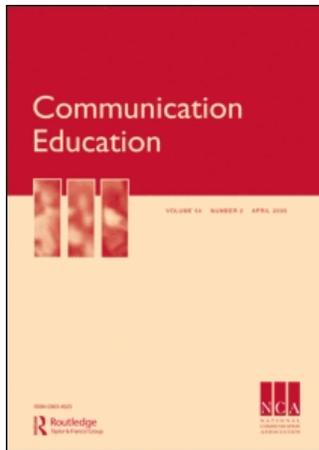


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Instructional Communication Predictors of Ninth-Grade Students' Affective Learning in Math and Science

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The purpose of this study was to examine how students' perceptions of their teachers' instructional communication behaviors were related to their affective learning in math and science. A survey was used to collect perceptions from 497 ninth-grade students. The following conclusions were yielded from the data: (1) students' perceptions of their math and science teachers' use of clarity and content relevance behaviors, rather than their teachers' use of nonverbal immediacy and disconfirmation behaviors, predicted students' desire to pursue additional study in math and science as well as consider careers in the fields of math and science; (2) students did not perceive meaningful differences in their affective learning between math/science and nonmath/science courses; and (3) students perceived minimal differences between their math/science and nonmath/science teachers' use of instructional communication behaviors.

Keywords: Math and Science Education; Teacher Communication Behaviors; Affective Learning; Ninth-Grade Students

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Math and science education in the United States has received increased attention over the past several years. When compared to other industrialized countries, few American students pursue higher education in math and science (Feller, 2006; Stage, 1997). According to a report published by the Business-Higher Education Forum (2005), the United States currently ranks 17th in its production of mathematicians, scientists, and engineers. Of the 868,000 baccalaureate degrees granted worldwide in engineering, a mere 7% were earned in the United States (Business-Higher Education Forum, 2005).

Compounding this apparent lack of interest in pursuing higher education in math and science is the fact that the number of jobs requiring formal math and science education is projected to increase four times faster than the number of qualified candidates (Stage, 1997). At the same time, the number of qualified math and science teachers is projected to decrease (Milanowski, 2003).

Students' interest level in pursuing math and science education in higher education begins to develop as early as the ninth grade (Dedmond, 2005; Hughey & Hughey, 1999; Stodolsky, Salk, & Glaessner, 1991). According to Gibbons, Borders, Wiles, Stephan, and Davis (2006), the ninth grade is an important transition year because students make decisions about high school coursework relevant to college, and choices made during this time period can either enhance or limit college options and career decisions. Jacobs, Finken, Griffin, and Wright (1998) found that students' successes in high school math and science predicted their interest in pursuing math and science as an academic major in college as well as their interest in pursuing careers in the fields of math and science. Additionally, Jacobs et al. (1998) found that students' interests in math predicted their pursuit of careers in math and science.

The purpose of this study is to examine how student perceptions of teacher communication behaviors influence students' affective learning for math and science. Affective learning is concerned with students' attitudes, beliefs, and values that relate to the knowledge and psychomotor skills they have acquired (McCroskey, Richmond, & McCroskey, 2002). Affective learning occurs when students develop an appreciation and value for math and science education. Specifically, this study examines whether (1) teachers' communication behaviors predict ninth-grade students' desire to pursue additional study and careers in math and science; (2) teachers' communication behaviors are related to students' study strategies; (3) there are differences in students' perceptions of their affective learning between the math/science and nonmath/science content areas; and (4) there are differences in students' perceptions of their math/science and nonmath/science teachers' instructional communication behaviors.

Literature Review

Affective Learning Theory

Krathwohl, Bloom, and Masia (1964) defined the affective domain of learning as "the objectives that emphasize a feeling or tone, an emotion or degree of acceptance or rejection" (p. 7). Similar to the other two domains of learning (e.g., cognitive,

psychomotor), the affective domain is conceptualized as a taxonomy including five levels of affective responses: receiving, responding, valuing, organizing, and value complex. Lower levels of affective learning include students being willing to minimally receive and respond to classroom information, whereas higher levels of affective learning include students who have modified and organized their attitudes, beliefs, and values in such a way that they perceive their world differently (Krathwohl et al., 1964).

Three of the many behavioral indicators of higher-order affective learning include students self-regulating their learning (e.g., selecting study strategies that meet their needs), transferring what they learned in the classroom to their lives, and pursuing study outside the formal structure of a course or classroom (Krathwohl et al., 1964). In the context of the current study, affective learning is manifested when ninth-grade students engage in self-directed study strategies (e.g., taking notes, outlining, separating main ideas from details) that have been shown to enhance their learning (Romainville, 1994; Weinstein & Hume, 1998), express an interest in taking additional courses in math and science, and demonstrate a desire to pursue a college degree and career in a math or science-related field.

From a theoretical perspective, it is important to identify how affective learning functions to enhance students' cognitive learning. Cognitive learning focuses on the acquisition of knowledge and the ability to understand and use knowledge (Bloom, 1956). According to Immordino-Yang and Damasio (2007), learning occurs when we "tag emotions" to the information we are acquiring or developing; in the classroom, teachers are typically responsible for helping students with this tagging process. Brain-injured individuals have allowed educators to see the complexities of learning and how learning is a function of a number of affective and cognitive neurological systems working in tandem. Immordino-Yang and Damasio argued, "Knowledge and reasoning divorced from emotions and learning lack meaning and motivation and are of little use in the real world. Simply having the knowledge does not imply that a student will be able to use it advantageously outside of school" (p. 5). Therefore, instruction that emphasizes cognitive learning outcomes without an appropriate emphasis on affective learning may impact both cognitive and affective learning outcomes as well as impact students' study strategies.

