*Science Education International*
*Vol. 16, No. 4, December 2004, pp. 273-292*

*International Council of Associations in Science Education*

# *Implications of Reported Use of Constructivism with Diverse Populations*

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ABSTRACT *This research study was designed to probe for the existence of interactions between students' characteristics and teachers' use of constructivist-influenced instruction in elementary science. The findings of the study show a link between teachers' reported use of constructivist-influenced instruction and students' characteristics. Teachers at schools with high percentages of minority students reported use of constructivist-influenced instructional practices to a greater degree than teachers at schools with lower percentages of minority students. Given these findings, attempts to improve achievement of CLDS in the elementary classroom are unlikely to succeed if not complemented by improvements in other, equally important, educational institutions: families, communities, and the social and economic environment.*

KEY WORDS: *Elementary science, constructivism, culturally and linguistically diverse students, student characteristics*

## Introduction

The proclamation of Project 2061 (Rutherford & Ahlgren, 1990) to produce a scientifically literate society in the United States by the year 2061 is beginning to seem less achievable. As we approach the midpoint of the first decade of the 21 century, we are becoming a more diverse society with increasing numbers of culturally and linguistically diverse students (CLDS). The unique issues associated with ensuing that all students are given access to quality science education are becoming more pronounced. The persistent achievement gap between minority students and their non-minority peers has continued to exist even after a decade of standards-based reforms (Rodriguez, 1997; Seiler, 2001). Efforts to close this persistent achievement gap have traditionally been centered at the school level with the classroom teacher as the focal point.

In as much as the teacher and her students are the main participants in curriculum reform, efforts for a more complete understanding of the complex interactions that take place within the classroom learning community are necessary. Thus, research on instructional practices in the classroom community becomes one of paramount importance. Given the broad range of research that has been conducted on elementary science curriculum since the early 1960's, the question becomes: "Are teachers using research-supported teaching methodologies in classrooms with majority CLDS?"

The purpose of this study was to begin the process of documenting teachers' use of a collection of pedagogical methodologies that have been shown to increase student learning in elementary science classroom. The methodologies are direct sensory experiences, high cognitive involvement, cooperative learning, and higher-level assessments, and can be loosely grouped under the term constructivist-influenced instruction. Constructivist-influenced instruction has its pedagogical foundations in the learning cycle.

One notable outgrowth of the 1960's curriculum project, SCIS, was the learning cycle, which provided a more systematic model for science instruction. The theoretical foundation for the learning cycle was in large part related to the early works of Atkin and Karplus (1962) and Lawson, Abraham, and Renner (1989) (as cited in Tobin, Tippins, & Gallard, 1994). The learning cycle was defined as a method of instruction characterized by the use of an investigation prior to formal introduction of a science concept (Tobin, et al., 1994). The essential structure continues to be: (a) an exploration activity occurs early in the instruction, (b) teacher-led content learning and concept development is emphasized after the exploration, (c) a concluding activity may or may not be followed by assessment, and (d) assessment may be ongoing throughout the cycle (Bybee, et al, 1989). The central tenets of the learning cycle were closely aligned with the theoretical foundations of constructivism.

*Defining Constructivism*

Elementary science education has evolved throughout the twentieth century from a subject focused on nature studies to a series of courses heavy on varied content and process skills. One of the most profound changes during this period was the gradual transformation of the pedagogical and philosophical foundation of elementary science. Several historical, political, and intellectual events marked the shift in elementary science education from textbook-driven and teacher-centered to student-centered, active, constructivist-based instruction.

Constructivism had its foundation in the works of 17$^{th}$ century philosopher Gambattista Vico, Russian psychologist Lev Vygotsky, and the seminal works of Jean Piaget. Over the past 50 years, numerous educational philosophers, researchers, and science educators have written works that have guided the development of constructivism as a viable theory on which to base student learning.

*Types of Constructivism*

Research reveals that there are different versions of constructivism originating from divergent philosophical perspectives. The radical constructivist perspective discounts the possibility that knowledge can be transferred from knower to student and places the student in the position of defining his own reality (Bettencourt, 1993). According to von Glasersfeld (1993) radical constructivism takes into account the role of social interaction in the construction of knowledge, but it is primarily concerned with the interpersonal construction that was occurring. Social constructivism, an outgrowth of radical constructivism and cognitive science, places equal emphasis on the external processes in the environment and those processes internal to the learner that support construction of knowledge.

The area of social constructivism most concerned with the impact of social and cultural factors on students' conceptions was contextual social constructivism (CSC). Lapadt (2000) defined contextual social constructivism as a belief that validates the diverse cultural and experiential histories both students and teachers bring to the classroom. In the science classroom, teachers present the relevant cultural tools of science and through dialogue and physical experiences, the students construct understandings. According to Driver et al. (1994), the teacher provides the tools of science and acts as a guide, while supporting students as they build understandings through interactive discourse.

Research studies by Lapadt (2000) and Driver et al. (1994) supported the perspective that science learning was a process of enculturation. In a case study of two middle school students, Lapadt (2000) researched the central role of discourse in representing, negotiating, and constructing scientific understanding. The study concluded that students' construction of understanding depended on their prior conceptions and inclinations, as well as the teacher's scaffolding of discourse and interaction with science materials (Lapadt, 2000). The notion that experiences with tools and physical events (Lapadt, 2000; Driver et al., 1994) in concert with discourse influence development of cognitive products had roots in Russian psychology. An outgrowth of the Russian psychology school was activity theory, the concept that learning was a direct result of human actions.

