at least indicate to students how one might find out or what factors limit the possibilities for doing so. Of course, responding "I don't know" is preferable to proffering incorrect information, but such a response should be accompanied by suggestions (or asking students for suggestions) of how students and teacher might find out more.

A high score on this scale would be characterized by the teacher responding to students' questions with relevant information beyond that included in the lesson, or enriching the lesson by providing deeper knowledge of the phenomena or by linking it to other phenomena or experiences known to students.

On the other hand, more extensive transmission of knowledge from teacher to students is not always better. The teacher's mastery of the subject should not give way to long monologues that are too advanced for students to grasp, or that impede them from carrying out their own inquiry processes.

A low score would be characterized by multiple inaccuracies in the information that the teacher transmits to students (for example, clouds are made of water vapor, hail is caused by very cold weather, or seasons are produced by the varying distance of the Earth from the sun).

Note: Unlike many of the scales, this one focuses more on teacher behavior than on students. As with all of the scales, however, the interaction between teacher and students is the focus of observation; in this case, how the teacher's mastery of the content affects the information students receive and the teacher's ability to promote students' own inquiry processes.

Teacher's Knowledge of Science Content

1. The teacher transmits multiple inaccuracies to students in his/her explanations of the phenomena under study, or makes statements that indicate a fundamental misunderstanding of the facts or processes involved.

2. The teacher transmits 1-2 minor scientific inaccuracies during the lesson. His/her grasp of the science content is generally accurate, but shallow and/or tenuous. Uncertainties are not pursued with students as potential paths toward deeper understanding of the topic.

3. The teacher's knowledge appears accurate, but limited to the bounds of the lesson content. Further queries by students, if they arise, are met with responses of "I don't know" or "That's not part of the lesson," with no discussion of how one might investigate further.

4. Once or twice, the teacher transmits to students' accurate and relevant information about the topic that goes beyond what is covered in the lesson. This may occur spontaneously or in response to students' questions.

5. The teacher demonstrates knowledge of the topic that goes beyond the merely adequate, enriching the discussion with "extra" information throughout the lesson. He/she is able to link the topic to other phenomena known to students in accurate and relevant ways, allowing for deeper discussion.

Diversity of Cultural Experiences and Materials

To what extent does the teacher integrate students' cultural experiences and materials in instruction?

Most often, "normal" classroom instruction reflects the cultural experiences and artifacts of the dominant ethnolinguistic group. This scale measures the extent to which teachers incorporate and accommodate cultural experiences and materials that students from other groups bring to the class. To provide effective instruction for students from diverse backgrounds, teachers need to articulate student experiences with the nature and content of science.

Ideally, teachers should have knowledge of students' lives at home and in the community. They should be able to draw upon materials and community resources (e.g., people with relevant knowledge and skills, places, institutions) that reflect the cultural diversity of their students, use culturally relevant examples and analogies drawn from students' lives, and consider instructional topics from diverse cultural perspectives.

Note: Teachers may use cultural analogies or examples from the mainstream culture that would likely be incomprehensible to students from non-mainstream backgrounds. These episodes are not considered in this scale, which is designed to measure teachers' incorporation of elements from cultures that are traditionally under-represented in science classrooms. However, observers should describe these episodes in observation notes.

1. The teacher does not use or mention diverse cultural experiences or materials in instruction.

2. The teacher mentions different cultural experiences and materials, but does not incorporate them as part of instruction.

3. The teacher uses a few (1-2) examples of diverse cultural experiences and materials, and incorporates them as part of instruction.

4. The teacher uses cultural experiences and materials of diverse origins, and incorporates them as important in instruction. The teacher encourages students to share their own cultural experiences and materials.

5. The teacher incorporates a variety of cultural experiences and materials into classroom instruction. Students volunteer to share cultural experiences and materials.

Students' Home Language in Regular (Non-Bilingual) Classrooms

To what extent does the teacher use students' home language to enhance understanding in regular (non-bilingual) classrooms?

Students from diverse language backgrounds may bring knowledge of their home languages to the classroom. This scale indicates the extent to which teachers use students' home language in regular (non-bilingual) science instruction, and/or encourage students to use their home language.