Influence of Teacher Communication Behaviors on Affective Learning

To encourage ninth-grade students to pursue additional course work, higher education, and possible careers in math and science, it is important that ninth-graders develop an affinity for the subject matter. This learning goal requires instructors to create a communication-based teaching-learning focus (Hurt, Scott, & McCroskey, 1978; McCroskey, Richmond, & McCroskey, 2005) using a number of instructional communication behaviors that have been shown to impact students' affective learning: nonverbal immediacy, clarity, content relevance, and teacher confirmation (Mottet, Richmond, & McCroskey, 2006). According to Comadena, Hunt, and Simonds (2007), the more these behaviors play a part in an instructor's repertoire, the greater possibility of an "additive effect" on students' affective outcomes.

Nonverbal immediacy. Immediacy refers to the degree of perceived physical or psychological closeness between communicators (Mehrabian, 1969, 1971). Nonverbal behaviors that stimulate perceptions of physical and psychological closeness include vocal variety (e.g., pitch, rate, volume), smiling, eye contact, forward body leans, and open body position. A number of studies have examined the positive relationships between teachers' nonverbal immediacy and students' affective learning (Andersen, 1979; Andersen, Norton, & Nussbaum, 1981; Kelley & Gorham, 1988; McCroskey, Richmond, & Bennett, 2006; Plax, Kearney, McCroskey, & Richmond, 1986).

Nonverbal immediacy behaviors impact students' affective responses (Richmond & McCroskey, 2000). Using Mehrabian and Russell's (1974) emotional response theory, which was further extended by Russell and Barrett (1999), Mottet and Beebe (2002) examined the relationships between teacher nonverbal immediacy behaviors and students' perceptions of their emotional responses and affective learning. Mottet and Beebe found that teacher nonverbal immediacy behaviors positively influenced students' pleasure, arousal, and dominance emotional responses. Of the three emotional responses, pleasure was the primary predictor of students' affective learning (Mottet & Beebe, 2002). These findings support Immordino-Yang and Damasio's (2007) notions that the emotions serve as a "rudder" that ultimately guides the learning process.

Clarity. Chesebro and Wanzer (2006) defined teacher clarity as "a cluster of teacher behaviors that contributes to the fidelity of instructional messages" (p. 95). Teacher clarity behaviors, including verbal fluency behaviors (e.g., eliminating stammering, vocalized pauses, and false starts) and structural clarity behaviors (e.g., using previews/reviews, verbal transitions, and signposts), influence students' affective learning (Avtgis, 2001; Chesebro & McCroskey, 2001; McCroskey, 2003).

There are few explanations in the research literature that clarify the relationships between teacher clarity and students' affective learning. It appears that clarity has its primary impact on students' cognitive learning (Chesebro & Wanzer, 2006). Instructional communication researchers have traditionally argued that affective learning is an antecedent to cognitive learning (Rodriguez, Plax, & Kearney, 1996). Krathwohl et al. (1964), however, have suggested that teachers simultaneously use affective learning objectives to reach cognitive outcomes and cognitive learning objectives to reach affective outcomes. Furthermore, Jacob (1957) argued that affective learning develops when cognitive learning occurs. It could be that cognitive learning (understanding) is an antecedent to affective learning (valuing). A teacher's instructional behaviors, such as clarity, may facilitate comprehension and provide clear purpose, thus helping students to construct knowledge for themselves and value new learning (Cornel, 1999).

Content relevance. According to Keller (1983), content relevance behaviors are those messages that are targeted to students' personal needs and goals. Teachers make course content relevant to students when they explicitly state how the course material relates to students' career goals, link course content to other areas of content, or use

students' experiences to demonstrate or introduce a concept (Frymier & Shulman, 1995). Relevancy also includes highlighting the importance of concepts, providing explicit examples, and developing opportunities for students to use previously learned concepts (Burden, 2000). Content relevance behaviors have been shown to be positively correlated with students' affective learning (Frymier & Houser, 2000).

According to Frymier and Shulman (1995), content relevance behaviors enhance students' affective learning because they motivate students to learn. Frymier and Shulman use Keller's (1983) ARCS (attention, relevance, confidence, and satisfaction) model of motivation to explain the impact of teachers' content relevance behaviors on student learning. Keller's motivation model shares many of the qualities of the affective learning taxonomy, specifically students being willing to receive and attend to information, finding satisfaction in responding to information, and finding value and usefulness in the information they are learning (Krathwohl et al., 1964).

Teacher confirmation. Ellis (2000) defined teacher confirmation as "the process by which teachers communicate to students that they are valuable, significant individuals" (p. 265). Confirming messages are those that help people believe in themselves and value their personal sense of self worth. Ellis (2000, 2004) found teacher confirmation behaviors to explain 30% of the variance in students' affective learning. Teacher confirmation behaviors also enhance students' cognitive learning (Lathan, 1997) and self-efficacy (Chu, Jamieson-Noel, & Winne, 2000). Theories related to confirmation have historically suggested that individuals have a fundamental need to be validated in order to be self-efficacious (Buber, 1988; Laing, 1961). Krathwohl et al. (1964) described affective learning as a process of internalization, which seems compatible with the self-discovery process that occurs when teachers use confirming messages. Internalization is a process and a product that happens when students accept certain values, attitudes, and interests into their belief systems and are guided by these regardless of other outside influences (Krathwohl et al., 1964). Burleson and Goldsmith (1998) argued that confirming messages are comforting and encourage higher-order thought processing and a valuing of learning.