### *Cultural-Historical Activity Theory*

Cultural-historical activity theory (CHAT) developed based on the works of German philosophers Kant, Hegel, Marx, and Engels (Engeström, 1999). The works of these philosophers were interpreted by the noted Russian psychologist Vygotsky and his students, Leont'ev and Luria, and formed the foundation for cultural-historical psychology, which later evolved into CHAT. This philosophical framework was used to analyze human practices as a developmental process. CHAT, or activity theory as it is referred to in the literature, posits that conscious learning emanates from performance (Engeström, 1999; Jonassen & Rohrer-Murphy, 1999; Vygotsky, 1978). According to Jonassen and Rohrer-Murphy (1999), activity cannot be understood or analyzed apart from the context of historical and cultural environment in which it occurs. Thus, elementary science teaching or learning cannot be studied without accounting for the socio-cultural inputs of the student, the teacher, and the external activity systems. The use of activity theory offered science educators new tools for analysis of the complex interactions that occur in the science classroom.

### *The Constructivist Science Classroom*

In explaining how students learned, constructivists contended that all knowledge was constructed based on past experiences and the interactions of the learner with the social environment (Airasian & Walsh, 1997; Henriques, 1997; Noddings, 1992; Simon, 1995). The interactions of teacher and students–albeit complex–can be analyzed and interpreted using CHAT. The science classroom can be designated as an activity system.

An activity system is composed of activities (teaching and learning). The subject refers to the individual or group of actors engaged in an activity and whose point of view is taken in the analysis of the activity. The object refers to physical or mental products within the system. Instruments/tools can be mental or material and are used in the change process to help achieve the proposed outcomes of the activity (Jonassen & Rohrer, 1999; Engeström, 1994). The environment in which the activity system exists impacts the subject(s), object(s), and tool(s).

The environment is shaped by existing structures that shape outcomes. Interacting with the subject(s), object(s), and tool(s) are rules, community, and division of labor (see Figure 1). Rules are mechanisms that regulate actions and interactions within the activity system. The community is comprised of one or more people who share the objective with the subject(s). School administrators, other teachers, school board members, and parents are community members sharing the similar objective of desiring effective teaching and learning. The division of labor factors in how tasks are divided horizontally between community members, as well as any vertical division of power and status (Kaptelinin, 1996). Due to its complexity, activity systems are viewed as multi-layered.

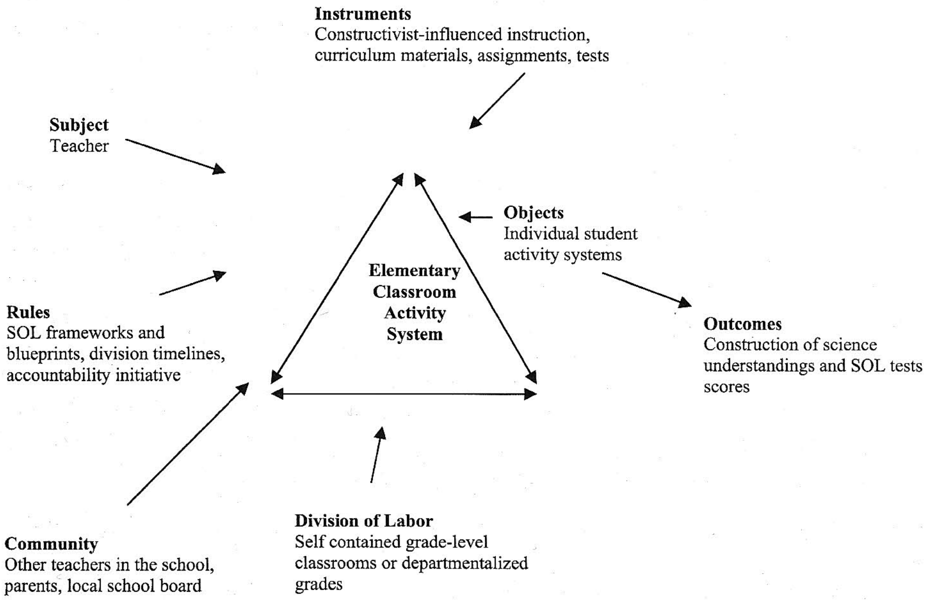


*Figure 1: The elementary classroom depicted as an activity system.*

A school is a multi-layered network of interconnecting activity systems that are continuously evolving based on cyclical time structures. This description fits the elementary science classroom. The teacher and students are subjects engaged in activities that interact with each other. The teacher performs her duties in an environment sustained by explicit and tacit rules. The expectations of the administration, the community, and relevant professional organizations act as motivators in the completion of those activities. The students, on the other hand, perform activities in the classroom, some of which lead to the construction of science understandings. Construction of science understandings is then the outcome of both the teacher's actions and the students' actions. The teacher's activity system can be labeled the superstructure within which are the multiple subsystems made up of the students.