Teachers may use students' home language as appropriate to enhance the students' understanding of instruction in regular (non-bilingual) classrooms. Even with students who are English proficient, teachers may use key terms in students' home language to promote understanding e.g., "vapor" in Spanish in a lesson on water vapor and evaporation).

Teachers may support and encourage students to use their home language among themselves to enhance understanding and construct meanings. Teachers may also encourage more fully bilingual students to assist less English-proficient students in their home language. Class descriptions should note if teachers are using the translations of key science terms provided in the units.

Note: Teachers may use students' home language for management purposes (e.g., to reprimand students for inattention or disruptive behavior). This differs from the use of the language *for instructional purposes* and thus does not count for ratings.

NA All (or almost all) students in the class are monolingual English speakers, OR, it is a bilingual classroom.

1. The teacher does not use students' home language in instruction, and does not allow or invite students to use their home language.

2. The teacher does not use students' home language in instruction, but invites a few students (10% or less) to use their home language a few times (10% or less). OR, the teacher uses the home language very minimally, but does not encourage students to do so.

3. The teacher uses students' home language in instruction minimally or not at all; but the teacher, some of the time (10%-20%), invites students to use their home language, or encourages more fully bilingual students to assist less English-proficient students in their home language. OR, the teacher uses the home language some of the time (10%-20%), but does not encourage students to do so.

4. The teacher uses students' home language in instruction a few times (10% or less). Additionally, the teacher, some of the time (10%-20%), invites students to use their home language or encourages more English proficient students to assist less English proficient students.

5. The teacher uses students' home language for instructional (not classroom management) purposes some of the time (10%-20%). Additionally, the teacher, much of the time (20%-50%), invites students to use their home language or encourages more fully bilingual students to assist less English-proficient students in their home language.

Linguistic Scaffolding to Enhance Meaning

To what extent does the teacher tailor his or her communication (verbal, gestural, written, graphic) to enhance students' understanding?

This scale is designed to measure the extent to which teachers provide linguistic scaffolding to enhance students' comprehension of academic content. Linguistic scaffolding refers to how teachers adjust the level and mode of their communication *(verbal, gestural, written, graphic)* to enhance students' comprehension. With effective linguistic scaffolding, teachers communicate at and slightly above students' level of linguistic competence to promote comprehension of the lesson. Teachers may also structure classroom environments in such a way as to encourage students to provide linguistic scaffolding for their peers.

Note: There may be a wide range of levels of English proficiency, as well as familiarity with scientific terminology, within a single classroom. The scale refers to the teacher's adaptation of his or her use of language to address all of these levels, not just one (be it the highest or the lowest).

First, teachers recognize the diversity of students' levels of language proficiency, appropriately structure activities to reduce the language load required for participation, and use language that matches students' levels of communicative competence in length, complexity, and abstraction. Teachers who fail to adequately adjust their verbal communication to students' level may regularly communicate at a level beyond some students' comprehension. Conversely, teachers may consistently "lower the bar" to accommodate the least proficient students, communicating at levels that fail to challenge other students or help increase their level of competence. Teachers may paraphrase the same idea in different ways, helping students' comprehension in some settings but confusing the students in other settings.

Second, ideally teachers communicate at and slightly above their students' level of communication. For example, during a lesson that involves the concepts of "increase" and "decrease," a teacher in a class with many English language learners (ELLs) helps them understand by also using the terms "go up" and "go down," hand gestures, or even a drawing. In another class, where students are more English proficient, a teacher asks the class to give scientific words, such as "expand" and "contract." In both classes, the teachers are promoting English language proficiency, while helping their students to understand scientific concepts.

Third, teachers build students' understanding and discourse skills by providing linguistic scaffolding. For example, when a student responds, "it condenses," a teacher asks the student to clarify what "it" refers to, and the student responds, "water vapor condenses."
The teacher extends the response by asking, "water vapor condenses into what?" Gradually, the teacher builds the understanding, "water vapor condenses into little water drops on a cold surface."