The reviewed research literature confirms predictions that teachers' communication behaviors impact college students' affective learning (Chesebro & McCroskey, 2001; Ellis, 2000; Frymier & Shulman, 1995; Mottet & Beebe, 2002). Few studies, however, have investigated the impact that teacher communication behaviors have on high school students' affective learning (Nussbaum, 1992). Having little reason to believe that teacher communication behaviors impact college students differently than high school students, the following prediction was tested:

- H1: Teacher nonverbal immediacy, clarity, and content relevance behaviors are positively related, while teacher disconfirmation behaviors are negatively related with students' math/science affective learning outcomes.

In addition to teacher communication behaviors impacting students' affective learning in math and science, the sex of the teacher and sex of the student are also variables that have been shown to impact students' affect for math and science

(Bevan, 2001). Much has been written about how high school and college females tend not to perform as well as males on standardized math tests (McGlone & Aronson, 2007). Researchers attribute these differences to a number of different reasons including student expectations of math, pedagogical strategies, teacher–student sex similarity, and stereotypes (Bevan, 2001; Boster et al., 2007; McGlone & Aronson, 2007). To examine if teacher and student sex impact ninth-grade students' affective learning outcomes, the following research question was asked:

RQ1: Does teacher and student sex interact to impact students' math/science affective learning outcomes?

Influence of Teacher Communication Behaviors on Student Study Strategies

Weinstein and Hume (1998) defined student study strategies as “any behavior, thought, or action a learner engages in during learning that is intended to influence the acquisition, storage in memory, integration, or availability for future use of new knowledge and skills” (p. 12). Fundamentally, strategic learners have the skills to learn successfully, the will or desire to want to use these skills, and the ability to self-regulate in order to be able to manage their learning (Weinstein & Hume). For example, Titsworth (2001, 2004) found that teacher communication behaviors had some bearing on students' note taking, which is one type of student study strategy.

Titsworth (2004) hypothesized that teacher clarity behaviors, which include verbal fluency behaviors (e.g., eliminating stammering, vocalized pauses, and false starts) and structural clarity behaviors (e.g., using previews/reviews, verbal transitions, and signposts), enhance the quality of students' note taking. Titsworth also found that students recorded more details in their note taking when listening to lecturers who were high in clarity behaviors and low (rather than high) in nonverbal immediacy behaviors. Teacher clarity behaviors and students' note taking impacted student learning outcomes accounting for 11% of the variance in students' test scores (Titsworth, 2001). He suggested that students may become distracted by a teacher's nonverbal immediacy behaviors, and this distraction may impact their note taking.

Student study strategies have also been linked to indicators of students' affective learning (Dansereau et al., 1979). Zimmerman, Bandura, and Martinez-Pons (1992) found positive relationships between student study strategies and student self-efficacy or students' confidence in their ability to learn. McCombs' (1994) findings confirmed the positive association between student study strategies, motivation, and self-regulating learning behaviors. Furthermore, Hattie, Biggs, and Purdie (1996) also found student learning strategies, motivation, and perceptions of their success to be positively related.

Knowing that student note taking, which is one form of a student study strategy, is impacted by teacher communication behaviors (Titsworth, 2001, 2004), and student study strategies are related to indicators of affective learning (Krathwohl et al., 1964; McCombs, 1994; Zimmerman, Bonner, & Kovach, 1996), the following two hypotheses were tested:

- H2: Students' study strategies in math/science classes are positively related to their teachers' perceived use of nonverbal immediacy, clarity, and content relevance behaviors, and negatively related to their teachers' perceived use of disconfirmation behaviors.
- H3: Students' study strategies are positively related to their math/science affective learning outcomes.

To examine further the influence that teacher communication behaviors and student study strategies have on students' affective learning, the following research question was asked:

- RQ2: What predictor variables (teacher communication behaviors, student study strategies) account for the most variance in math/science and nonmath/science students' affective learning outcomes?

Math/Science and NonMath/Science Instructor Communication Differences

The subject matter may also influence teachers' communication behaviors and thus students' affective learning. Specifically, science and math teachers may engender different affective learning outcomes than nonmath and science teachers. There are two possible explanations. The first reason is the result of current educational policy. The federal government enacted the No Child Left Behind (NCLB) act in 2002 for a number of reasons, one being that the United States was falling behind other countries in both student aptitude and interest in math and science, as well as reading (Linn, Baker, & Betebenner, 2002). This act requires that teachers teach a prescribed set of learning objectives and assess their students' learning through the use of state-mandated standardized exams. The NCLB policy prohibits students from advancing to the next grade until they successfully pass the standardized exam.

Many scholars and educators believe that the current assessment-based teaching and learning culture, which targets the math/science and reading content areas, has impacted how teaching occurs today (Neill, 2006; Weaver, 2004). The emphasis is on the learning product rather than the learning process (Harriman, 2005). Weaver (2004) argued that the current pedagogical emphasis focuses on teaching the content rather than on the student. According to Neill (2006), little time is devoted to teaching students how to value and appreciate the content their teachers present to them in the classroom. This cognitive and product-focused teaching and learning culture may be particularly salient to ninth-grade students since the ninth grade is pivotal in terms of career planning and preparation (Dedmond, 2005). Based on this reasoning, the following hypothesis was derived:

- H4: Math/science students report significantly lower affective learning outcomes than nonmath/science students.

The second reason why there may be differences in teachers' instructional communication behaviors based on the content they teach is their personality differences. It could be that preservice teachers self-select into their content area based on their personality type. Math and science teachers may possess a different

personality profile than nonmath and science teachers, and because of these personality differences, they communicate differently in the classroom. Instructional communication research clearly links differences in teachers' personality to differences in their communication behavior (McCroskey, Daly, Martin, & Beatty, 1998; McCroskey, Valencic, & Richmond, 2004). Only one instructional communication study, however, has examined differences in teacher communication behaviors based on the teacher's content area. Kearney, Plax, and Wendt-Wasco (1985) failed to find differences in students' perceptions of teacher nonverbal immediacy behaviors between task-(i.e., accounting) and relational-oriented (i.e., communication) courses.