*Role of the Constructivist Teacher*

A meta-analysis of pre-1980 studies on the impact of teaching strategies on student achievement showed that teachers have significant impact in situations where students have had an awareness of instructional objectives, received feedback, interacted with instructional materials, and engaged in varied activities (Wise & Okey, 1983). More recently, Brooks and Brooks (1999), Confrey (1990), Driver, et al. (1994), and Saunders (1992) held that the teacher plays a significant role in providing the environment for students to construct scientific understandings. The teacher provides students with her constructions of scientific knowledge and also establishes the rules of the scientific culture in the classroom. Since each student can not rediscover every scientific theory, the teacher has the responsibility of introducing the ideas and practices of the scientific community to her students (Driver et al., 1994). According to Driver et al. (1994), the teacher initiates students into scientific ways of knowing. In addition to setting up the parameters of the scientific culture, the teacher then has to devise instructional strategies to make established scientific ideas and practices meaningful to students on an individual level.

*Constructivist-Influenced Instruction*

Since constructivism was a philosophical perspective, it did not advocate any specific instructional or pedagogical approach. Researchers influenced by constructivism have established, through their research findings, theoretical understandings of how children develop understandings and how teachers can in turn assist them. Adherents to the theory of social constructivism point to specific instructional strategies instrumental in the constructive process. For the purpose of this study, these instructional strategies were grouped under the term Constructivist-Influenced Instruction ($CI^2$). These instructional strategies have the following components; 1) direct sensory experiences, 2) high cognitive involvement, 3) cooperative learning groups, and 4) higher level assessments.

The developers of the National Science Education Standards (NSES) define inquiry as actions that engage students in describing objects and events, questioning, constructing explanations, and testing and communicating those ideas with others (National Research Council, 1996). In an inquiry-based science classroom, science content and even science concepts are discovered by the students through interaction with materials and each other. These experiences engage students in activities that have the potential to promote understanding. Students are also placed in situations which result in disequilibrium (Saunders, 1992), thus forcing them to resolve the conflict either through assimilation or accommodation of the new information. This experience is similar to what CHAT theorists refer to as internalizations and externalizations in an expansive cycle. Direct sensory experiences also necessitate active cognitive engagement, which is also known as high cognitive involvement.

Instructional practices that promote high cognitive involvement are thinking out loud, developing alternative explanations, interpreting data, developing alternative hypotheses, designing experiments to test alternative hypotheses, and selecting plausible hypotheses from various competing explanations (Confrey, 1990; Saunders, 1992). As students participate in these instructional strategies, they also begin to develop functional scientific literacy. In addition to increasing their proficiency with scientific information, students also improve their facility with scientific discourse. High cognitive involvement occurs best in socially active environments.

To facilitate the development of cognitive involvement and discourse, students need to be placed in appropriate social settings. Interactions in cooperative settings produce cognitive as well as social complexity that creates more intellectual activity, which in turn increase learning (Joyce & Weil, 1996). Research by Qin, Johnson, and Johnson (as cited in Joyce & Weil, 1996) supported the notion that cooperative groups improve learning through problem-solving.

Assessments should mirror the content in that they operationally define what teachers teach and what students are expected to learn. In $CI^2$, since teachers place great value on scientific reasoning, understanding, and well-structured knowledge, assessments should reflect those values. Saunders (1992) maintain that the use of higher-level cognitive assessments encourage students to be more actively involved in meaningful learning. Taken together these instructional strategies parallel the theoretical tenets of social contextual constructivism and the learning cycle. Research related to this group of instructional strategies should mirror their complex mature.

### *Science Education Research Direction*

Given the complex nature of school communities, any research related to teachers' instructional practices will in and of itself have a certain level of complexity. Shymansky and Kyle (1992) synthesized critical issues in science curriculum reform and presented researchers with the challenge of looking at science education research from a more holistic perspective. In attempting to formulate research questions related to educating students in the atmosphere of high stakes accountability, researchers were urged by Shymansky and Kyle (1992) to look at all the factors at play in the complex, often contradictory atmosphere of the classroom. Those factors included students' and the school's cultures, the teachers' backgrounds and beliefs, and their interactions with the mental and physical tools, rules, and the power relationships within the school and external activity systems. The research base about teachers' use of constructivist-influenced instruction and how that use interacts with students' characteristics needs to be established. Since these factors cannot be studied in isolation, a theoretical framework was needed to serve as a unifier. Attention had to be given to all the factors and their interactions within the context of the elementary science classroom (Anderson & Helms, 2001). The Cultural-Historical Activity Theory (CHAT) can serve as that unifier. CHAT can be employed to study the complex interactions that occur in the science classroom between student characteristics and teacher practice.

## Purpose of the Study

This research study was designed to assess the existence of interactions between students' characteristics and teachers' use of constructivist-influenced instruction in elementary science. The following questions were developed for the study:

1. Do teachers use less constructivist-influenced instruction in schools with:

a. more minority students;
b. more lower income students?

These research questions were formulated to illustrate the interrelationships among the diverse components at work in the elementary classroom. The study attempted to show the presence of relationships between the characteristics of diverse students and how these in turn influence teachers' use of constructivist-influenced instruction.