Finally, teachers may also use ESOL strategies with ELLs, including:
- Non-verbal gestures, total physical response, modeling, and demonstration to explain difficult concepts
- Peer tutoring among students
- Transition from concrete to abstract thinking or ideas
- Reduction of difficult language to essential vocabulary or shorter, simplified utterances
- Multiple modes of representation using non-verbal, oral, graphic and written communication
- Use of realia (demonstration of real objects or events)

Linguistic Scaffolding to Enhance Meaning

1. The teacher does not communicate at the appropriate level and mode of language to enhance students' comprehension (the level of communication is either too high or too low, or is not varied to accommodate students with different levels of proficiency).

2. The teacher rarely communicates at the appropriate level and mode of language to enhance students' comprehension. The teacher provides linguistic scaffolding with a few students (10% or less) a few times.

3. There is at least one significant activity or event in which the teacher communicates at and slightly above students' level of communication, either with small groups of students (10%-20%) or with the whole class.

4. The teacher, much of the time (20%-50%), communicates at and slightly above students' level of communication. He/she uses at least two different types of scaffolding (verbal, gestural, written, and graphic). Many students (20%-50%), much of the time (20%-50%), demonstrate understanding of the teacher or the lesson.
There may be some evidence of linguistic scaffolding among students for then peers.

5. The teacher, most of the time (50%-90%), communicates at and slightly above students' level of communication. He/she uses a variety of communicative modalities (verbal, gestural, written, and graphic) to provide scaffolding for students throughout the lesson. Most students (50%-90%), most of the time (50%-90%), demonstrate understanding of the teacher or the lesson. Students are observed to provide linguistic scaffolding for their peers.

APPENDIX F: ILLUSTTRATIVE EXAMPLES OF RESPONSES TO VNOS ITEMS

(Adapted from Lederman et al., 2002)

NOS Aspect	*More Naive Views*	*More Informed Views*
Empirical NOS	Science is something that is straightforward and isn't a field of study that allows a lot of opinions, personal bias, or individual views—it is fact based. (Form C: Item 1)	Much of the development of scientific knowledge depends on observation. . . . [But] I think what we observe is a function of convention. I don't believe that the goal of science is (or should be) the accumulation of observable facts. Rather . . . science involves abstraction, one step of abstraction after another. (Interview follow-up on Form C: Item 1)
The scientific method	Science has a particular method of going about things, the scientific *method. (Form C: Item 1)*	When you are in sixth grade you learn that here is the scientific method and the first thing you do this, and the second thing you do that and so on . . . That's how we may say we do science, but [it is different from] . . . the way that we actually do science. (Interview follow-up on *Form C: Item 1)*
General structure and aim *of experiments*	An experiment is a sequence of steps performed to prove a proposed theory. *(Form C: Item 2)* Experiment is everything that involves the act of collecting data and not necessarily manipulation. (Interview follow-up on Form C: Item 2)	An experiment cannot prove a theory or a hypothesis. It just discredits or adds validity to *them. (Form C: Item 2)* An experiment is a controlled way to test and manipulate the objects of interest while keeping all other factors the same. (Form C: Item 2)
Role of prior expectations *in experiments*	You usually have some sort of idea about the outcome. But I think that to have a scientific and valid experiment you should not have any bias or ideas in advance. (Interview follow-up *on Form C: Item 2)*	To organize an experiment you need to know what is going to come out of it or it wouldn't really be a test method. I don't know how you would organize a test . . . if you don't have a general idea about what you are looking for. (Interview, follow-up on Form C: *Item 2)*
Validity of observationally based theories and *disciplines*	Science would not exist without scientific procedure which is solely based on experiments. . . . The development of knowledge can only be attained through precise *experiments. (Form C: Item 3)*	Experiments are not always crucial . . . Darwin's theory of evolution . . . cannot be directly tested experimentally. Yet, because of observed data . . . it has become virtually the lynchpin of modern biology. *(Form C: Item 3)*
Tentative NOS	Compared to philosophy and religion . . . science demands definitive . . . right and wrong answers. (Form C: Item 1)	Everything in science is subject to change with new evidence and interpretation of that evidence. We are never 100% sure about anything because . . . negative evidence will call a theory or law into question, and possibly cause a modification. (Form B: Item 1)
Difference and relationship between theories and laws	A scientific law is somewhat set in stone, proven to be true . . .A scientific theory is apt to change and be proven false at any time. (Form C: Item 5)	A scientific law describes quantitative relationships between phenomena such as universal attraction between objects. Scientific theories are made of concepts that are in accordance with common observation or go