Although the education research literature does not directly attribute differences in teaching style to personality, the research does suggest that teachers' possess different beliefs and judgments about how course content should be taught (Shavelson & Stern, 1981). Teachers' beliefs and judgments have been shown to impact their teaching practices and decision-making in the classroom (Shavelson & Stern, 1981). Along with Shavelson and Stern, Butty (2001) described how teachers' instructional practices and teaching styles differed based on teachers' conceptions of the subject matter and their cognitive processes. Butty further suggested that content areas have different pedagogical traditions. The math content area has a teacher-versus student-centered tradition, with teachers placing greater emphasis on lectures and textbooks than on the desire to help their students think critically across subject areas and apply their knowledge (Butty). Because of the minimal research examining teacher communication style differences between the various content areas, the following research question was asked:

- RQ3: Do students perceive math/science teachers using significantly less non-verbal immediacy, clarity, and content relevance behaviors and significantly more disconfirmation behaviors than nonmath/science teachers?

Method

Sample

Survey participants included 497 ninth-grade students (239 male, 258 female) enrolled in a middle-class, suburban, ninth-grade school in central Texas. In terms of student ethnicity, 33% ($n = 164$) of the participants self-identified as Hispanic, 45% ($n = 224$) as White, 16% ($n = 80$) as African American, and 6% ($n = 29$) as Asian.

Procedures

The survey included seven instructional communication measures that were modified to ensure age-appropriateness and to accommodate the attention span of the ninth-grade sample. Careful attention was given to each measure to preserve the instrument's validity. Modifications included shortening the various measures and

making survey items more concrete. Specific examples of how the instruments were modified are detailed below under Instrumentation.

The survey was developed after consulting with several ninth-grade educators and faculty members from the College of Education. The survey was piloted using 25 ninth-grade students from a school unaffiliated with the research sample. The survey was revised and formatted to resemble a standardized exam, which is a format that students understand.

After receiving permission from the university's institutional review board, the school's principal, and the students' parents, a 10-member research team surveyed all students enrolled at the school during the 11th week of an 18-week school term. Each trained member of the research team entered a preassigned classroom, collected parental permission forms, introduced the research study, and instructed students how to complete the survey using scripted instructions. Students were surveyed during the third period of the school day and were instructed to complete the survey while thinking about the teacher they had during their second period. The second period was selected, since it included the most number of faculty members and content areas. On average, it took students 20 minutes to complete the survey.

Students reported their perceptions of 47 different faculty members' instructional communication behaviors (13 male; 33 female) who taught in 25 different content areas. The 25 different content areas were collapsed into three categories including math/science (algebra, biology, chemistry), humanities (English, modern language, geography), and other (band, vocational, sports, health), with 157 students focusing on a math/science teacher, 233 focusing on a humanities teacher, and 107 focusing on a teacher who was neither math/science or humanities (other). For this study, only the math/science and humanities teacher categories were examined ($N=390$), and these categories were labeled and referred to as math/science ($n=157$) and nonmath/science ($n=233$) throughout the manuscript. The "other" category was not examined, since these courses are considered extracurricular and not a part of the mainstream curriculum.

Instrumentation

Teacher nonverbal immediacy. Student perceptions of teacher nonverbal immediacy were measured using a modified version of Richmond, Gorham, and McCroskey's (1987) Nonverbal Immediacy Behaviors (NIB) instrument. Modifications included omitting redundant items and clarifying language. Six of the original 14 items were used representing all nonverbal codes to ensure content validity: gestures, vocalics, smile, movement, eye contact, and relaxed posture. Language clarification included replacing "monotone voice" with "boring voice." The item assessing touch was excluded from the modified instrument, since it is generally agreed upon that touch is inappropriate at the secondary education level. The modified NIB instrument asked students to indicate the frequency of their teachers' nonverbal behaviors using a 5-point scale (0 = never, 4 = very often). Means, standard deviations, ranges, and internal consistency coefficients for all instruments are reported in Table 1.

Table 1 Means, Standard Deviations, Ranges, and Reliabilities for all Variables

Variables	<i>M</i>	<i>SD</i>	Range	α
Nonverbal immediacy	16.31	4.47	0–24	.75
Clarity	17.05	4.94	0–24	.89
Content relevance	13.95	5.91	0–28	.84
Disconfirmation	10.40	6.84	0–36	.87
Study strategies	26.33	6.93	9–45	.81
Total affective learning	37.43	12.04	12–60	.92
Attitude	11.50	2.83	3–15	.82
High school	9.22	4.03	3–15	.94
College	8.86	4.10	3–15	.95
Career	8.21	4.14	3–15	.94

Teacher clarity. Student perceptions of their teachers' use of clarity behaviors were measured using a modified version of Chesebro and McCroskey's (1998) Teacher Clarity Short Inventory (TCSI). Six of the original 10 items were included in the modified measure. To reduce the threat of fatigue, redundant items were omitted. In addition, items similar to "Projects assigned for the class have unclear guidelines" were omitted, since they were not appropriate for the age group. The modified TCSI asked participants to indicate their level of agreement on six clarity items using a 5-point scale (1 = strongly disagree, 4 = strongly agree).