*Methodology*

A major metropolitan area in central Virginia was selected according to their population of minority students and the number of students on free and reduced-price lunches. Data from the 2001 Free and Reduced-Price Lunch Program Eligibility Report (VDOE, 2001a) and the 2000-2001 Fall Membership Report (VDOE, 2001b) schools were used to select the sample. Purposive sampling was used to select schools with the following characteristics: (1) a high percentage of free and reduced-price lunch students, and a high percentage of minority students; (2) a high percentage of free and reduced- price lunch students, and a low percentage of minority students; (3) a low percentage of free and reduced-price lunch students, and a high percentage of minority students; and (4) a low percentage of free and reduced-price lunch students, and a low percentage of minority students.

Based on the established criteria, a total of eight schools were selected, with two in each category. Teachers from these schools were surveyed. Based on numbers compiled from localities in the sampling area, an average of twenty-five teachers fitting these criteria was on staff at each school.

*Procedure*

A two-part survey was constructed based on the research questions. The Teacher Demographic Form (see Appendix A) was constructed to collect information about teachers' experience, employment stability, and their exposure to constructivist-influenced instruction. A survey entitled Constructivist Influenced Instruction Science Teacher Survey ($CI^2STS$) (see Appendix B), based on Greer's (1997) Constructivist Teaching Instrument, was used to assess teachers' use of constructivist-influenced instruction.

These sets of data were analyzed using several statistical methods. The following descriptive statistics were used to organize the results from the three questionnaires: frequency of responses, range, percent, mean, median, and mode. Analysis of variance was used to provide a statistical basis for answering the research questions.

## Results

*Instrument Reliability*

The internal consistency of the primary instrument used in the study, the Constructivist-Influenced Instruction Science Teacher Survey ($CI^2STS$), was estimated by computing the inter-item consistency. The inter-item consistency is used to assess the homogeneity of responses on tests from a single administration (Cohen & Swerdlik, 1998). Test homogeneity is an important aspect of survey research, because it confirms the degree to which the instrument measures a single factor. The factor targeted by the CI$^2$STS was teachers' use of constructivist-influenced instructional strategies in the elementary classroom. A Cronbach's Alpha of the CI$^2$STS was computed across the 16 test items for 137 teacher responses. The alpha coefficient for the instrument was .89.

*Teacher Demographic Survey*

Participants were solicited at staff meetings or the surveys were distributed to individual teachers, and a total of 157 teachers responded. The overall response rate was 68%, with individual school rates ranging from 26% to 100%. A total of 144 teachers answered the question about exposure to professional development experiences related to constructivist-instructional practices. Teachers reporting exposure to constructivist-based professional development experiences (*Mean* = 3.4) had higher constructivist-influenced instruction scores on CI$^2$STS than those who reported no experiences (*Mean* = 3.3) ($F\ (1, 134) = 3.9$, $p = .05$).

Teachers in District A reported higher numbers of professional development experiences (69%) than teachers in District B (42%). An independent samples t-test was done comparing professional development exposure of teachers in the two districts. The results indicated a significant difference in the mean number of years of professional development between the two districts ($t\ (145) = 3.42$, $p < .001$).

In rating their knowledge of constructivism, 78% of all the teachers reported their knowledge as good or higher. When asked if they considered themselves constructivist teachers, 85% answered affirmatively (see Table 1).

Table 1
Teachers' Exposure to Professional Development and Teacher Self-Ratings

| School (*n*) | Professional Development Exposure % | | Self-Rating of Constructivist Knowledge % | | | | Constructivist Teacher Rating % | |
|---|---|---|---|---|---|---|---|---|
| | Yes | No | 1 | 2 | 3 | 4[a] | Yes | No |
| High Income/Medium Minority | | | | | | | | |
| AI (12) | 75 | 25 | 8 | 67 | 17 | 8 | 100 | 0 |
| AII (26) | 75 | 25 | 19 | 38 | 38 | 5 | 88 | 12 |
| High Income/Low Minority | | | | | | | | |
| BI (10) | 10 | 0 | 40 | 20 | 40 | 0 | 60 | 40 |
| BII (17) | 53 | 47 | 18 | 35 | 35 | 12 | 82 | 18 |
| Middle Income/Low Minority | | | | | | | | |
| BIII (33) | 39 | 61 | 30 | 45 | 21 | 4 | 82 | 18 |
| BIV (16) | 60 | 40 | 19 | 62 | 19 | 0 | 81 | 19 |
| Low Income/High Minority | | | | | | | | |
| AIII (14) | 57 | 43 | 14 | 71 | 0 | 2 | 86 | 14 |
| AIV (26) | 69 | 31 | 23 | 38 | 31 | 8 | 92 | 8 |

[a]Self-Rating of Constructivist Knowledge Scale 1- poor; 2- good; 3- very good; and 4-excellent.

Teachers identifying themselves as constructivist (*Mean* = 3.4) scored statistically significantly higher on the CI²STS than teachers who did not identify themselves as constructivist (*Mean* = 3.2), ($F$ (3, 129) = 4.4, $p$ =. 038). Teachers in District A had significantly higher constructivist self-ratings than teachers in District B ($t$ (143) = 2.03, $p < .05$).