		beyond and propose new explanatory models for the world. (Form C: Item 5)
Scientific theories Nature of	A theory is an untested idea, or an idea that is undergoing additional tests, Generally it hasn't been proved to the satisfaction of the scientific community. (Form C: Item 4)	In the vocabulary of a scientist the word theory is used differently than in the general population. It does not mean someone's idea that can't be proven. It is a concept that has considerable evidence behind it and has endured the attempts to disprove it. (Form B: Item 3)
Functions of	We learn scientific theories just so that scientists don't start all over from the beginning . . . they just can add to the old ideas. (Form C: Item 4)	Theories set a framework of general explanation upon which specific hypotheses are developed. Theories . . . also advance the pool of knowledge by stimulating hypotheses and research. (Form C: Item 4)
Logic of testing	Many theories can't be completely tested, e.g., the theory of evolution can't be tested unless you create your own world and then live for millions of years. (Form C: Item 5)	Most theories have things we cannot observe. So, we deduce consequences from them that could be tested. This indirect evidence allows us to see if the theory is valid. (Interview follow-up on Form C: Item 5)
Creative and imaginative NOS	A scientist only uses imagination in collecting data. . . . But there is no creativity after data collection because the scientist has to be objective. (Form B: Item 5)	Logic plays a large role in the scientific process, but imagination and creativity are essential for the formulation of novel ideas . . . to explain why the results were observed. (Form C: Item 10)
Inference and theoretical entities	There is . . . scientific certainty [about the concept of species]. While in the early days it was probably a matter of trial-and-error . . . nowadays genetic testing makes it possible to define a species precisely. (Form C: Item 7)	Species is . . . a human creation. It is a convenient framework for categorizing things. . . . It is a good system but I think the more they learn the more they realize that . . . we cannot draw the line between species or subspecies. (Interview follow-up on Form C: Item 7)
Theory-laden NOS	[Scientists reach different conclusions] because the scientists were not around when the dinosaurs became extinct, so no one witnessed what happened. . . . I think the only way to give a satisfactory answer to the extinction of the dinosaurs is to go back in time to witness what happened. (Form C: Item 8)	Both conclusions are possible because there may be different interpretations of the same data. Different scientists may come up with different explanations based on their own education and background or what they feel are inconsistencies in others ideas. (Form C: Item 8)
Social and cultural embeddedness of science	Science is about the facts and could not be influenced by cultures and society. Atoms are atoms here in the U.S. and are still atoms in Russia. (Form C: Item 9) Well, the society can sometimes not fund some scientific research. So, in that sense it influences science. But scientific knowledge is universal and does not change from one place to another. (Interview follow-up on Form C: Item 9)	Of course culture influence the ideas in science. It was more than a 100 years after Copernicus that his ideas were considered because religious beliefs of the church sort of favored the geocentric model. (Form C: Item 9) All factors in society and the culture influence the acceptance of scientific ideas. . . . Like the theory of evolution was not accepted in France and totally endorsed in Germany for basically national, social, and also cultural elements. (Form C: Item 9)

APPENDIX G: CULTURAL CONGRUENCE IN INSTRUCTION CATEGORIES (by Johnnie McKinley)

In this chapter, we will examine how the PTP educators implemented the following strategies:

Category: Meaningful, Complex Instruction

Strategies: Teachers …

- Use constructivist approaches with student knowledge as the basis for inquiring, representing ideas, developing meaning, elaborating, organizing, and interacting with content.
- Teach a continuum of basic to higher-order literacy skills, knowledge, and ways of thinking to help students derive and convey meaning from text and speech, solve problems, achieve goals, develop individual knowledge and potential, and participate in society.
- Develop metacognitive skills that help children learn how to learn.
- Provide large amounts of time reading a great variety of texts.
- Engage in collaborative team teaching.
- Engage all students using meaningful, relevant, and challenging curriculum, content, and instructional activities.
- Teach concepts and skills using integrated, holistic, interdisciplinary lessons.
- Engage students in real-life, project-based contextual and vocational activities.
- Teach skills within the context of meaningful applications.