Teacher content relevance. Student perceptions of their teachers' use of content relevance behaviors were measured using a modified version of Frymier and Shulman's (1995) Content Relevance Scale (CRS). Seven of the original 12 items were included in this measure. Redundant items were omitted to prevent fatigue, and language was adapted to make the items age appropriate. For example, "Uses student experiences to demonstrate or introduce a concept" was modified to read "This teacher explained a new objective by using examples from my life." The modified CRS asked students to indicate the frequency of their teachers' content relevant behaviors using a 5-point scale (0 = never, 4 = very often).

Teacher disconfirmation. Student perceptions of their teachers' use of disconfirmation behaviors were measured using items from one of the four subfactors comprising Ellis's (2000) Teacher Confirmation Measure (TCM). Nine of the original 11 items assessing teacher disconfirmation were used in this study. Selected items were omitted or modified to make the items age-appropriate. For example, "Teacher displays arrogant behavior (e.g., tries to look 'smart' in front of the students or communicates a 'big me, little you' attitude) was omitted because of lack of comprehension. "Teacher belittles students" was modified to read, "Teacher puts students down." The modified teacher disconfirmation measure (TDM) asked participants to indicate their level of agreement on nine disconfirmation behaviors using a 5-point scale (0 = strongly disagree, 4 = strongly agree).

Student study strategies. Students' self-reports of their study strategies were patterned after Weinstein and Palmer's (1990) The Learning and Study Strategies Inventory—High School Version (LASSI-HS). The LASSI-HS is a 76-item self-report measure that assesses 10 types of learning and study strategies: attitude, motivation, time management, anxiety, concentration, information processing, selecting main ideas, study aids, self-testing, and test strategies. A nine-item measure was developed for this study using modified items from three of the 10 subfactors of the LASSI-HS: information-processing, self-testing, and test strategies. A sample item representing information processing was "I make connections between what I learn in this class and my own life." A sample item representing self-testing was "I often stop reading my textbook for this class to think about what I am reading." A sample item representing test strategies was "When preparing for an exam, I test myself by using practice exams, flashcards, or review study guides."

Items representing the other subfactors were omitted for two reasons. First, three of these subfactors (i.e., attitude, motivation, concentration) assessed aspects of affective learning that were considered redundant with the affective learning measure, which is described below. Second, four of the subfactors were considered inappropriate because they assessed self-regulation and study strategies that fell outside the scope of the current study (i.e., time management, anxiety, selecting main idea, and study aids).

The resulting Student Study Strategies Measure (SSSM) assessed students' perceptions of their study strategies by asking them to indicate how well the item reflected their study behaviors using a 5-point scale (1 = not at all like me, 5 = very much like me).

Student affective learning. Affective learning was measured using a modified version of McCroskey's (1994) Affective Learning Scale (ALS). Students were asked to complete a 12-item affective learning measure, which assessed their affective learning in their second-period classes. This 12-item measure comprises four subfactors with each subfactor including three 5-point bipolar scales. The first subfactor, labeled "Attitude" throughout the manuscript, assessed students' attitude about the content they were learning using the following bipolar adjectives: bad/good, not valuable/valuable, and negative/positive. Higher mean scores reflected more positive attitudes.

The second subfactor, labeled "High School" throughout the manuscript, assessed students' interest in taking additional courses in the same content area when they get to high school using the following bipolar adjectives: not likely/likely, would not/would, and not interested/interested. Higher mean scores reflected greater interest in taking additional courses in high school.

The third subfactor, labeled "College" throughout the manuscript, assessed students' interests in taking additional courses in the same content area when and if they go to college using the following bipolar adjectives: not likely/likely, would not/would, and not interested/interested. Higher mean scores reflected greater interest in taking additional courses in college.

The fourth subfactor, labeled “Career” throughout the manuscript, assessed students’ interests in pursuing a job or career that uses the information they are learning in their second period class using the following bipolar adjectives: not likely/likely, would not/would, and not interested/interested. Higher mean scores reflected greater interest in pursuing a job or career using similar content.

Data Analysis

H1, H2, and H3 were tested using one-tailed, Pearson product-moment correlations. H4 was tested by computing five individual one-way analyses of variance with teacher type (math/science, nonmath/science) serving as the independent variable and the four subfactors of affective learning (attitude, high school, college, career) and the total affective learning score serving as the dependent variables. To guard against type one error, the significance level was set at .01.

RQ1 was answered by computing a two-way ANOVA with teacher sex and student sex serving as the independent variables and students’ total affective learning score serving as the dependent variable. RQ2 was answered by computing five individual stepwise multiple regression analyses with teacher communication behaviors (i.e., nonverbal immediacy, clarity, content relevance, disconfirmation) and student study strategies serving as predictor variables and the four subfactors of student affective learning (i.e., attitude, high school, college, career) and the total affective learning score serving as criterion variables. To guard against type 1 error, the significance level was set at .01.

RQ3 was answered by computing four individual one-way analyses of variance with teacher type (math/science, nonmath/science) serving as the independent variable and students’ perceptions of their teachers’ instructional communication behaviors (i.e., nonverbal immediacy, clarity, content relevance, disconfirmation) serving as the dependent variables. To guard against type 1 error, the significance level was set at .01.

Results

Because student ethnicity has been shown to influence student perceptions and student learning outcomes (Gainor & Lent, 1998; McWhirter, Hackett, & Bandalos, 1998), student ethnicity was examined before any of the hypotheses were tested to see if ethnicity impacted any of the variables of interest in this study. Six individual one-way analyses of variance were computed with student ethnicity (Hispanic, White, African American, Asian) serving as the independent variable and students’ perceptions of their teachers’ instructional communication behaviors (nonverbal immediacy, clarity, content relevance, disconfirmation), student study strategies, and affective learning serving as dependent variables. All six *F*-ratios were nonsignificant at a significance level of .01, which was used to control for type 1 error.