*Constructivism Influenced Instruction Science Teacher Survey.*

A total of 157 teachers returned surveys. A decision was made to eliminate cases missing more than two items on Part 3 of the CI²STS. Twenty cases were deleted from further analysis of the CI²STS, for a total of 137. Item means were inserted for cases having 14 or more completed items. The data were analyzed using analysis of variance. The factors were racial groups, income groups, and accreditation status.

*Question 1A:* Do teachers use less constructivist-influenced instruction in schools with more minority students?

Analysis of the mean scores across the eight schools on the CI²STS determined that the range of differences between the mean scores was relatively small (see Table 2). Since all of the schools' mean scores were greater than 3 on a scale of 1-4, most teachers were reporting high use of Constructivist-Influenced Instruction. Additional analysis showed three schools in particular had the highest CI²STS mean scores. Those schools, AI, AII, and AIII, had minority populations of 33.4% or greater. This clustering of middle to high minority population schools resulted in greater variation between groups than there was within the two racial categories. The mean square between groups (minority, non-minority) was 2.95 compared to a mean square within groups of .137. This resulted in a large $F$ statistic (13) and significance.

Table 2.
Analysis of Variance for Research Questions

| Source | *Sum of Squares* | *df* | *Mean Squares* | *F* |
|---|---|---|---|---|
| Racial Group | | | | |
| Low/Medium/High | 2.951 | 1 | 2.95 | 21.53*** |
| Within Groups | 18.501 | 135 | .137 | |
| Total | 21.452 | 136 | | |
| Income Group | | | | |
| Low/Middle/ High | 2.85 | 2 | 1.42 | 10.23*** |
| Within Groups | 18.60 | 134 | .14 | |
| Total | 21.45 | 136 | | |
| Accreditation | | | | |
| Between Groups | 2.306 | 2 | 1.15 | 8.07*** |
| Within Groups | 19.146 | 134 | .14 | |
| Total | 21.452 | 136 | | |

***$p < .001$

Teachers at schools with the highest numbers of minority students reported using significantly more constructivist-influenced instruction (*Mean* = 3.7), $F$ (1,136)= 13, $p < .001$) than teachers at schools with medium numbers of minority students (*Mean* = 3.4) and low numbers of minority students (*Mean* = 3.2). A Tukey

Post Hoc Test indicated the significant difference was between high minority schools (*Mean* = 3.7) and low minority schools (*Mean* = 3.2).

*Question 1B:* Do teachers use less constructivist-influenced instruction in schools with lower income students?

The factor student family income level was determined using the percentage of students on free and reduced-price lunch (FRPL) in the school's population. The schools were grouped into three income categories: (1) low FRPL, 0% to 33.3%; middle FRPL, 33.4% to 66.6%; and high FRPL, 66.7% to 100%. Low FRPL schools were in effect high-income schools and high FRPL schools were low-income.

The mean reported use of constructivist-influenced instruction between the three income groups was statistically significant. Teachers at schools with lower income students (*Mean* = 3.5) reported using significantly more constructivist-influenced instructional strategies $F$ (2, 134) =10, $p$< .001) than teachers at schools with middle income students (*Mean* = 3.2) and high income students (*Mean* = 3.4). A Tukey Post Hoc Test was done to determine which groups had significant differences. A significant difference was indicated between low-income groups and middle-income groups and between high and middle-income groups. When schools within districts were compared, income of students did not have a statistically significant impact on teacher score (District A *Mean* =1.8, $F$ (1,60) =1.2, $p$< .283) (District B *Mean* = 1.6, $F$ (1, 73) = .09, $p$< .783) on the Constructivist-Influenced Instruction Science Teacher Survey ($CI^2STS$).

Since it was not possible to have a completely balanced (Income X Race) design, it was useful to make a direct comparison between the eight schools. The results of an ANOVA across the eight schools indicated that $CI^2STS$ mean scores were significantly different ($F$ (7, 129) = 4.7, $p$< .001). When a multiple comparison of mean scores was conducted the following differences were apparent:

1. BIII, Middle Income/Low Minority (*Mean* = 3.1) and AIV, Low Income/High Minority (*Mean* = 3.7).
2. BIV, Middle income/Low Minority (*Mean* = 3.3) and AIV, Low income/High Minority (*Mean* = 3.7).

Teachers at the two middle income/low minority schools had lower **Constructivist-Influenced Instruction Science Teacher Survey** mean scores than those teachers at AIV, a low income/high minority school.

Based on the results of the ANOVAs of mean $CI^2STS$ scores (Table 3) compared across racial groups, income groups, schools, and districts, teachers at low income/ high minority schools were reporting significantly higher usage of constructivist-based instructional strategies. The mean differences between schools with middle and low percentages of minority students were the most significant.