Category: Scaffolding Instruction to Home Culture and Language

Strategies: Teachers …

- Teach to historical, cultural, social, ethnic, and linguistic differences.
- Provide scaffolding to match or link curriculum, materials, lesson content and format, and instructional methods to students' home culture, interests, experiences, and prior learning.
- Scaffold and engage students' learning using visual images and familiar vocabulary to connect prior knowledge and new learning.
- Provide core instruction in Standard English.

- Teach academic content in preschool.

Category: Responding to Student Traits and Needs

Strategies: Teachers …

- Demonstrate knowledge of content.
- Understand and use speech and expressions familiar to students.
- Select and use a variety of instructional methods and interactive strategies.
- Vary strategies to meet students' motivational preferences.
- Match instructional strategies to student traits, abilities, and learning style preferences.
- Promote student use of multiple intelligences to gain, use, and respond to knowledge.
- Provide materials and learning centers for varied styles and modalities.
- Allow students to express visual, tactile, emotional, and auditory preferences.
- Incorporate student preferences for verbal expressiveness.
- Incorporate student preferences for active kinesthetic participation.
- Limit lectures to 5–10 minutes and augment them with visuals and examples.

Category: Culturally Relevant Curriculum Materials

Strategies: Teachers …

- Select and use culturally relevant curriculum materials from all cultural groups.
- Select and use culturally relevant visual representations of all cultural groups.
- Select and use culturally relevant books, pictures, and bulletin board items.
- Recognize culturally relevant events.
- Use manipulatives, models, artifacts, and concrete representations of concepts.
- Use primary (original) source materials.

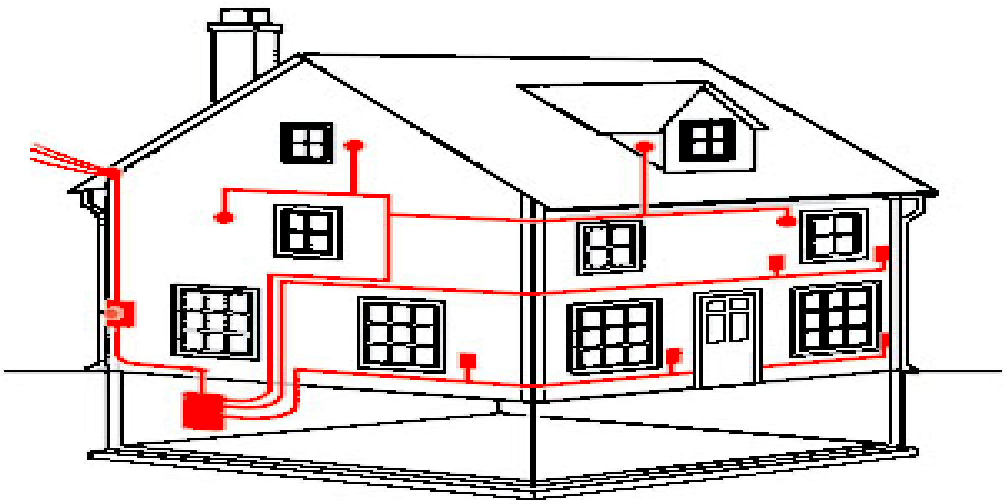
APPENDIX H: LIST OF POSSIBLE WORDS FOR ELLS' INSTRUCTION

List of possible words for ELLs' Instruction

Term/statement	Transliteration (Female Way of Speech)
Thank you	shokran lekey
Come here	teaaleeh ela hoona
Here we go	tefedhalee
Good morning	Sebah elkheyr
You welcome	ahlan wa sehlan
Good work	Aamel jeyid
Job well done (excellent)	momtazeh
How are you today?	Keyfa halokee alyewom?
Why were you absent	limatha kontee ghaeibeh?
Are you ok?	Hel antee bikheyer?
Please	min fedlikee
Please sit down	ejlisee min fedlikee
Please be quiet	oskotee min fedlikee
Sit down on the chair	ejlisee ala elkorsey
How can I help you?	Keyfa momkin asaadekee?
Do you need a dictionary?	Hel toreed kamoos?
Do you have a pen/pencil?	Hel meakee kelem?
Do you have a paper?	Hel meakee wereka?
Do you have a book?	Hel meakee kitab?