H1 predicted that teacher nonverbal immediacy, clarity, and content relevance behaviors are positively related, and teacher disconfirmation behaviors are negatively related with students’ math/science affective learning outcomes. This hypothesis was supported. All correlation coefficients are reported in Table 2.

All total affective learning outcomes were statistically significant and related in the appropriate direction with each of the teacher communication behaviors. Teacher clarity and content relevance behaviors were the most strongly related, accounting for 14% and 15%, respectively, in math/science students' affective learning outcomes.

RQ1 asked whether teacher and student sex interact to impact students' math/science affective learning outcomes. The two-way ANOVA produced a nonsignificant interaction effect, $F(3, 152) = 3.73, p > .05$, and two significant main effects for teacher sex, $F(1, 152) = 4.55, p < .05, \eta^2 = .03$, and student sex, $F(1, 152) = 4.85, p < .05, \eta^2 = .03$. These results suggest that teacher and student sex do not interact to impact students' math/science learning outcomes. Two main effects—one for teacher sex and one for student sex—did emerge from the analysis. In terms of teacher sex, all students reported significantly more math/science affective learning when learning from a male teacher ($M = 38.60, SD = 10.88$) than when learning from a female teacher ($M = 34.19, SD = 11.80$). In terms of student sex, male students ($M = 38.67, SD = 11.19$) reported significantly more math/science affective learning than female students ($M = 34.12, SD = 11.98$). However, given the small effect sizes obtained for both main effects, these findings are not considered particularly meaningful.

Table 2 Intercorrelations Between Variables for Math/Science and NonMath/Science Courses

Scale	1	2	3	4	5	6	7	8	9	10
<i>Math/science courses (n = 157)</i>										
Immediacy	–	.57	.51	–.56	.20	.20	.37	.12*	.20	.08*
Clarity		–	.54	–.66	.16	.38	.52	.27	.34	.20
Relevance			–	–.42	.14*	.39	.41	.31	.37	.25
Disconfirmation				–	.14*	–.29	–.43	–.19	–.26	–.17
Study strategy					–	.29	.37	.25	.19	.17
Total affective learning						–	.68	.81	.86	.79
Attitude							–	.40	.53	.40*
High school								–	.60	.50
College									–	.58
Career										–
<i>Nonmath/science courses (n = 233)</i>										
Immediacy	–	.63	.59	–.62	.24	.30	.42	.27	.20	.08*
Clarity		–	.56	–.69	.28	.39	.57	.29	.29	.11*
Relevance			–	–.51	.29	.35	.40	.28	.26	.15
Disconfirmation				–	–.27	–.33	–.40	–.25	–.30	–.09*
Study strategy					–	.28	.29	.23	.28	.05*
Total affective learning						–	.63	.80	.83	.71
Attitude							–	.46	.42	.20
High school								–	.57	.37
College									–	.83
Career										–

Note. With the exception of the correlation coefficients marked with an asterisk, all correlations are significant at the .05 level.

H2 predicted that students' study strategies in math/science classes are positively related to their teachers' perceived use of nonverbal immediacy, clarity, and content relevance behaviors, and negatively related to their teachers' perceived use of disconfirmation behaviors. This hypothesis was partially supported. Math/science students' perceptions of their teachers' nonverbal immediacy ($r = .20, p < .01$) and clarity ($r = .16, p < .05$) behaviors were positively related to students' study strategies, whereas teacher content relevance ($r = .14, p > .05$) and disconfirmation ($r = -.14, p > .05$) behaviors were unrelated to student study strategies.

H3 predicted that students' study strategies are positively related to their math/science affective learning outcomes. This hypothesis was supported. All correlation coefficients are reported in Table 2. Results indicated that students' study strategies were positively related to their total affective learning for math/science classes ($r = .29, p < .05$) accounting for 8% of the variance. The influence of students' study strategies on math/science affective learning outcomes appeared to diminish as students consider taking additional math/science classes in college ($r = .19, p < .05$) and pursuing a career ($r = .17, p < .05$) in math/science-related field.

RQ2 asked what predictor variables (teacher communication behaviors, student study strategies) account for the most variance in math/science and nonmath/science students' affective learning outcomes. Findings are reported in Table 3. Based on the results, teacher communication behaviors and student study strategies are slightly more predictive of math/science students' total affective learning outcomes than nonmath/science students' total affective learning outcomes accounting for 23% and 20% of the variance, respectively. Among math/science students, teacher clarity and content relevance behaviors along with student study strategies were equal predictors of students' affective learning. Among nonmath/science students, teacher clarity appeared to be the consistent and strongest predictor of students' affective learning. Interestingly, neither teacher nonverbal immediacy nor disconfirmation behaviors predicted students' affective learning outcomes.

H4 predicted that math/science students report significantly lower affective learning outcomes than nonmath/science students. This hypothesis was not supported. Differences in affective learning outcomes between students in math/science and nonmath/science classes are reported in Table 4.

Although math/science students reported lower affective learning on two of the four subfactors (attitude and high school), these statistically significant differences lack meaningfulness, since the amount of variance attributable to the different course content (i.e., math/science versus nonmath/science) was minimal (Levine & Hullett, 2002).

RQ3 asked whether students perceive math/science teachers using significantly less nonverbal immediacy, clarity, and content relevance behaviors, and significantly more disconfirmation behaviors than nonmath/science teachers. Differences in perceived teacher communication behaviors between students in math/science and nonmath/science classes are reported in Table 5.