**Summary of Findings**

Teachers at schools with high percentages of minority students reported use of constructivist-influenced instructional practices to a greater degree than teachers at schools with lower percentages of minority students. There were also statistically significant differences in teachers' use of $CI^2$ practices based on income levels of the majority of students at schools participating in the study. Post Hoc analysis indi-

Table 3.
Mean CI²STS Scores of Teachers by School Affiliation

| School (*n*) | Mean CI²STS [a] | *SD* | Minimum | Maximum |
|---|---|---|---|---|
| High Income/Medium Minority | | | | |
| AI (9) | 3.47 | 0.03 | 2.56 | 4.00 |
| AII (16) | 3.42 | 0.38 | 2.82 | 4.00 |
| High Income/Low Minority | | | | |
| BI (7) | 3.40 | 0.03 | 3.31 | 3.56 |
| BII (17) | 3.32 | 0.39 | 2.63 | 3.94 |
| Middle Income/Low Minority | | | | |
| BIII (33) | 3.13 | 0.36 | 2.56 | 3.94 |
| BIV (18) | 3.29 | 0.37 | 2.50 | 3.94 |
| Low Income/High Minority | | | | |
| AIII (12) | 3.31 | 0.30 | 3.00 | 3.94 |
| AIV (26) | 3.66 | 0.37 | 2.94 | 4.00 |

*Note.* Mean values represent total teachers' mean score on the CI²STS at each school.
[a]Difference between highest and lowest school mean scores was .53.

cated the significant differences were in specific combinations of income groups. Those combinations were (1) schools with low income and medium income students; and (2) schools with high income/medium income students.

There were no statistically significant differences between schools and districts mean CI²STS scores based on teacher experience and employment stability. Exposure to constructivist-based professional development experiences was a factor affecting use of CI² practices in the classroom.

The data collected regarding teachers' used of Constructivist-Influenced Instruction (CI²) in elementary classrooms indicated that teachers are generally using these instructional practices across all schools surveyed. This result indicated that teachers were embracing science education reform measures advocated by the *National Science Education Standards* (NRC, 1996).

*Limitations*

This research on the broad question of the existence of interactions between students' characteristics and teachers' reported use of constructivist-influenced instructional strategies in an atmosphere of reform was limited by several factors. One factor was that results applied only to the teachers in the eight schools surveyed and did not allow for generalization to other elementary school teachers. Another limitation was that there could have been selection effects caused by the research design. According to Walberg (1974), teachers at schools with high percentages of minority and lower income students tend to be less experienced. Teachers may have different patterns related to use of constructivist-influenced instruction based on their experience and other factors that are outside of the control of the study.

Given that the data was a self-report of constructivist-influenced instructional strategies, there was the possibility that the answers were biased in their favor. Teachers may have reported higher use of constructivist-influenced instructional practices, because they may have perceived those strategies as better than other strategies. Also, this research does not include classroom observations of teachers, thus there was no corroborating data.

**Discussion**

The intent of the study was to probe for the existence of relationships between students' racial group, achievement, family income characteristics, and teachers' reported use of constructivist-influenced instruction. The findings of the study show a link between teachers' reported level of use of constructivist-influenced instruction and students' characteristics. Overall teachers reported high use of $CI^2$.

There are several explanations for the higher reported use of constructivist-influenced instruction among teachers in schools with low income/high minority students. One possible reason may have been their higher exposure to constructivist-based professional development experiences as reported in the Teacher Demographic Information Form. Since the teachers of low income/high minority students had greater exposure to constructivist instructional strategies through their professional development experiences, they may have been practicing more of those strategies in their classrooms. The question that arises is. To what extent were those teachers executing constructivist-influenced instruction strategies in the manner intended by their developers?

There was a significant difference in years of experience across the eight schools. Since teachers at high percentage minority schools tended to have less years of experience, their pre-service education experiences may have included more exposure to constructivist theory and pedagogy. This possible higher exposure to constructivist-based instructional pedagogy may explain their statistically higher reported use of $CI^2$.

Another explanation was that although the teachers in the current study reported high use of constructivist-influenced instruction, they may not have been necessarily using those strategies as intended by developers. Over the past decade, constructivism as an epistemology and framework for student-centered instruction has had wide exposure in educational literature. It is the opinion of this researcher that many teachers have heard the term *constructivism* and have some idea of what it means, but they may not have undergone the transformation necessary to become constructivist teachers. Several of the instructional strategies subsumed under constructivist-influenced instruction, such as cooperative learning, and hands-on learning (direct sensory experiences), have been widely used by classroom teachers (Czerniak & Lumpe, 1996; Sutherland, Wehby, & Gunter, 2000). True constructivist teaching involves more than using a few instructional strategies. It requires of teachers the following: (1) promotion of student autonomy and commitment, (2) development of students' reflective process, and (3) identification and negotiation of tentative solution paths with the students (Confrey, 1990). Although there was no observational evidence collected in this study, teachers may be reporting use of constructivist-influenced instructional strategies while continuing to teach in a traditional manner.

The change processes teachers have to navigate to fully embrace constructivist teaching required major restructuring of their pedagogical understandings. This conceptual change, as defined by Stofflett and Stoddart (1994), is by no means an easy process. Teachers must first come to a point where they think a change is necessary. They must then be exposed to experiences that support the change processes. Then they have to be supported, through reflection and coaching, to fully internalize the change.

Based on the researcher's prior study of three elementary teachers' movement towards constructivist teaching (McDonnough, 1999), it was theorized that because teachers experienced great challenges with transformation from traditional to constructivist teaching, only the most committed were willing to complete the process. The three teachers in the McDonnough study were in the process of completing a master's degree in mathematics education that placed great emphasis on constructivism. Their struggle with the change process was supported through reflection, peer coaching, and input from their graduate instructors. Of note was the degree of implementation of constructivist teaching within the group. The teachers' levels of transformation from traditional to constructivist were related to each individual teacher's characteristics and the characteristics of their students. In cultural-historical activity theory (CHAT) terms, each teacher's historicity and classroom environment, which included the students' historicities, influenced her transformation. Conclusive evidence of use of constructivist-influenced instruction can only be ascertained with further research.