APPENDIX I: READING STRATEGY (RELATING TEXT AND VISUALS)

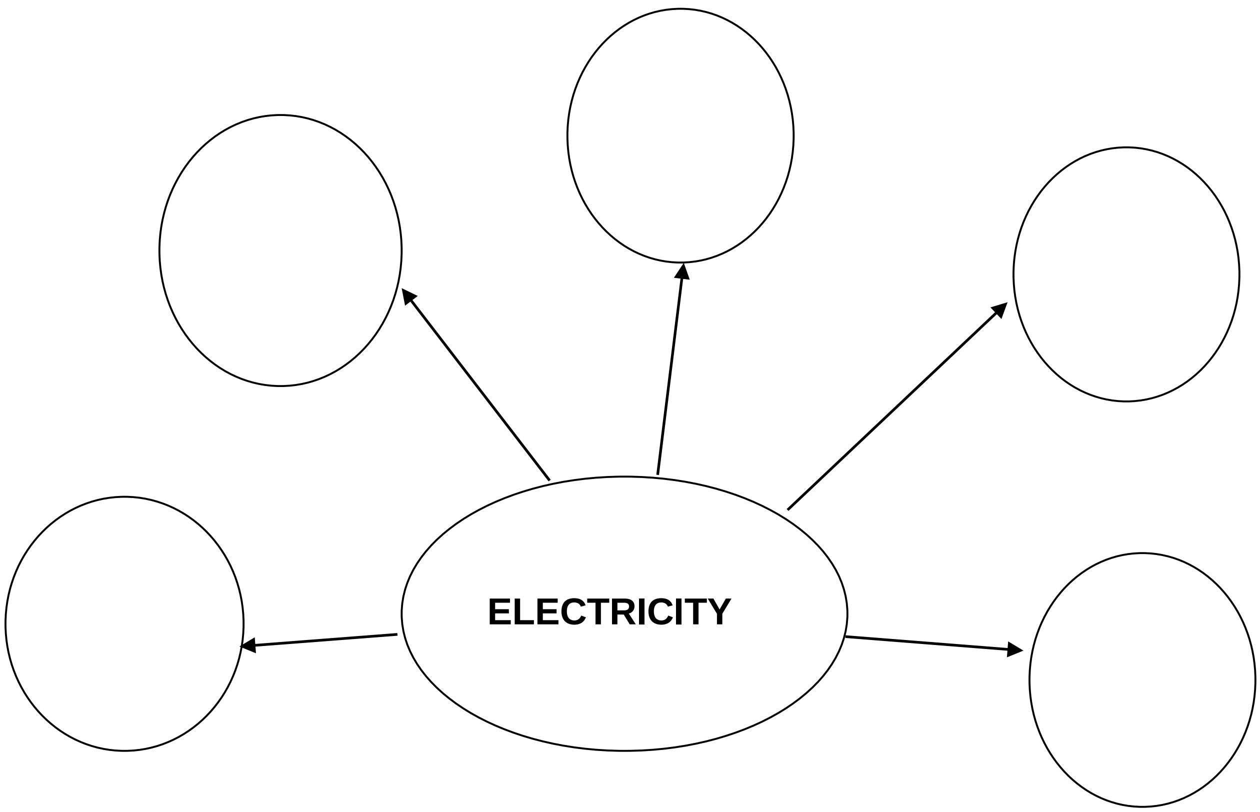
Use the table below and list three things about circuits as you study the complete house circuit diagram below.



What Can Be Seen in the Circuit Diagram?
Wire bringing current from outside. a.______________________________ ______________________________ b.______________________________ ______________________________ c.______________________________ ______________________________

APPENDIX J: SEMANTIC WEB ABOUT ELECTRICITY

Working in pairs, write or draw all words, phrases or concepts related to electricity below.