The results suggest that students perceive math/science teachers using significantly less nonverbal immediacy, clarity, and content relevance behaviors, and significantly

Table 3 Stepwise Multiple Regression Analyses for Variables Predicting Affective Learning

Affective Learning	Math/science			Nonmath/science		
	β	Significance	Variance	β	Significance	Variance
Attitude	[$F = 29.14^*$, $R^2 = .37$]			[$F = 59.58^*$, $R^2 = .35$]		
Nonverbal immediacy						
Clarity	.39	.000	.10	.54	.000	.27
Content relevance	.16	.035	.02			
Disconfirmation						
Study strategies	.25	.000	.07	.14	.013	.02
High School	[$F = 11.86^*$, $R^2 = .14$]			[$F = 13.32^*$, $R^2 = .11$]		
Nonverbal immediacy						
Clarity				.25	.000	.06
Content relevance	.28	.000	.08			
Disconfirmation						
Study strategies	.21	.007	.04	.15	.023	.02
College	[$F = 14.59^*$, $R^2 = .16$]			[$F = 15.87^*$, $R^2 = .12$]		
Nonverbal immediacy						
Clarity	.21	.021	.03	.23	.000	.05
Content relevance	.25	.005	.04			
Disconfirmation						
Study strategies				.20	.002	.04
Career	[$F = 9.61^*$, $R^2 = .06$]			[$F = 6.49^*$, $R^2 = .03$]		
Nonverbal immediacy						
Clarity						
Content relevance	.24	.002	.06	.17	.011	.03
Disconfirmation						
Study strategies						
Total Affect	[$F = 15.37^*$, $R^2 = .23$]			[$F = 18.18^*$, $R^2 = .20$]		
Nonverbal immediacy						
Clarity	.22	.012	.03	.25	.001	.04
Content relevance	.24	.005	.04	.17	.020	.02
Disconfirmation						
Study strategies	.21	.005	.04	.16	.014	.02

* $p < .01$.

more disconfirmation behaviors than nonmath/science teachers. Of the four types of teacher communication behaviors assessed, perceived teacher clarity (7%) and content relevance (4%) behaviors accounted for larger amounts of variance between the class content areas (i.e., math/science, nonmath/science) than the teacher nonverbal immediacy (2%) and disconfirmation (2%) behaviors.

Discussion

The purpose of this study was to examine how students' perceptions of their teachers' instructional communication behaviors were related to their affective learning in math and science. Specifically, this study examined (1) if teachers' communication

Table 4 Differences in Affective Learning Outcomes Between Students in Math/Science and NonMath/Science Classes

	Math/science		Nonmath/science		F ratio	Significance	η^2
	M	SD	M	SD			
Total affective learning	35.50	11.79	38.12	11.15	4.92	.03	1%
Attitude	10.90	2.86	11.73	2.62	8.62	.00	2%
High school	8.38	3.88	9.56	3.86	8.59	.00	2%
College	8.36	3.89	9.03	4.00	2.73	.09	
Career	8.14	4.00	8.04	4.01	.06	.80	

Note. *n* size for math/science = 157, nonmath/science = 233.

behaviors predicted ninth-grade students' desire to pursue additional study and careers in math and science, (2) if teachers' communication behaviors were related to students' study strategies, (3) if there were differences in students' perceptions of their affective learning between the math/science and nonmath/science content areas, and (4) if there were differences in students' perceptions of their math/science and nonmath/science teachers' instructional communication behaviors.

Five general conclusions were yielded from this study. First, it was expected that teachers' use of all instructional communication behaviors (nonverbal immediacy, clarify, content relevance, disconfirmation) would predict students' affective learning outcomes. The data revealed that while clarity and content relevance behaviors did impact students' affective learning, contrary to research conducted with college students (Mottet, Richmond, & McCroskey, 2006), nonverbal immediacy and disconfirmation behaviors did not influence affective learning. It is rare when teacher nonverbal immediacy behaviors do not predict students' affective learning.

There may be two explanations for these findings. First, the lack of a relationship between nonverbal immediacy and affective learning may be due to the fact that students, because of the NCLB program, are separated from the emotional and social attachments necessary for optimal learning to occur (Immordino-Yang & Damasio, 2007). It could be that students in the high-stakes assessment culture with a heavy emphasis on cognitive learning outcomes may be immune to teachers' use of

Table 5 Differences in Math/Science and NonMath/Science Teachers' Perceived Use of Instructional Communication Behaviors and Student Study Strategies

	Math/science		Nonmath/science		F ratio	Significance	η^2
	M	SD	M	SD			
Nonverbal immediacy	15.90	4.40	17.04	4.45	6.11	.01	2%
Clarity	15.49	5.39	18.14	4.11	30.11	.00	7%
Content relevance	12.36	6.16	14.71	5.40	15.87	.00	4%
Disconfirmation	11.05	6.42	9.00	6.41	9.69	.00	2%
Study strategies	27.00	5.94	25.77	7.03	3.24	.07	

Note. *n* size for math/science = 157, nonmath/science = 233.

nonverbal immediacy and disconfirmation behaviors (Cawelti, 2006). A second explanation may be that, although most instructional communication models posit that affective learning is an antecedent to cognitive learning (Rodriguez, Plax, & Kearney, 1996), it is possible that with early high school students, cognitive learning is an antecedent to affective learning (Jacob, 1957). Before students can appreciate math and science, they first need to understand, apply, analyze, and evaluate math and science (Aiken, 1976).