This study also showed relationships between teachers' use of $CI^2$ strategies and students' racial characteristics, family income level, and student achievement. The students receiving the highest level of constructivist-influenced in $CI^2$ were in schools with high percentages of minority, lower income, and lower achieving populations. By all accounts, the achievement levels of students in these schools should be higher since their teachers are reporting high use of instructional strategies that have been shown to increase students' achievement in science and other subject areas (Renner, Marek & Stafford, 1988; Barman, Barman, & Miller, 1996; Rubin & Norman, 1992; Blank, 2000). The evidence that their achievement levels were lower than students in other income groups points to the involvement of additional factors influencing their achievement. These factors are three-fold. One set of factors may involve the influence of family income and social conditions. The other factor may be the incompatibility of constructivist-influenced instructional practices, as practiced by the teachers in the study, with students' historicities. A third factor may be the lack of data on growth in learning over time with teachers who reported high use of constructivism.

According to Rothstein (2000), other factors influencing student achievement include family capital, health conditions, housing conditions, and environmental conditions. Most of these factors are related to family income. Family capital includes parents' income, parent education level, access to resources, and parent-child relationships. In the geographic region from which the sample population in this study was drawn, income categories tended to cluster in racial groups. The urban district (District A) had high populations of lower income minority students and the suburban district (District B) had higher income non-minority students. This population distribution was a result of past social and statutory conditions.

Between 1970 and 1990 concentrations of lower income African Americans increased in inner-city areas (Gramlich, Laren, & Seland, 1992; Kasarda, 1993). The concentration of lower income students into urban school districts resulted in the concentration of the challenges associated with educating culturally and linguistically diverse students. In studies by Duncan and Brooks-Gunn (1997), Mayer (1997), and Blau (1997), strong relationships were identified between income deprivation and educational achievement. Income was shown to explain a larger percentage of the variance in academic achievement than ethnicity. These lower income students also had higher rates of mobility, which had been identified as a contributing factor to low achievement (Skandera & Sousa, 2002). Hallahan (1992) attributed the rise in the numbers of special education students to factors associated with poor prenatal and early childhood health. These urban schools had to grapple with educating populations hampered by multiple economic, social, and health factors that influenced achievement. They also had the added pressures imparted by state-level accountability measures that focused on improving student achievement.

Two of the urban schools in the study (AIII and AIV) were confronted with many of the factors cited as prevalent in schools with large percentages of low-income students. Although their teachers reported the use of instructional strategies associated with increasing student achievement, these schools' students were performing at levels below that of medium and high-income students. The link between student achievement and family income level may be understood if we focused on the resources available to these lower income schools. Schools with large percentages of lower income students tend to spend less money on instruction. Their funding is diluted by higher indirect costs such as ancillary services, security, and maintenance (older building stock). Students enter school less prepared for instruction. Students are also without the cultural capital afforded to higher income students.

Due to the results of this study the use of constructivist-influenced instructional practices in schools with high percentages of low income, lower achieving students warrants further research, using CHAT as a theoretical framework. A possible explanation for these students lower achievement may have been an incompatibility between their historicities and CI$^2$. Since these lower income students are coming to school less prepared for instruction, they may be in need of instruction that accounts for their unique social and cultural histories (Seiler, 2001). Use of instructional methods involving the learning cycle would provide students with methodologies consistent with CI$^2$ in addition to direct instruction. During phase two of the learning cycle, teacher-led content learning promotes concept development. Students would have the opportunity to construct understanding through exploration and discourse, while they were supported in their content acquisition. Designing instruction that allows for students' prior social, cultural, and academic experiences will enhance their overall instructional experiences. Research by Seiler (2001) points to the need for designing learning environments that "create space .... for students' science interests and cultural funds of knowledge" (p. 1001). Seiler suggests that valuing the cultural attributes and students' ways of knowing into the science curriculum could help reverse the disturbing trend of the widening achievement gap and disaffection of CLDS with traditional science instruction.

According to cultural-historical activity theory (CHAT), activity and outcomes of activity cannot be understood apart from the context of the historical and cultural environment in which they occur.

Attempts to improve student academic performance that do not take into consideration the multiple cultural, economic, social and health factors influencing student achievement will be lacking in intellectual honesty and will not succeed. The issue of increasing student academic performance can be approached from two vantages in the context of this study. Teacher educators can focus on improving and refining teachers' pedagogical and content knowledge in an attempt to increase their effectiveness in the classroom. They can also lead the call for paradigm shifts in how we approach the issue of increasing student achievement in general and achievement of CLDS in particular.

**Recommendations**

This research study probed for the existence of relationships between students' characteristics and teachers' reported use of constructivist-influenced instruction. The outcomes of the study drew attention to teachers' reported classroom behaviors, generated questions about the actual occurrence of those reported behaviors and how other factors may influence student achievement.