APPENDIX K: JEOPARDY BUZZER ACTIVITY

Name: ______________________________

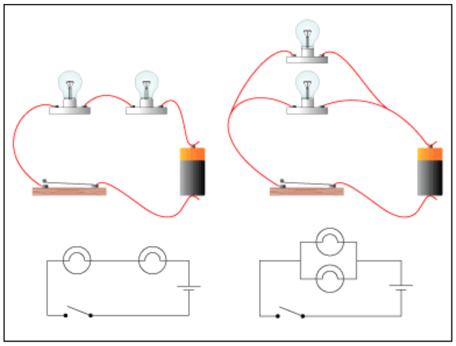
Jeopardy Buzzer Project

Objective: Groups will design and construct a working buzzer system that will be used during future review games

Materials: Each group will receive the same materials (battery, wiring, button, buzzer, box)

Requirements:

- Each group must use the required materials to create a working buzzer
- Group members must sketch out the electrical wiring diagram in their notebooks (example shown below)



- Group members must answer the post activity questions in their notebooks

Post Lab Questions:

1. What safety precautions should be used when building electrical circuits?
2. Was your design a series or parallel circuit? What are the benefits of series circuits and the benefits of parallel circuits?
3. What would be needed in order to add a light bulb that lights up when the button is pressed? Explain how you could do this.

Grading:

- Working buzzer system

- 15 points
- Correct electrical circuit diagram with path of current, voltage, and parts labeled
    - 10 points
- Post activity questions answered in lab notebook
    - 10 points
- Design of buzzer shows effort and creativity
    - 10 points

APPENDIX L: PRE AND POST GRADE AND STUDENT SURVEY T-TESTS

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	pregrade	69.8333	24	18.70519	3.81818
	postgrade	87.7917	24	8.51076	1.73725
Pair 2	PreLearning	2.7569	24	.62935	.12847
	PostLearning	3.1250	24	.58204	.11881
Pair 3	PreSelfConcept	2.7321	24	.56567	.11547
	PostSelfConcept	3.0536	24	.50694	.10348
Pair 4	PreActivities	3.2969	24	.53899	.11002
	PostActivities	3.4531	24	.47321	.09659
Pair 5	PreScienceOut	2.7292	24	.48358	.09871
	PostScienceOut	2.9097	24	.61381	.12529
Pair 6	PreFuture	2.4750	24	.72186	.14735
	PostFuture	2.6583	24	.83714	.17088
Pair 7	PreImportance	2.9250	24	.60953	.12442
	PostImportance	3.2500	24	.47273	.09650

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	pregrade & postgrade	24	.743	.000
Pair 2	PreLearning & PostLearning	24	.673	.000
Pair 3	PreSelfConcept & PostSelfConcept	24	.550	.005
Pair 4	PreActivities & PostActivities	24	.475	.019
Pair 5	PreScienceOut & PostScienceOut	24	.671	.000
Pair 6	PreFuture & PostFuture	24	.617	.001
Pair 7	PreImportance & PostImportance	24	.545	.006

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	pregrade - postgrade	-17.95833	13.63014	2.78224	-23.71384	-12.20283	-6.455	23	.000
Pair 2	PreLearning - PostLearning	-.36806	.49142	.10031	-.57556	-.16055	-3.669	23	.001
Pair 3	PreSelfConcept - PostSelfConcept	-.32143	.51119	.10435	-.53728	-.10557	-3.080	23	.005
Pair 4	PreActivities - PostActivities	-.15625	.52161	.10647	-.37651	.06401	-1.468	23	.156
Pair 5	PreScienceOut - PostScienceOut	-.18056	.46082	.09407	-.37514	.01403	-1.919	23	.067
Pair 6	PreFuture - PostFuture	-.18333	.69010	.14087	-.47474	.10807	-1.301	23	.206
Pair 7	PreImportance - PostImportance	-.32500	.53018	.10822	-.54887	-.10113	-3.003	23	.006

APPENDIX M: PRE AND POST T-TESTS FOR CONSTRUCTS OF INSTRUCTIONAL PRACTICES

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	PreSU	3.6500	10	.66875	.21148
	PostSU	4.6750	10	.62417	.19738
Pair 2	PreSI	1.7333	10	1.01592	.32126
	PostSI	4.3667	10	.93558	.29586
Pair 3	PreSD	3.4500	10	.79757	.25221
	PostSD	4.7500	10	.35355	.11180
Pair 4	PreTKSC	4.1000	10	.65828	.20817
	PostTKSC	4.9500	10	.15811	.05000
Pair 5	PreDCEM	1.0000	10	.00000	.00000
	PostDCEM	2.6500	10	1.47290	.46577
Pair 6	PreSHL	1.4500	10	.15811	.05000
	PostSHL	3.1500	10	.81820	.25874
Pair 7	PreSA	3.2667	10	1.06342	.33628
	PostSA	4.7667	10	.16102	.05092
Pair 8	PreLSEM	4.0000	10	.31427	.09938
	PostLSEM	4.3333	10	.27217	.08607