The second general conclusion yielded from this study suggests that teachers' use of clarity and content relevance behaviors as well as student study strategies predict students' affective learning similarly regardless of the course content (math/science, nonmath/science). It appears that both of these instructional message variables may enhance students' affective learning in a manner similar to Keller's (1983) process model of student motivation. Keller argued that in order for students to be internally motivated to learn, their attention needs to be captured and maintained, course material must be perceived as useful, and students must feel confident and satisfied with their learning. Keller's model parallels the emotional experiences associated with Krathwohl et al.'s (1964) taxonomy of affective learning where students slowly internalize their learning by being willing to receive and respond to new information, obtaining satisfaction from responding, seeing the value and usefulness of the learning, and finally by organizing the new feelings, attitudes, and values into a value complex or disposition. It appears that teachers' use of clarity behaviors coupled with content relevance behaviors allow students to feel self-efficacious and empowered (Zimmerman, Bandura, & Martinez-Pons, 1992).

The third general conclusion yielded from this study is that teachers' use of clarity and content relevance behaviors predict ninth-grade students' thinking about pursuing additional study in the math/science content areas in high school and college, as well as considering careers in the fields of math and science. Teachers' use of clarity and content relevance behaviors accounted for 8% of the variance in students' wanting to pursue additional math/science courses while in high school, 7% of the variance in students' wanting to pursue math/science in college, and 6% of the variance in students' wanting to pursue a math/science career. Although these variance estimates are small, it is important to interpret the results within the instructional context. The research literature examining ninth-grade teachers consistently suggests that ninth grade may be the most challenging grade level within the primary and secondary educational system to teach (Gibbons et al., 2006; Stodolsky et al., 1991). Influencing ninth-grade students' future thinking about additional study in math and science, even minimally, may be considered an important educational gain.

The fourth general conclusion yielded from the study is that ninth-grade students did not perceive meaningful differences in their affective learning between math/science and nonmath/science courses. Researchers argued that with instructor-directed teaching and learning models (Butty, 2001), which are a manifestation of the "No Child Left Behind" educational policies, students would learn the content, but would not learn to appreciate and value the content (Harriman, 2005; Neill, 2006;

Weaver, 2004). Researchers suggested that this affective learning deficit would be particularly salient in the math and, to a lesser degree, science content areas, since students are tested in math and must achieve a certain competency level before advancing to the tenth grade (Marx & Harris, 2006; Stodolsky et al., 1991). The data from this study suggest that there are no meaningful differences in ninth-grade students' affective learning between math/science and nonmath/science course content areas and that students self-report moderate amounts of affective learning ($M = 36$, Range = 12–60).

The fifth and final general conclusion yielded from the study is that students perceived minimal differences between their math/science and nonmath science teachers' use of instructional communication behaviors. Although Kearney et al. (1985) failed to find differences between what they labeled task- and relationally oriented courses, there is some research suggesting that teacher characteristics (e.g., beliefs, judgments, and respect for tradition) may vary by discipline (Butty, 2001; Shavelson & Stern, 1981). Our findings revealed that students' perceived math/science teachers using slightly fewer instructional communication behaviors (i.e., nonverbal immediacy, clarity, and content relevance) that positively influence student learning and using slightly more instructional communication behaviors (i.e., disconfirmation) that negatively influence student learning. The minimal amount of variance in teachers' nonverbal immediacy (2%) and disconfirmation (2%) behaviors that was attributable to the teacher type (math/science versus nonmath/science) suggests that these differences may lack meaning. Also negligible were the teacher clarity and content relevance behaviors where teacher type only accounted for 7% and 4% of the variance, respectively.

Limitations

As with any research study, it is important to interpret the research results in the context of the limitations of the study. First, the sample for this study consisted of ninth-grade students from a single school in the central Texas. Although this ninth-grade learning center included a diverse student population, the school is located in a suburban, middle-class community. Caution should be taken when generalizing the conclusions from this sample to the larger ninth-grade student population.

Second, as previously mentioned in the Method section, many of the instructional communication instruments were modified for the ninth-grade sample by shortening the instruments, using more concrete and age-appropriate vocabulary, and replacing items to make them more context-specific. Although these instruments were considered internally consistent, the instruments were modified and should be reassessed for validity.

Third, the research design, which was restricted by the school's principal, did not allow researchers to control for the variance attributable to student perceptions of teacher behaviors *within* the math/science and nonmath/science groupings. Instead, the research design only allowed researchers to examine the variance in student perceptions of teacher behaviors *between* the math/science and nonmath/science

groups. An improved design would require identifying teachers and their students, which is not a popular policy in today's public education. To strengthen the empirical findings presented in this research study, researchers are encouraged to foster relationships with educational leaders who will allow them to design studies that control for *between* and *within* types of variance.

Conclusion

The findings from this study suggest important implications for instructors. Instructors are encouraged to develop and continue using a repertoire of instructional messages, such as clarity and content relevance behaviors, especially when teaching high school students. Teacher clarity behaviors include speaking fluently (without stammering, vocalized pauses, false starts), providing concrete (rather than abstract) definitions, examples, and explanations targeted to students' experiences and language comprehension, and organizing material for students by providing previews, transitions, reviews, and outlines (see Chesebro, 2002). Content relevance behaviors include informing students how the instruction builds on the students' existing skills, using analogies and examples familiar to students, finding out what students' interests and goals are and matching instruction to these interests and goals, stating explicitly how the instruction relates to future activities of students, and asking students to relate the instruction to their future goals (see Frymier, 2002).

Our findings suggest that these teachers' communication behaviors impact ninth-grade students' affective learning in math and science. Specifically, teachers' communication behaviors influence students' desire to take additional course work in math and science in high school and college, and, to a lesser extent, pursue a career in a math or science-related field. Teaching math and science educators how to communicate more effectively with their students may play an important role in increasing the number of students who not only have increased affect for math and science, but also may pursue a math and science-related career. Any effort that reduces the number of students left behind by helping them excel in math and science is worth additional attention and further study.

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