The research data were collected through a self-report instrument. This data collection method limited the scope of the information. Future research on teachers' use of constructivist-influenced instruction and its relationship to students' characteristics should use data collection strategies more in line with qualitative research methodology. Through extensive open-ended interviews, insight into teachers' espoused and enacted perceptions about constructivism can be gained. Structured classroom observations using an instrument, such as the observer form of the Constructivist Teaching Inventory (Greer, 1997), over the course of a school year can also be conducted in conjunction with teachers' participation in conceptual change-based professional development.

Teachers' content and pedagogical knowledge can be enhanced with professional developmental experiences designed to increase their understanding of the educational and social inputs that are most effective for teaching culturally and linguistically diverse students. Teachers' transformations to constructivist practitioners can be accomplished using sound research-based strategies. One approach is long-term professional development experiences grounded in conceptual change pedagogies. These experiences should be focused on individual schools.

CHAT can be used as a framework to assess teachers' transformation within a school over time. The school can be viewed as the primary activity system. The influence of external activity systems on the school and in turn individual classrooms will also be assessed, because these external activity systems may have a great deal of influence on the classroom. The interaction between teachers' and students' characteristics (race, gender, social class) should also be examined in terms of the power relationships that develop in classrooms and the school. These relationships tend to have a direct impact on the instructional climate.

Other factors should be researched in concert with teacher transformation. The rules, instruments and objects used in elementary science should be reviewed to assess their effectiveness in building the foundation necessary to produce life-long scientific literacy. These rules, instruments and objects would include curriculum and instructional approaches. The organizational structure of instructional and administrative teams within schools should also be reviewed.

The students as objects of instruction also influence teacher actions and the outcomes of effective instruction. Researching the factors that affect students' capacity to benefit from instruction could substantially impact teacher effectiveness. Knowledge about the importance of health, environmental conditions, and families in their impact on student achievement can raise the levels of achievement for all students.

The challenge of researching these various factors and their influence on student achievement may seem too complex to undertake, but lack of a comprehensive approach will doom other attempts to failure. In closing, attempts to improve achievement of CLDS in the elementary classroom is unlikely to succeed if not complemented by improvements in other, equally important educational institutions: families, communities, and the social and economic environment.

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## Appendix A

### Teacher Demographic Information Form

1. How many years have you taught? ___________
2. What grade are you presently teaching? __________
3. Is your class self-contained? yes ____ no ____
4. What grades have you taught in the past three years? __________________
5. How many years have you been at your present school? ________
6. What is your school's location? (check one) urban____ suburban ____ rural ____
7. What is your school's population?
   0-200 ____ 201-500 ____ 501-700 ____ 701+ ____
8. What is the percentage of minority (African-American, Hispanic, Southeast Asian, and Native American) at your school?
   75% -100% ____ 50% - 74% ____ 25% -49% ____ less than 25% ____
9. What grade levels are housed in your school?
   K-2nd ___ K-5th ___ K-6th ___ 4th- 8th ___ other ___
10. Have you had any exposure to constructivist-based pedagogy?
    yes ____ no ____
11. Where did you acquire your exposure? (check all that apply)
    Teacher Preparation Program ____
    Professional Development Program ____
    Personal Research ____
    Other ____
12. How would you rate your knowledge of constructivism?
    excellent ____ very good ____ good ____ poor ____
13. Do you consider yourself a constructivist teacher?
    yes ____ no ____
14. Do you use constructivist-based teaching strategies in your classroom?
    yes ___ no ____
15. If no, do you desire to use constructivist-based teaching strategies in your classroom?
    yes ____ no ____

## Appendix B

### CI² –Constructivist Influenced Instruction Science Teacher Survey

Please use the scale below to respond to the following statements about your classroom. Circle the appropriate letter.

**A= Almost Never** **B= Seldom** **C= Often** **D= Almost Always**

1. In my classroom a variety of activities and resources are used as material for learning.
   1) A B C D
2. Opportunities for both confirming and disconfirming solutions are provided.
   2) A B C D

3. Students are allowed to explore and construct meaning from classroom experiences.
3) A B C D
4. In my classroom students participate in laboratory investigations.
4) A B C D
5. Students are provided with opportunities for high cognitive involvement such as thinking out loud and developing alternative hypotheses.
5) A B C D
6. In my classroom, attempts are made to assess, activate, supply, and/or make use of background knowledge.
6) A B C D
7. Students are questioned to help them think through an issue for themselves.
7) A B C D
8. Activities in my classroom require students to explain and elaborate to other students the results of learning.
8) A B C D
9. Students work in collaborative groups in a variety of contexts.
9) A B C D
10. In my classroom, students learn predominantly through interaction with others and the teacher.
10) A B C D
11. Students interact frequently for the purpose of clarifying and challenging ideas.
11) A B C D
12. Assessments are designed to evaluate students' abilities to apply, analyze, synthesize, or evaluate science concepts.
12) A B C D
13. In my classroom, questions and classroom discussion are predominantly open-ended.
13) A B C D
14. Thematic, discussion-generating questions are used more than literal-level recall and known-answer questions.
14) A B C D
15. Activities are constructed around big ideas. Discrete pieces of information are used to support big ideas.
15) A B C D
16. In my classroom, the major themes are returned to frequently during the lesson.
16) A B C D

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