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	PreSU & PostSU	10	.096	.791
Pair 2	PreSI & PostSI	10	-.068	.853
Pair 3	PreSD & PostSD	10	.345	.329
Pair 4	PreTKSC & PostTKSC	10	.053	.884
Pair 5	PreDCEM & PostDCEM	10	.	.
Pair 6	PreSHL & PostSHL	10	.923	.000
Pair 7	PreSA & PostSA	10	.548	.101
Pair 8	PreLSEM & PostLSEM	10	-.433	.211

Paired Samples T-Tests

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	PreSU - PostSU	-1.02500	.86963	.27500	-1.64709	-.40291	-3.727	9	.005
Pair 2	PreSI - PostSI	-2.63333	1.42682	.45120	-3.65402	-1.61265	-5.836	9	.000
Pair 3	PreSD - PostSD	-1.30000	.75277	.23805	-1.83850	-.76150	-5.461	9	.000
Pair 4	PreTKSC - PostTKSC	-.85000	.66875	.21148	-1.32839	-.37161	-4.019	9	.003
Pair 5	PreDCEM - PostDCEM	-1.65000	1.47290	.46577	-2.70365	-.59635	-3.542	9	.006
Pair 6	PreSHL - PostSHL	-1.70000	.67495	.21344	-2.18283	-1.21717	-7.965	9	.000
Pair 7	PreSA - PostSA	-1.50000	.98445	.31131	-2.20423	-.79577	-4.818	9	.001
Pair 8	PreLSEM - PostLSEM	-.33333	.49690	.15713	-.68880	.02213	-2.121	9	.063

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ABSTRACT

USING THE INSTRUCTIONAL CONGRUENCE MODEL TO CHANGE A SCIENCE TEACHER'S PRACTICES AND ENGLISH LANGUAGE LEARNERS' ATTITUDES AND ACHIEVEMENT IN SCIENCE

by

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May 2015

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Major: Curriculum and Instruction; Science Education

Degree: Doctor of Philosophy

The purpose of the current study was to examine the effects of adapting the instructional congruence model on the English Language Learners' (ELL) attitudes and achievement in science. Changes in teacher's views and practices were documented. The mixed-method approach was adapted. Data sources were the "Attitude Towards Science" survey, VNOS-C questionnaire, Luykx and Lee (2007) observational instrument, Gee (1997) discussion categories, video recordings, and pre- and post-tests. A science teacher and a class of 24 ELL female students in a charter school participated in this research. The results of this study indicated that student achievement increased significantly and students' attitudes improved in all contexts. At the conclusion of the study, all teacher's views on NOS were reported to be informed, teacher's practices were rated higher, and different classroom interactions increased significantly. The instructional congruence model in science education has been successful in reaching different learners, improving students' attitudes and achievement in science and enhancing teacher's views and practices. This model has significant potential for meeting the challenging goals of reformed science education.

AUTOBIOGRAPHICAL STATEMENT

Hania Salame is an educator with over fifteen years of teaching experience. Prior to pursuing her PhD degree in Curriculum and Instruction (Science Education), Hania held two masters degrees: Masters of Science in Biological Sciences and Masters of Art in Teaching. She received her professional teaching certificate seven years ago and is certified to teach Biology and Mathematics. Her career focus has been on the effective teaching of science and mathematics concepts to English language learners from the Middle Eastern origins. Academically, Hania made the dean's list multiple times.

In addition to holding a full time teaching position, Hania is currently the academic coordinator of an online program as well. Hania is the standardized test supervisor, data team leader, and the senior math teacher at Riverside Academy West. She is also the lead teacher in the School Improvement Plan Committee and in the Standardized Test Preparation class. She received Distinguished Teacher's Award multiple times. Additionally, Hania received Teacher Excellence Award for two consecutive school years from Global Educational Excellence